STUDIES ON THE FISHERY, BIOLOGY AND POPULATION DYNAMICS OF FLATFISHES (*CYNOGLOSSUS* SPP; FAMILY : CYNOGLOSSIDAE) ALONG THE KERALA COAST

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IN

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BY

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D E C L A R A T I O N

I hereby declare that the matter embodied in this Thesis entitled "Studies on the fishery, biology and population dynamics of flatfishes (*Cynoglossus* spp; Family: Cynoglossidae) along the Kerala coast" is the result of investigations carried out by me in the Department of Zoology, Christ College, Iringalakuda, University of Calicut under the supervision and guidance of Dr.N.D.Inasu, Professor and Head, Department of Zoology, Christ College, Iringalakuda, University of Calicut and has not been submitted for award of any Degree/Diploma/Associateship/ Fellowship of any other University or Institute.

CANDIDATE

SUPERVISOR

C E R T I F I C A T E

This is to certify that this thesis entitled "Studies on the fishery, biology and population dynamics of Flatfishes (*Cynoglossus* spp; Family: Cynoglossidae) along the Kerala coast" submitted to the University of Calicut for the award of Degree of Doctor of Philosophy is a record of original research work done by A.A.Jayaprakash during the period of his study in the Department of Zoology, Christ College, Iringalakuda, University of Calicut, Kerala under my supervision and guidance and the thesis has not formed the basis for award of any Degree /Diploma/ Associateship/Fellowship or similar title to any candidate of any university or Institute.

Signature of the Guide

C O N T E N T S

PREFACE

Flatfishes of the order Heterosomata or Pleuronectiformes comprising the halibuts, flounders and soles constitute one of the important commercial fisheries in India especially along the Kerala coast. They are bottom fishes characterised by asymmetrical body, for in the adults the eyes lie either on the right or left side of the head. Although 91 species have been found to occur in the seas around India only a few support a fishery of commercial importance. Among these the Malabar sole *Cynoglossus macrostomus* Norman is the most dominant species that supports a fishery of commercial importance along Kerala and Karnataka coast. In fact it constitutes a single species fishery along the Kerala coast like oil sardine or Indian mackerel. There have been some earlier studies on flatfishes about their taxonomy, distribution, abundance, fishery and biological aspects. But no attempt has hitherto been made towards a comprehensive study of this group especially the Malabar sole in the context of changing fishing scenario. The impact of mechanisation of the fishing crafts and modernisation of gears and the expansion of the ambit of operation by the fishermen have resulted in increased exploitation of various fishery resources including the Malabar sole. But still the resource remain underexploited along Kerala coast. In view of this it was thought to study and update our information on the biology and fishery of the Malabar sole and a few related species along Kerala coast.

In this connection time series data on the production trends of flatfishes in India and in the different maritime states have been analysed. The exploitation of Malabar sole and related species by the trawls at Cochin and Neendakara (Quilon) and by the minitrawls at Ambalapuzha in Kerala have been studied. The study has covered detailed biological aspects of the dominant species *Cynoglossus macrostomus* Norman and some aspects of the biology of related species *C.arel, C.bilineatus* and *C.puncticeps.* The taxonomy of the species selected for biological studies and a faunistic list of flatfishes along Kerala coast also have been given. Emphasis was given to evolve a system of fishery forecast by correlating the Malabar sole fishery with time series data on environmental parameters like rainfall, sea level and solar periodicity in the Malabar upwelling ecosystem. A comparative study on the effect of these environmental factors on other single species fisheries like oil sardine, Indian mackerel and Bombay duck also has been made. The results of the studies are presented in nine Chapters as Introduction, Taxonomy, Food and feeding, Reproduction, Age and growth, Length-weight relationship and condition factor, Fishery, Stock assessment and Malabar sole fishery in relation to environment. A Summary and the Bibliography are given at the end.

The present work has been carried out during the three years full time study leave granted to me by the Indian Council of Agricultural Research, New Delhi. The observations, collection and analyses of the samples were carried out from August 1994 to October 1996. The work was initiated under the supervising guidance of late Dr.A.G.Govindankutty, Professor and Head of the Department of Zoology, Christ College, Iringalakuda. Consequent on his premature demise in July 1996 the study was continued under the Supervising Guide Dr.N.D.Inasu, Professor and Head of the Department of Zoology, Christ College, Iringalakuda of Calicut University. The work was carried out in the Zoology department of this college.

A C K N O W L E D G E M E N T S

I wish to express my deep sense of gratitude and indebtedness to Dr.N.D.Inasu, Professor and Head of the Department of Zoology, Christ College, Iringalakuda, University of Calicut under whose supervision the work was carried out and completed. Also I wish to express my gratitude and indebtedness to late Dr. A.G.Govindankutty, former Professor and Head of the Department of Zoology of the same college under whose guidance the work was initiated and partly completed. I extend my sincere thanks to all the staff of the Department of Zoology of the College.

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

The flatfishes of the order Pleuronectiformes or Heterosomata comprising halibuts, flounders and soles are widely distributed all over the World Oceans. They are all bottom fishes and are characterised by asymmetry, for in the adults both the eyes lie either on the right or on the left side of the head. These fishes are closely related to the perch like fishes and have remarkable capacity to change the colour of their body to match the surroundings. Most of them live in moderate depth. Some of them extend to deeper waters while a few live close to inshore and even in estuaries. They are predacious and carnivorus feeding on small fish, worms, molluscs and crustaceans. They are prolific breeders. Most flatfishes are small while a few like the halibuts attain large size. Some of the species are greatly esteemed for their delicate and flavoured flesh. They are cheap and are within the easy reach of the low income consumers.

The total global production of flatfishes (Av. 1986-92) was 1.2 million tonnes forming 1.6% of the total fish production of 98 million tonnes. The highest contribution of 6.3 lakh tonnes (50.9%) came from the Atlantic followed by 5.8 lakh tonnes

(46.5%) from the Pacific. Compared to these two oceans the catch from Indian ocean was only 0.3 lakh tonnes constituting 2.6%.

The important species that contributed to the global production of flatfish were the European plaice, *Pleuronectes platessa* which constituted 1.7 lakh tonnes forming 14.2%, followed by the Greenland halibut *Reinhardtius hippoglossoides* 1.4 lakh tonnes (11.9%) and the yellowfin sole *Limanda japonesa* (1.2 lakh tonnes, 10.5%). Other species which contributed 30000 t – 70000 t were the common sole *(Solea vulgaris)*, the American plaice *(Hippoglossoides platessoides)*, the Rock sole *(Lepidosetta bilineata)* and the Pacific halibut *(Hippoglossus stenolepis)*. The remaining species each constituted less than 30,000 t annually. Norman (1927 and 1928) described 91 species of this group (Heterosomata) from Indian waters. But it is only a very small number that contribute to any large catches and in fact only the Malabar sole *Cynoglossus macrostomus* Norman has been found supporting a regular fishery of commercial importance, mainly along the Kerala and Karnataka coasts. Species of the same genus that occur in stray catches are *C. arel*, *C. bilineatus*, *C. puncticeps* and *C. dubius*. Species of *Solea* and *Synaptura*, members of the Soleidae occasionally come in small quantities in the miscellaneous catches. *Psettodes erumei*, called the Indian halibut occurs in small quantities on both the east and west coasts and has been known to occur in deeper waters, unlike the tongue soles or Cynoglossids which are mainly confined to the shallow waters. Among the flounders also a few species like

Pseudorhombus arsius, P. javanica, P. elevatus occasionally form seasonal and stray catches. It is quite possible that one or more of the other species of flatfishes known to occur in our waters, may occur in some numbers occasionally here and there when they will be useful, as almost all the species seem to be more or less suitable for use as food. Most of the smaller varieties of flounders discarded as trash are used for making fish meal. The Malabar sole, *C. macrostomus* occurs along both the coasts of India and is essentially a shallow water form though it migrates and gets scattered in the relatively deeper waters of the fishing ground during the off season. This species supports a fishery of commercial importance along the Kerala and Karnataka coasts.

In India, the average flatfish landing was 37,322 t and the contribution from Kerala amounted to 42.9% (16,026 t) during 1985 to 1996 period. Among the flatfishes the soles comprised 34,800 t (93.2%) out of which 15,603 t forming 44.8% was from Kerala alone. The Malabar sole, *Cynoglossus macrostomus* dominated (95-97%) the sole landings in this state. Although a few other species of *Cynoglossus* were noticed their landings were not in appreciable quantities to constitute a fishery.

The Malabar sole *C. macrostomus* being the most dominant among the flatfishes and also by virtue of the magnitude of the fishery along the Kerala coast has received the attention of many workers. The importance of flatfishes and their fishery have been shown by Seshappa and Bhimachar (1955), Rao (1967), Seshappa (1968) and Ferozkhan and Nandakumaran (1993). The pioneering works on this species are those of Seshappa and Bhimachar (1951) who indicated the utility of scales of this species as age indicators. Later, Seshappa and Bhimachar (1954, 1955) studied the fishery and biology of the Malabar sole *C.semifasciatus.*

Seshappa (1968) and Seshappa and Chakrapani (1983) studied the length frequency distribution of the Malabar sole. Recently, Ferozkhan and Nandakumaran (1993) studied the population dynamics of the Malabar sole. A scalemetric comparison and the meristic characters of the Malabar sole have been made by Seshappa (1984), and Seshappa and Chakrapani (1984). Comparison of the morphometric characters of five *Cynoglossus* species have been made by Seshappa (1972). Further, Seshappa (1994) studied the coefficient of abnormalities and the homogeneity of the Malabar sole populations. Some of the interesting observations on the Malabar sole with a normal eye on the blind side (Seshappa,1970), on the lateral line sensory canal system (Seshappa, 1971) and the occurrence of an ambicoloured specimen (Seshappa; 1974,1974 a) also have been reported.

Information on other flatfishes are available from the studies of Seshappa (1974 b) on the fishery and biology of the large tongue sole *Cynoglossus dubius.* Seshappa (1978) reported on a collection of tongue soles from Moplah Bay with a description of *C. lida.* Kuthalingam (1957, 1960) gave an account of the life history and feeding habits of *Cynoglossus lingua* and *Solea elongata*.

The length weight relationship in the Malabar sole *C. macrostomus* have been worked out by Victor (1978) and in *C. lida* by Seshappa and Chakrapani (1981), in *Cynoglossus* species by Seshappa (1981), in *Psettodes erumei*, *Pseudorhombus arsius* and *Synaptura commersoniana* by Das and Mishra (1989).

Details of the food and feeding habits are available from the works of Mookerjee *et al.* (1946) on *Cynoglossus dubius*; Seshappa and Bhimachar (1955) on the Malabar sole; Pradhan (1959) on *Pseudorhombus elevatus*; Kuthalingam (1957, 1960) on *Cynoglossus lingua* and *Solea elongata*; Pradhan (1964) on *Psettodes erumei*; Ramanathan *et al.*(1975, 1977) on *Cynoglossus macrolepidotus*; and Ramanathan and Natarajan (1980) on *P.erumei* and *Pseudorhombus arsius*. Ramaiyan *et al.* (1987) gave a check list of estuarine and marine fishes of Parangipettai coastal waters.

Literature on the eggs, larvae and spawning of flatfishes are available from the works of Chidambaram (1945), Chidambaram and Venkataraman (1946), Gopinath (1946), John (1944,1951), Jones and Menon (1951), Nair (1952 a,b), Kuthalingam (1957), Balakrishnan and Devi (1974) and Ramanathan and Natarajan (1979). Seshappa and Bhimachar (1955) and Bensam (1965) described the eggs, larvae and metamorphosis in the Malabar sole.

Observations on the growth, mortality and theoretical yield on *Cynoglossus macrolepidotus* have been made by Krishnankutty (1967) and Krishnankutty and Qasim (1967). Recently, Ferozkhan and Nandakumaran (1993) studied the population dynamics of the Malabar sole, *C. macrostomus*. Electrophoretic studies of serum patterns in flatfishes have been studied by Menezes (1975, 1979). The Malabar sole *Cynoglossus macrostomus* (Norman) has been referred to *C. semifasciatus* (Day) in the earlier works until Menon (1971) confirmed its identity. A sytematic monograph of tongue soles of the genus *Cynoglossus* has been published by Menon (1977).

The review of the literature indicated that among flatfishes, the Malabar sole, *Cynoglossus macrostomus* seemed to have received the attention of many investigators probably due to the magnitude of its fishery along the Kerala coast. Most of these studies have been carried out from Calicut area. Further, with the exception of a few most of the investigations belonged to the pre-mechanisation era. Mechanisation and induction of sophistication in technology have resulted in increased landings of all fishes including the Malabar sole. The trawlers operating at major centres like Calicut, Cochin, Munambam (North of Cochin) and Neendakara though mainly target the shrimps also exploit the flatfishes as by-catch along with other fishes, in varying proportions almost throughout the gear. The most recent development is the introduction of minitrawls in and around

Ambalapuzha region. Presently more than 3000 units are in operation that mainly exploit the 'Karikadi' *Parapenaeopsis stylifera* and the Malabar sole is the second dominant component in this gear.

In the context of changing pattern of exploitation and increased catches of the flatfishes especially the Malabar sole along the Kerala coast it was felt necessary to update our information on this valuable resource. Hence the present work was undertaken to elucidate various aspects of the fishery, biology and population dynamics of commercially important species like *C. macrostomus*, and as well to study certain aspects of the biology of other co-occurring species like *C. arel*, *C. bilineatus* and *C. puncticeps*. Studies on the systematics of *Cynoglossus* species from Kerala selected for investigating biological aspects have been made. The material for systematics and faunistic studies were collected from landing centres at Calicut (Lat.11°15'N and Long.75°49'E), Cochin (Lat.09°58'N, Long.76°17'E), Ambalapuzha (Lat.09°30'N, Long.76°23'E) and Neendakara (08°54'N, 76°38'E) as indicated in Figure 1.1.

Samples for biological studies on the Malabar sole and other species were collected from the trawl landings at the fisheries harbours at Cochin and Neendakara (Quilon) and from the minitrawl catch at Ambalapuzha during 1994-95 and 1995-96. Weekly trips were made to Cochin and fortnightly trips to the other two centres.

During each sampling day 100-150 Malabar soles were measured from the trawl catches. The total length of the fish in mm and the total weight of the measured sample were taken using a scale and a monopan balance respectively. About 100-200 fishes were then collected, packed in an ice box with sufficient quantity of ice and brought to the laboratory. The specimens were cleaned and preserved in 5% formalin. After two days of preservation the samples were analysed and this practice was followed uniformly throughout the course of investigation. Since other species of *Cynoglossus* formed stray catches, they were also collected whenever available. Also for faunistic studies other fishes belonging to Pleuronectiformes also were collected.

Special care was taken in the collection of specimens of tongue soles for taxonomic studies. Abnormal and mutilated fishes were rejected. The fins and rays were spread out using pins and formalin was sprayed on them so that when the pins were removed after half an hour, they remained in spread out condition making it easy the counting of the fin rays. The measurements taken and the methods followed are described in detail in the Chapter on Taxonomy.

For detailed biological studies the samples of Malabar sole preserved in formalin were used. After thorough washing the total length (mm) and weight in gram of individual fishes were taken. The weight to the nearest 0.01 g was taken using a triple beam balance. Scale samples for growth ring studies were taken from the pectoral region just below the midlateral line on the eyed side. Scales from each fish were washed in 5% KOH and separately mounted dry between two glass slides for further study. Each fish was then cut open to note the condition of feed. The gut contents were washed into a small petridish and observed under a binocular microscope. The qualitative and quantitative analysis of the food items were made. The maturity stages were noted by cutting open the fish. After taking the length of the ovaries (in mm) they were dissected out, weighed on an electronic balance and then preserved for ova diameter and fecundity studies.

The length measurements of fishes taken from three centres were treated separately. The measurements were grouped into 5 mm class intervals for length frequency studies. The results of age and growth obtained from length frequency studies were compared with the results obtained from ELEFAN-1 programme and scale studies.

The flatfish fishery in India with special reference to Kerala is described. The catch statistics from the published works (Anon. 1969, 1980, 1982, 1983, 1986, 1989, 1995), from NMLRDC of CMFRI and the data collected during the present studies were utilised for this purpose.

In the following Chapters the taxonomy of the *Cynoglossus* species occurring along the Kerala coast with a key to the Indian species; the food and feeding habits; reproduction; age and growth; length-weight relationship and condition factor; the flatfish fishery in India with special reference to trawl and mini trawl operations in Kerala; stock assessment of Malabar sole and Malabar sole fishery in relation to environmental factors like rainfall, sea level and solar periodicity have been discussed. A summary of the results obtained and the bibliography are given at the end.

The Malabar sole *Cynoglossus macrostomus* Norman has been referred to *C.semifasciatus* (Day) by earlier workers until Menon (1971) confirmed its identity. A detailed study on the systematics of four species of *Cynoglossus* occurring along Kerala coast selected for biological studies and a key to the Indian species of *Cynoglossus* are presented. Also a faunistic list of all flatfishes occurring in Kerala is given in Chapter II.

The significance of the studies on food and feeding habits of fishes has been recognised as an accepted fact that the distribution and fluctuation in the availability of food organisms of a species are important factors that may affect its behaviour like migration, growth, condition, breeding, shoal formation and even fishery. The stomach contents of the Malabar sole *C.macrostomus* and *C.arel* have been analysed qualitatively and quantitatively. The food of other species like *C.bilineatus* and *C.puncticeps* were analysed qualitatively as these fishes were not regularly represented in the fishery. Comparison of the food intake in males and females of Malabar sole from Cochin were compared further with the results obtained from other centres. The occurrence of various dietary components have been correlated with their *in situ* abundance in the environment. The food items in immature and adult fishes, average feeding condition and intensity of feeding in Malabar sole also have been discussed. The results of these studies are presented in the Chapter III on food and feeding habits.

Recognising the significance of biological factors in successful management of the fishery, the reproduction in *C. macrostomus* and *C.arel* were studied and the results are projected in Chapter IV. Description of the structure of gonads and the classification of the maturity stages with respect to the Malabar sole are given. Based on the ova diameter studies, the seasonal variation in the maturity stages and gonado-somatic index the spawning season and the frequency of spawning were assessed. The size at first maturity and fecundity in Malabar sole and *C.arel* have been determined. Fecundity in relation to factors such as length of the fish, weight of the fish and weight of the ovary were also studied. The sex ratio in Malabar sole has been worked out month-wise and centre-wise and comparisons between three centres have been made. The studies on ova diameter and the ratio between different size groups of ova indicated that the malabar sole is not a multiple spawner.

Since the growth parameters are essential for successful fishery management an attempt has been made to estimate the age and growth of the Malabar sole using the length frequency data, ELEFAN-1 Programme and also by using growth rings on scales. The studies indicated that growth checks found on scales are annual in nature and formed as a result of the spawning stress. The theoretical growth was estimated by fitting von Bertalanffy's growth equation to the results obtained from length frequency method. The quarterly length increments were utilised for this purpose. The initial growth was found to be very fast. Nearly 70 per cent of the growth in the life span of the fish is attained at the end of one year itself indicating a high k value. The growth pattern at Cochin and Neendakara have been compared. The growth parameters were estimated by arithmetic and graphical methods. Age and growth was also estimated by the ELEFAN-1 programme and the results are presented in Chapter V. These growth parameters were used for stock assessment studies.

The length-weight relationship of *C.macrostomus* was calculated with two objectives, firstly as a means of interconversion and secondly, to calculate the "condition factor". Separate length-weight equations were derived for males and females, and through the analysis of covariance the significance of variation of the regressions of these categories were tested. The length-weight relationship of *C.arel* was also studied for comparison. Utilising the length-weight equation the relative condition factor of *C.macrostomus* was calculated for different size groups and for immature and mature categories in different months. The results are presented in Chapter VI.

The data on the landings of flatfishes, though available are scattered and a comprehensive account on their production trends in different maritime states and on an all India basis is lacking. Hence the available time series data for the different maritime states were analysed with special reference to Kerala and presented. The exploitation of the flatfish in Kerala at important centres like Cochin, Ambalapuzha and Neendakara (Quilon) are also described. The monthly effort, catch, catch per unit effort of trawlers, seasonal and inter annual variations have been worked out for the period from January 1994 to December 1996. The monthly mean fish length and mean weight of the Malabar sole in the trawl catch at Cochin and Neendakara and by the minitrawl in Ambalapuzha also have been worked out and the results are discussed in Chapter VII.

Chapter VIII deals with the stock assessment of Malabar sole in Kerala. Except for the studies made by Ferozkhan and Nandakumaran (1993) at Calicut no published accounts are available on the stock of Malabar sole. Based on the growth parameters obtained the total mortality, natural mortality and fishing mortality have been worked out. Further, the exploitation rate, exploitation ratio and annual survival rate have been studied. The stock assessment of Malabar sole and prediction of yields from the fishery have been made by employing tools like Virtual Population Analysis and the Beverton and Holt yield per recruit model, based on which management measures stipulated.

Chapter IX deals with the Malabar sole fishery in relation to the environmental factors of the Malabar upwelling ecosystem. The influence of sun spot activity, southwest monsoon rainfall, sea level and onset timings of the southwest monsoon on the Malabar sole fishery have been worked out by analysing time series data on all these parameters. This is a new aspect of study made for the first time. Good correspondence in the abundance of Malabar sole with solar activity, rainfall and sea level have been observed. Since the results were interesting a comparative study on the effect of these environmental factors on the abundance of other single species fishery constituted by oil sardine (*Sardinella longiceps*) also has been made. The results of these observations have been discussed. Apart from these, the existence of a 35 year cyclic rhythm in the monsoon has been highlighted. A decadal trend in the fishery of Malabar sole and oil sardine was discernible. Based on the trend in the fishery of Malabar sole simple forecast of its fishery has been attempted. A 50 year cycle in the abundance of oil sardine is reported for the first time based on which a long term fishery forecast for this species has also been made.

Chapter X of the thesis deals with the summary of the results of all these investigations and in the Bibliography the literature cited in the text are presented.

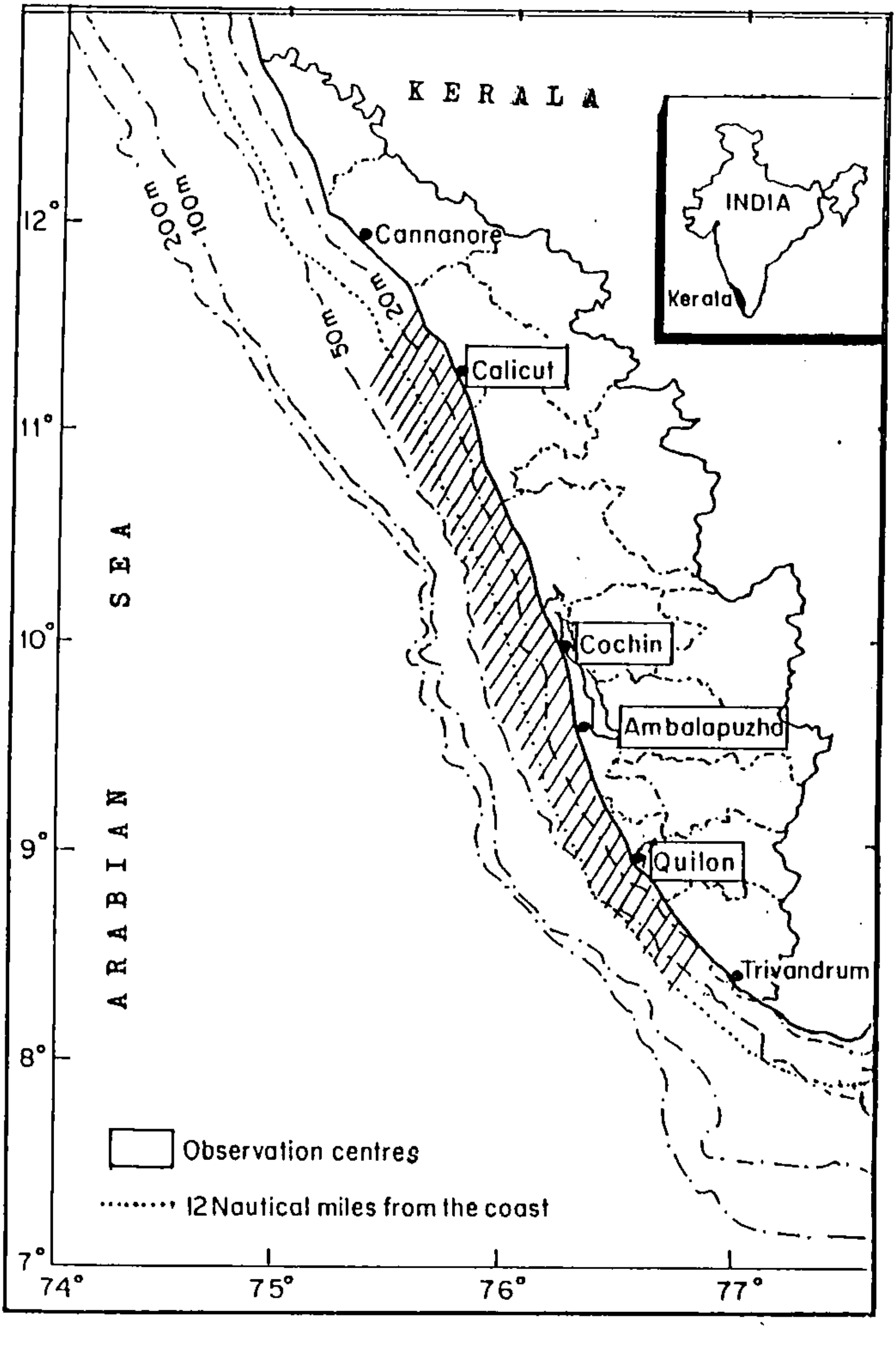

Fig. 1.1 Map of Kerala showing places of collection of material for the study during 1994 to 96

CHAPTER 2

TAXONOMY

CHAPTER 2

TAXONOMY

INTRODUCTION

The flatfishes of the Order Pleuronectiformes or Heterosomata are readily distinguished from all other fishes by their compressed body and head with both eyes on the same side, either right or left. The eyed (upper) side also differs from the blind (underside) in colour, development of paired fins, and in the nature of the scales and of the lateral line. The larval flatfish has an eye on each side of its head, but as it grows, one of the eyes moves over the top of the head to lie on the same side as the other. Flatfishes are either right sided (dextral), with both eyes on the right side of the head, or left sided (sinistral), with both eyes on the left side, but in some species reversed specimens (a sinistral individual of a species that is usually dextral or *vice versa* may occur.

Flatfishes spend most of their time on the bottom resting on their blind side, which is mostly colourless; the pigmented (upper) side is coloured to match the substrate, thus concealing the flatfish from prey and predators alike. Their ability to change the colouration to match the surrounding is remarkable. They often bury themselves in the sediment, with only their eyes and nostrils uncovered. The eyes of some of the species protrude from the head and can be moved independently.

It seems reasonable to suppose that flatfishes evolved from some ancestral species that was accustomed to lying on its side to rest or hide itself. The most primitive flatfishes, the Psettodidae, are apparently derived from a percoid ancestor, as indicated by their pelvic fins with a spine and 5 soft-rays, dorsal and anal fin spines, teeth on the vomer and palatines, and well-developed supermaxilla. Whether all of the other flatfishes are derived from psettodid ancestor or from some other group of fishes is a moot point.

Most flatfishes occur in depths of 10-200 m, a few live in deeper waters, and some are found close to inshore, even in estuaries. Many species are highly valued as food fishes and are taken in considerable quantities by trawlers. They are known from temperate and tropical waters of all three major oceans.The small buoyant eggs are produced in enormous numbers, with the larger species spawning more than a million eggs at one time. Though some grow upto 100 mm, most of them are less than this size. But the giant halibut of the North Atlantic attains a length of 3 m and a weight of 326 kg.

The flatfishes are well represented in our waters, and over 91 species have been recorded from the seas around India. Except a few most of the flatfishes do not contribute to a fishery of commercial importance. The Malabar sole *Cynoglossus macrostomus* Norman belonging to the family Cynoglossidae contribute to a fishery of commercial importance along the coast of Kerala. The present work deals with the systematics of four species of *Cynoglossus* such as *C.macrostomus* Norman, *C.arel* (Schneider), *C.bilineatus* (Lacepede) and *C.puncticeps* (Richardson) from Kerala coast selected for studying various biological aspects. Also a key to the *Cynoglossus* species occurring in Indian waters has been prepared. During the course of work a number of other flatfishes belonging to different families of the Order Heterosomata have been found to occur in various gears in Kerala. A check list of these fishes has been prepared and given at the end of the chapter.

Work on the systematics of *Cynoglossus* species are those of Bleeker, (1851); Gunther, (1862); Day, (1865,1877); Norman, (1928); Weber and de Beaufort, (1929); Munro, (1955); Qureishi, (1960); Punpoka, (1964); Menon, (1977); Hussain and Alikhan, (1981); and Fischer and Bianchi, (1984).

MATERIAL AND METHODS

Flatfishes of the family Cynoglossidae belonging to the order Pleuronectiformes (Heterosomata) occurring along the coast of Kerala were collected from the trawl landings at Calicut, Cochin, Ambalapuzha and Neendakara in Quilon. (Figure 2.1). Immediately after collection they were put in ice box and brought to the laboratory. After careful washing the specimens for the studies were kept on a plywood board to spread out the dorsal, anal and caudal fin by using small pins. A little conc. formalin was applied on the fins by a small camel brush and allowed to remain for few minutes to harden these structures, and further they were preserved in 5% formalin for detailed studies on morphometric and meristic characters. In the laboratory the specimens were carefully washed and the following measurements were taken.

Standard length : Taken from the tip of the snout to the mid lateral posterior margin of the hypurals.

Head length: Taken from the tip of snout to the posteriormost point reached by the fleshy margin of the opercle.

Diameter of the eye: The vertical diameter taken between the dorsal and ventral rims of the fixed eye.

Snout length: The distance between the tip of the snout to the anterior rim of the fixed eye.

Interorbital width: The nearest distance between the upper rim of each orbit where ever the eyes are separate.

Distance between corner of the mouth and opercle: The direct line distance between the inside corner of the cleft of the mouth and posterior most point reached by the fleshy margin of the opercle.

Since the dorsal and anal fins are confluent with the caudal fin, the caudal fin rays were counted by placing the fin on the glass stage of the binocular microscope and projecting strong light through it.

Vertebrae: For making vertebral counts, the specimens after morphometric and meristic studies were kept in water for more than a week to loosen the musculature which were then removed by a sharp scalpel to count the vertebrae. The counts were cross checked by collecting fresh specimens and boiling them in water for 30-40 seconds. The flesh could be easily removed by an ordinary tooth brush.

The morphometric and meristic characters, their range and mean are given in Table 2.1.

The outline classification of the flatfishes is as follows:

Superclass	:	Gnathostomata
Class	:	Osteichthyes
Subclass	:	Actinopterygii
Subdivision	:	Teleostei
Infradivision	:	Euteleostii
Super order	:	Acanthoptergii
Series	:	Percomorpha
Order	:	Pleuronectiformes (Heterosomata)

In the Systema Naturae (1758) Linnaeus placed all the flatfishes known to him in a single genus, *Pleuronectes*. During the last decade of the eighteenth century and the first part of the nineteenth, eight more genera of flatfishes were described, and Cuvier (1817) established a family for their reception, but grouped them together with the gadoids, gobiesocids, echineids and ophicephalids in a division of sub-branchial malacopterygians characterised by the thoracic position of the ventral fins and the absence of spines in the dorsal fins. Muller (1846) restricted the number of forms associated with the flatfishes in a higher systematic category, but still placed them together with the gadoids and ophidioids in his new order Anacanthini. According to Norman (1934) it was not until 1871 that Cope finally isolated the flatfishes in their own order, the Heterosomata, subsequently called Pleuronectiformes by other authors.

Various authors have divided the order Heterosomata into a larger or smaller number of families. The extreme point of view among fairly modern writers are probably those of Jordan (1923), who recognised eleven families and, Weber and de Beaufort (1929) recognised only four. Regan (1910) presented a classification founded on considerable anatomical investigation that divided the order into five families: Psettodidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae.

Six families are currently recognised (Nelson, 1984); and al are represented in the seas around India, but very few species contribute to a fishery of commercial importance.

KEY TO THE SUBORDERS/FAMILIES

1 (a) Dorsal fin not extending onto head (to or past eye); anterior dorsal-fin rays spinous (Suborder Psettodoidei)...Psettodidae 1

(b) Dorsal fin extending onto head at least to eyes; dorsal fin without spines 2

2 (a) Preopercular margin free and visible, not covered by skin; lower jaw generally prominent (Suborder Pleurenectoidei) 3

(b) Preopercle margin not entirely free, hidden beneath skin; lower jaw never prominent (suborder Soleoidei) 5

3 (a) Pelvic fin with one spine and 5 soft rays; vomer with teeth .... Citharidae

(b) Pelvic fins without a spine, only soft rays; vomer usually without teeth 4

4 (a) Eyes on left side (sinistral) ....Bothidae

(b) Eyes on right side (dextral)..............Pleuronectidae

5 (a) Eyes on right side ....Soleidae

(b) Eyes on left side ....Cynoglossidae

The Soles (Soleidae and Cynoglossidae) are distinguished by having a small month, the lower jaw not prominent, the jaws of the blind side strongly curved and toothed, no preopercular margin, the gill membranes fused with free branchiostegal rays, the symmetrical position of the nasal organs, the absence of a postcleithrum in the pectoral arch, and the absence of ribs. In spite of these common characteristics Norman (1934: 38) doubted whether the two families are really closely related. Norman cited the example of certain Australian and New Zealandian genera of the Pleuronectid subfamily Rhombosoleinae *(Ammotretis, Colistium, Itorhamphus)* in which some of the species exhibit a strong general resemblance to members of the soleidae. It is remarkable that especially in *Colistium* the general form of the body, the shape of the head, particularly, its preorbital part, the small eyes, the symmetrical nasal organs, the strongly curved jaws of the blind side, the absence of teeth in the ocular side, the extension of the dorsal fin to the end of the snout are all characteristics found in the members of the soleidae. The development of the membranous folds on the blind side of the rays of the marginal fins, the modification of many of the scales on the blind side of the head to form filamentous processes, and the fringed lower lips are some of the other soleid features exhibited by members of Rhombosoleinae (Norman, 1926: 259). Chabanaud (1933,1934 a, 1936,1937) gave much consideration to the probable polyphyletic origin of the Soleoidea from other flatfishes. Kyle (1921: 119-121) believed that the flounders and the soles, and and even the divisions within each of these groups, have had separate origins from symmetrical fishes.

It seems probable that the origin of the unique asymmetry of flatfishes was a single evolutionary event. But it must be admitted that the Heterosomata as a whole are held together by little more than the single character that the two eyes are on one side of the head. Many of the features in which the several families agree now appear to represent convergent adaptations (Hubbs, 1945). The work of Parker (1903) on optic nerves of the Heterosomata is however, of special significance in this connection. In ordinary bony fishes the optic chiasma is dimorphic in character, the right nerve crossing over the left about as often as the left over the right. In the families Soleidae, Cynoglossidae and Psettodidae, the chiasma is dimorphic, with the nerve of either left or the right eye the more dorsal in the optic Chiasma. In all other flatfishes, whether dextral or sinistral, the nerve of the migrating eye is dorsal. In the genera of flounders, which are normally dextral (with eyes and colour on the right side), the left nerve crosses over the right in all individuals, even though the individual is variant in having the eyes on the right side. As a result the chiasma is characterised as partly uncrossed in normal individual but doubly crossed in the reversed specimens. Parker (1903) interpreted the correlation of the type of chiasma with the position of the eye in flounders as adaptive, for when the nerve of the migrating eye is dorsal the chiasma is particularly uncrossed rather than doubly crossed as it is when the nerve of the migrating eye is ventral in the chiasma. The chiasma remains dimorphic, however, in both dextral and sinistral soles. This can be due to the relative development of the optic nerves in the two groups. In the flounders, for example, the optic lobes and nerves are larger than in the soles (Evans, 1937: 309-310) and are much more conspicuous than the olfactory nerves, occupying a large part of the cavity in which they lie. A complicated arrangement (double crossing) of the nerves may, therefore, involve a mechanical or developmental disadvantage. In soles on the other hand, the optic nerves are tiny strands lying loose in an extensive space under the large olfactory nerves. In these fishes the olfactory and tactile senses are presumably better developed than the visual. Thus, the double twist of the optic nerves in half the individuals of each species of sole has apparently not been of sufficient selectional significance in the soles, as it has in the flounders to a fixation of the optic chiasma type in correlation with the usual position of the eye.

The soles in having several characters in common including the primitive dimorphic type of chiasma, form a natural group, probably split off very early from the other Heterosomata.

Family: Cynoglossidae

The members of the family Cynoglossidae are typically sinistral, with a dimorphic optic chiasma; the jaws are strongly asymmetrical; usually there are two nares on each side of the head, the anterior one tubular, the narial tube of the eyed side always arising in front of the fixed eye; the dorsal and anal fins are confluent with the caudal; the dorsal fin extends on to the head parallel to the axis of the cranium, the first dorsal ray never being inserted behind the vertical from the posterior margin of the eye, this ray remaining above the level of the migratory eye even when the dorsal fin is extended to the tip of the snout; the pectoral fins are lacking in the adult; the pelvic fin of the eyed side is also lacking (except in rare individual cases where it is situated on the eyed side much above the mid ventral line, as in the case of *Cynoglossus zanzibarensis*, the pelvic fin of the blind side is present with four rays always inserted on the mid ventral line; the anus and the opening of the oviduct are on the blind side; the urinary papilla is long and situated midventrally in front of and attached to the first anal fin ray; the scales are generally ctenoid; the tactile fringes of the lower side of the head are either short or absent and are replaced by epidermal thickness; and there are no epidermal hairs.

The rostral process of the neurocranium is absent or rudimentary; abdominal vertebrae are usually 9, sometimes 10, or even rarely 12; the number of caudal vertebrae is 33 to 66; the neural arch is complete in all the vertebrae, including the first abdominal vertebra; the haemal arches are complete as far forward as the fourth abdominal vertebra; and an anal interhaemal spine is present, attached to the first caudal haemal spine near its extremity.

The body cavity containing the digestive and urinary organs do not extend backwards, but is restricted to the anterior side of the body. Only the ovaries and post urethral portion of the urinary bladder occupy the caudal region, and swim bladder is absent in the adult. The family Cynoglossidae though comprising over 100 species is a very homogenous group; which is evident from the fact that it is comprised of only three genera: *Symphurus* Rafinesque, 1810; *Cynoglossus* Hamilton-Buchanan, 1822; and *Paraplagusia* Bleeker, 1886. The genera *Symphurus* and *Cynoglossus* contain most of the species; *Paraplagusia* consists of only four species *P. bilineatus* (Bloch), *P. blochi* (Bleeker), *P. japonica* (Temminck and Schlegel), and *P. guttata* (Macleay). The three genera are so homogenous that their subdivision into subgenera would appear only artificial. Inspite of its evident homogeneity, the family Cynoglossidae is divisible into two subfamilies, the Symphurinae consisting of the genus *Symphurus* and Cynoglossinae consisting of the genera *Cynoglossus* and *Paraplagusia*. The two subfamilies are perfectly distinguishable from the point of view of their respective morphology and the geographical distribution. *Paraplagusia* can be distinguished from *Cynoglossus* mainly by its possession of a series of fringes on the lips on the ocular side. In all other features including the osteology, *Paraplagusia* is very similar to *Cynoglossus*. In the well developed and more strongly bent erisma and strongly hooked snout, the tip reaching the rear of the lower eye or even beyond, *Paraplagusia* is considered as a form more highly specialised than *Cynoglossus* for a burrowing habit.

KEY TO THE GENERA OF FAMILY: CYNOGLOSSIDAE

1. Ventral fins connected with anal, lateral line on ocular side, snout hooked, mouth inferior 2

   Ventral free from anal, no lateral line on ocular side,snout hooked, mouth anterior .... *Symphurus*

2. Lips with fringes, 2 or 3 lateral lines on ocular side............................ *Paraplagusia*

   Lips without fringes, 1,2, or 3 lateral lines on ocular side .... *Cynoglossus*

THE LATERAL -LINE SYSTEM A well developed lateral-line system is characteristic of all fishes belonging to the family Cynoglossidae, the exception is for *Symphurus*.

Head region: The head region of all the species of the Cynoglossinae has a complex system of canals. In all the species a supraorbital canal is present, which extends from the snout through the area above the eye and is connected to the mid-lateral line in the posterior part of the head. Above the supraorbital,the cephalodorsal canal commences at the snout, runs posteriorward along the dorsal edge of the head, and is connected to the supraorbital commissure (a dorsal branch of the supraorbital line at the posterior end of the head). These two canals are invariably developed in all the species of Cynoglossinae. From the posterior end of the supraorbital canal the preopercular canal commences, running ventrally towards the preopercular region. In some forms it turns and runs forward to the corner of the mouth, while in others it turns backward and runs to the edge of the opercular region. From the anterior end of the lower jaw to the operculum stretches the mandibulo-opercular canal. At its posterior end it turns upward and is connected to the preopercular canal in some *(C. bilineatus)*, whereas in other groups the mandibulo-opercular canal gives off a dorsal branch at the posterior corner of the mouth, thereby connecting it to the preopercular canal. In certain other species the mandibulo-opercular canal is not connected with the preopercular canal. On the ocular side there is also a small preorbital canal that starts from the tip of the snout and extends obliquely upward in a straight line to before or below the upper eye.

On the blind side of the head the lateral-line system is poorly developed or totally absent. Only small traces of the supraorbital, cephalodorsalic, or preopercular canals are found in some forms like the *C.bilineatus* and *C.canariensis*.

Abdominocaudal region: The Cynoglossinae are the only flatfishes that possess many lateral lines. Members of both *Cynoglossus* and *Paraplagusia* have two or three lateral lines on the ocular side. On the blind side they are generally fewer in number or are totally absent. In *C. dubius* Day, *C. monodi* Chabanaud, *C. canariensis* Steindachner, *C. senegalensis* Kaup, *C. borneensis* (Bleeker) there is only one lateral line on the blind side, while in *C. bilineatus* (Lacepede), *C. attenuates* Gilchrist, *C. lachneri* Menon, and *C. dispar* Day there are two lateral lines on the blind side. In all other members of *Cynoglossus* the lateral line system is totally absent on the blind side.

Of the lateral-lines on the ocular side the most constant is the midlateral line, which extends from the junction of the supraorbital canal with the supraorbital commissures of the lateral-line system of the head region and runs in the midaxis of the body to the base of the caudal fin. In some species like *C.bilineatus* this line branches into three at the base of the caudal fin, the middle running along the axis of the caudal fin, and the other branches running parallel to the middle one and extending onto the caudal fin. The next lateral line of more or less constant occurrence on the ocular side in most of the species is the dorsolateral line, which starts from the junction of the cephalodorsal canal with the supraoccipital commissure of the head region and proceeds posteriorly in a zig-zag manner along the dorsal edge of the abdomino-caudal region, extending into the dorsal fin a little distance behind the caudal base. The position of the entrance of this line into the dorsal fin varies in different species and among individuals of the same species. The third and the least constant lateral line of the ocular side is the ventro lateral line, which starts at the posterior end of the base of the pelvic fin and runs posteriorly in a zig-zag manner along the edge of the anal fin and extends onto the anal fin a short distance before the caudal. The place of entrance of this line onto the anal fin also differs in different species and among individuals of the same species. The ventrolateral line, though well developed in some species, the presence or absence of this line should not be depended upon for species differentiation as the character is highly variable. Norman (1926), Jordan and Starks (1906) and Menon (1977) had already hinted at the unreliability of this character for species or generic differentiation in cynoglossid fishes. The midlateral line is the most constant and well developed and is found in all the species of *Cynoglossinae*, while the dorsolateral, though present in all the species, except in a few, is highly variable as regards its nature and extend. It is, however, fully developed in all the species where the ventrolateral is present.

SCALES

Along the lateral line in the Cynoglossinae the pored scales usually have the perforating duct simple at its anterior opening, but in *C. lingua* and *C. dubius* it is different. In these species the midlateral canal on the ocular side, instead of opening through simple pores on every scale, opens by means of ducts into the adjoining scale above or below. In *C. senegalensis* single duct alternate with two ducts, compared to two ducts opening on one side in *C. lingua*, and in *C. dubius* there are three openings on one side followed by an opening on the opposite side.

The scales are generally ctenoid, those of the lateral line having an imbricate arrangement with the lateral-line canal in the middle. In all the species, in the ctenoid scales of the lateral-line are provided with spinnules above and below the canal. There is a good deal of variation in the nature of scales of the two sides, as well as those of the lateral-line among Cynoglossinae. In ctenoid the spinnules are invariably more strongly developed on the ocular than on the blind side. In some, scales are ctenoid on ocular side and cycloid on blind side, whereas in some species scales are cycloid on both sides. In some species the scales of the lateral line are cycloid, while they are ctenoid on other areas of the ocular side. Chabanaud (1956) observed that the scales of the upper side are ctenoid in *C. cadenati* and *C. gilchristi* (at least in the young stages of both species). Modifications in the nature of scales with age has been observed in species like *C. arel*, which have mainly ctenoid scales including those of the lateral line, a number of cycloid scales are found in the lateral line toward the posterior end, especially near the base of the caudal fin.

Based on the modification and nature of scales, Chabanaud (1965) divided *Cynoglossus* into two groups based on the nature of scales on the upper side of the body, namely, 1) those with the entire upper side with ctenoid scales and 2) those with the lateral line scales cycloid and the rest of the scales ctenoid. However, in the case of big specimens of *C.arel* which are characterised by ctenoid scales on the upper side including those of the lateral line, a number of cycloid scales occur in the lateral line. Modification in the nature of the scales on the upper side is correlated with age, beginning from the posterior end of the fish at the base of the caudal fin. The most conservative scales are in the rows closest to the dorsal and anal fins, the rest gradually becoming cycloid with age. Hence, generally it is not possible to decide to which of the two groups a specimen belongs unless juveniles or immature specimens are examined.

SPECIES GROUPS AND COMPLEXES

Taxonomically the genus *Cynoglossus* has several lines of evolution representing six groups and 17 complexes (Menon, 1977)

Groups	Complexes
The *canariensis* group	The *canariensis* complex
	The *bronni* complex
	The *bilineatus* complex
The *kopsi* group	The *kopsi* complex
	The *itinus* complex
	The *ogilbi* complex
	The *ecaudatus* complex
	The *sealarki* complex
The *arel* group	The *arel* complex
The *cynoglossus* group	The *cynoglossus* complex
	The *monopus* complex
	The *puncticeps* complex
	The *lida* complex
The *carpenteri* group	The *carpenteri* complex
The *heterolepis* group	The *heterolepis* complex
	The *macrophthalmus* complex

The canariensis complex is the most primitive complex of species within the *canariensis* group and is characterised by a single lateral line on the blind side. Its members are distributed at the western extremity of the generic range. The *bilineatus* complex is the next evolved group. It extends to the northern (Japan) and southern (Australia) periphery. Fishes of this complex possess two lateral-lines on the blind side. The *attenuates* complex of species retain the primitive two lateral lines on the blind side but a reduction in the number of caudal fin rays. Members of this complex are found along the east Africa, Seychelles and the seas of India and Pakistan. Species like *C.browni* has no lateral line on the blind side, and hence is closely related to the *canariensis* complex. probably this species might have evolved from a *canariensis*-like ancestor through the loss of the lateral line on the blind side.

The *kopsi* group is characterised by the absence of lateral lines on the blind side. But they have large eyes, either contiguous or with a narrow interorbital space. The snout is short and obtusely pointed. The angle of the month is distinctly near to the tip of the snout.

The contiguous or subcontiguous nature of the eye is considered a useful specialisation for a burrowing habit. Two lines of specialisation seem to have taken place in *Cynoglossus*. In the first case, where the eyes are of large size, they have become contiguous or have come closer. The adipose eye lid becoming thick and scaly gives sufficient protection while ploughing or burrowing into the sand or mud. In the other group the eyes are small and reduced as in *heterolepis* group.

The *kopsi* group consists of 5 complexes, of these the *kopsi* complex is considered more primitive and is more nearer to the *canariensis* group, the body scales being somewhat larger than in the member of any other complex. The large imbricate scales are disadvantage for the burrowing mode of life. The *Kopsi* complex is characterised by two nostrils on the ocular side, large body scales. Other complexes of the *Kopsi* group comprise closely related species. There is gradual reduction of the size of scales from the original *Kopsi* stock. The *Kopsi* complex is restricted to an area from the Indo-Australian Archipelago to southern Japan and westward through India and Pakistan to Cargados, Garajos, Seychelles, and the Persian Gulf.

The *arel* group consists of fishes that are large growing. They are characterised by fairly large eyes but separated by a narrow interorbital space. The body is much elongated. long and obtusely pointed snout. The large eyes and scales shows similarity to the members of the *canariensis* and *bilineatus* complexes. Hence they are considered to have evolved as an early offshoot from the main stock, which gave rise to the canariensis group.

The *cynoglossus* group consists of small adult fishes. They have relatively small eyes separated by a narrow interorbital space. The snout is moderately elongated with the angle of the mouth situated nearer to the tip of the snout than to the branchial opening. Scales are relatively smaller. They are closer to *arel* group especially in the position of the eyes, the lateral-line system, and the caudal fin ray count. They are considered as a recent offshoot from the stock that gave rise to the *arel* group. The *carpenteri* group comprises of large adult size fishes, is most probably derived from an early cynoglossus-like ancestor through the elongation of the body, shifting of the angle of mouth nearer to the branchial opening, reduction in size of the scales and an addition of the third lower lateral line. The *heterolepis* group is closely related to the *carpenteri* group. This group differs in having a small or minute eyes with a wide interorbital space. They probably evolved as an early offshoot of the stock that gave rise to the *carpenteri* group.

Genus *Cynoglossus* Hamilton-Buchanan, 1822.

Cynoglossus Hamilton-Buchanan, 1822: 32, 365 [type species: *Cynoglossus lingua* Hamilton-Buchanan, monotype.]

Cantoria Kaup, 1858: 106 [type-species: *Plagusia potonus* (not *Potous* of Cuvier) Cantor = *Cantoria penanganensis* Kaup, monotype.]

Arelia Kaup 1858: 107 (type species: *Pleuronectes arel* Schneider = *Arelia schneider* Kaup, tautonymy.)

Icania Kaup, 1858: 109 (type species: *Plagusia cynoglossus* = Cantor = *Icania cynoglossus* Kaup,monotype.)

Trulla Kaup, 1858: 109 (type species: *Trulla cantori* Kaup = *Plagusia trulla* Cantor, tautomymy.)

Areliscus Jordan and Snyder, 1900: 380 (type species: *Cynoglossus joyneri* Gunther, monotype.)

Cynoglossoides Bonde, 1922: 23 (type species, *Cynoglossus* *attenuates* Gilchrist, 1905, monotype.)

Cynoglossoides (not Bonde, 1922) Smith, 1949: 165 (type-species: *Cynoglossus ecaudatus* Gilchrist, 1908, original designation; preoccupied by *Cynoglossoides* Bonde 1922.)

Dollfusichthys Chabanaud, 1931: 304 (type-species: *Dollfusichthys sinusarabici* Chabanaud, monotype.)

Dexiourius Chabanaud, 1947 b: 443 (type-species: *Cynoglossus semilaevis* Gunther 1873 b, monotype.)

Body lanceolate, eyes on left side, centre of the migratory eye usually placed in advance of centre of fixed eye and usually anterior to its anterior border, pectorals absent; only pelvic fin of blind side present, with four rays, all inserted ventrally in front of anal and connected to it by a membranous extension of its last ray. Dorsal, anal and caudal are confluent. The abdominocaudal region of the ocular side always bears a mediolateral line. The dorsolateral line generally runs in a zig zag or interrupted manner posteriorward and enters the dorsal fin, the position of the entrace varying from species to species and within same species. The ventrolateral line, when present, originates from the posterior end of the base of the pelvic fin and also runs in a zig-zag or interrupted manner along the base of the anal fin, entering the anal fin some distance before the base of the caudal. On the blind side the lateral lines are generally fewer in number than on the ocular side; one or two or often absent. On the occular side of the head a complex system of lines is present, which in its essentials is invariable.

The scales are generally ctenoid on the ocular side, ctenoid or cycloid on the blind side; the scales on the mediolateral line are imbricate and travessed by the lateral-line canal, the scales having spinnules above and below the pores of the lateral line. On the ocular side the anterior nostril is tubular, arising in front of the fixed eye a short distance from the sublachrymal sulcus; the posterior nostril when present is generally simple opening in the interorbital space when the eyes are separate, or somewhat in front of the middle of the eyes when the eyes are contiguous; on the blind side the anterior nostril is generally tubular, arising above the anterior half of the upper lip, the posterior opening or slit generally lying at a level slightly higher and above the posterior half of the upper lip, the internarial space varying from two-thirds to three-fourths of the distance between the posterior nostril and the corner of the mouth opening. The jaws are strongly asymmetrical; only the jaws of the blind side are armed with teeth; the latter are needle shaped, arranged on the dentary and the premaxilliary, forming a wide, short band with a meniscoidal outline. The mouth is rather narrow, the snout hooked and overhanging the mouth opening. The lips are not fringed. The gill opening is narrow; the gill membranes are united, free from isthmus. The urinary papilla is on the eyed side and wholly joined to the first anal ray. The ovarian duct opens into the posterior half of the anus situated on the blind side.

The length of the neurocranium is less than its height; the cerebral çavity is longer than the rhinophthalmic part of the skull; the vault of the cavity is complete; the sacculi are not prominent.

Vertebral diapophyses are absent. Abdominal vertebrae 9 or 10 and rarely 11 or 12, caudal vertebrae 33 to 66.

The species of *Cynoglossus* were well known to 18th century naturalists. The first species of *Cynoglossus* known to science was Schneiders *Pleuronectes arel* from Tranquebar, on the east coast of India. Two years later, Lacepede (1802) described a species from China and the East Indies under the name *Achirus bilineatus*.

Hamilton-Buchanans' genus *Cynoglossus* was the seventh in his order Apodes, consisting of "fishes having the dorsal spine bone and wanting ventral fins." He characterised the genus as comprising fishes 'with both eyes on one side of the head and with a flat body, formed for swimming on the side opposite to the eye". Under his genus *Cynoglossus*, Hamilton-Buchanon included only one species, *C. lingua*. In the same work Hamilton-Buchanan described another species *Achirus cynoglossus*, under his fourth order Thoracini, comprised of fishes having the dorsal spine of bone and ventral fin placed immediately under the pectorals. He recognised however, the close relationship of this species to *C. lingua.* Jordan and Starks (1906) restricted the name *Cynoglossus* to species with two lateral lines on ocular side and placed those with three lateral lines in *Areliscus*. Bonde (1922) considered forms with two lateral lines on each side as *Cynoglossoides*.

DISTRIBUTION

The geographical distributional area of *Cynoglossus* comprises the eastern tropical Atlantic, the eastern Mediterranean, the whole of Indian Ocean, including the Malay area in the east, the persian Gulf, the Gulf of Oman and the Red sea, the whole of the East coast of Africa as far south as the Cape of Good Hope in the west, the west Pacific from south China to south Japan, and the whole of the periphery of the Australian continent. The eastern and northern limit of *Cynoglossus* is Tokyo at 35° 40′N; the southern limit is the mouth of the Murray River, South Australia, at 34°10′S. The western limit is marked by the Canary Islands, about 30°N in the Northern hemisphere, and Angola, about 10° S in the Southern Hemisphere (Fig. 2.1).

A comparison of the meristic and morphometric characters, their range and mean in different species of *Cynoglossus* considered for studying various biological aspects from along the Kerala coast are given in Table 2.1.

KEY TO THE SPECIES OF GENUS *CYNOGLOSSUS* FROM INDIA

1. Lateral line present on the blind side........................2
   No lateral line on the blind side.............................. 4

2. One lateral line on the blind side .... *C. puncticeps*
   More than one lateral line on the blind side...............3

3. Anal fin with less than 90 rays, 13-16 scales between lateral lines on ocular side ....*C. bilineatus*

Anal fin with more than 90 rays, 18-20 scales between lateral lines on ocular side..............*C. dispar*

4. Two lateral lines on ocular side.......................... 5
Three lateral lines on ocular side 12

5. Scales ctenoid on both ocular and blind side..............6

Scales ctenoid on ocular and cycloid on blind side..11

6. Angle of mouth nearer to the snout....................... 7

Angle of mouth nearer to the branchial opening.......*C. lida*

7. Eyes on short stalk (pedunculate)................*C. monopus*

Eyes not pedunculate 8

8. Angle of mouth extending beyond the fixed eye 9

Angle of mouth extending to below vertical from middle of the fixed eye..................*C. puncticeps*

9. Transverse scales between lateral lines 11-14.............10

Transverse scales between lateral lines 14-16. *C. macrostomus*

10. Snout pointed, 70-78 rays in anal fin ....*C. cynoglossus*

Snout rounded, 70-90 rays in anal fin ......*C. semifasciatus*

11. 7-9 transverse scales between two lateral lines .... *C. arel*

11-12 transverse scales between two lateral lines..*C. lingua*

12. Scales ctenoid on both sides of the body,
57-72 lateral line scales ....*C. kopsi*

Scales cycloid on both sides of the body
75-96 lateral line scales .... *C. carpenteri*

Cynoglossus macrostomus Norman (Plate 1)

Common Names :
Malabar sole : English
Manthal : Malayalam
Nangu : Kannada

Cynoglossus hamiltoni [not Gunther] Day, 1877: 436, pl.95: Fig.3 [Hooghly at Calcutta]; 1889:458.

Cynoglossus macrostomus Norman, 1928: 204 [Type-locality:Hooghly Estuary, near Calcutta].

Cynoglossus luctuosus Chabanaud,1947e:813 [type-locality: Madras].

Cynoglossus semifasciatus [not Day]- Seshappa and Bhimachar, 1955: 183 - Saramma, 1963:77. Seshappa 1981:141 [Kerala coast].

Cynoglossus cynoglossus (not Hamilton-Buchanan)- Saramma, 1963:77 - [Kerala coast].

Cynoglossus macrostomus Norman, - Victor, 1978: 188.

Description: Body flat and elongate, with dorsal and anal fins joined to caudal fin. Eyes on left side of the body with no space between them; snout short and obtusely pointed, rostral hook short.

Depth of the body 22.7 - 27.9, head length 24.2 - 30.7 percent of standard length. Eye diameter 5.2 - 10.4, interorbital space 1.2 - 3.3 and some times absent. Two nostrils on ocular side, anterior one tubular, posterior nostril simple and lie in the anterior half of the interorbital space. Maxillary extends to well beyond posterior margin of fixed eye. Angle of mouth nearer to the tip of snout than branchial opening.

Scales: Ctenoid on both sides

Lateral-line System: Two lateral lines on ocular side, dorsolateral line curving onto dorsal fin at a short distance from caudal base, mid lateral line with 79-91 scales, 14-16 transverse scales between them. No lateral line on the blind side.

Fins: Dorsal with 100-107 and anal with 79-84 rays.

Vertebrae: 47-51, 9 abdominal and 38-42 caudal vertebrae.

Colouration: Light brown on eyed side with dark brown mottling forming diffuse, irregular crossbands; dorsal and anal fins grey/black.

Size: Largest specimen examined 168 mm from Quilon.

Distribution: Seas and estuaries of India. Known popularly as the Malabar sole.

Distinguishing characters of similar species: *Cynoglossus macrostomus* closely resembles *C. semifasciatus,* particularly with regard to extension of the maxillary beyond the posterior border of the fixed eye, and the vertebral and fin ray counts. *C. mascrostomus*, is however, easily distinguishable by the large number of interlinear scale rows (14-16 CF.11-14) and the mid lateral line scale rows 79-91 cf.70-78), the more elongate body; longer head and the colouration, especially the distinctive blackish nature of the fins.

Cynoglossus arel (Schneider), 1801 (Plate 1)

Common Names	:
Large scaled tongue sole	: Bengali
Lep	: Marathi
Aral Nangu	: Malayalam

Pleuronectes arel Schneider, 1801: 159 [type-locality: Tranquebar, east coast of Madras].

Cynoglossus arel Norman, 1928:201 - De Silva, 1956:199 (Palk Bay, Ceylon) - Saramma, 1963: 76 [Kerala coast].

Cynoglossus melampetala Richardson, 1846:281 [China]. Whitehead, 1969: 218, pl. 29 a.

Cynoglossus melampetalus - Gunther, 1862: 496. Bleeker, 1873:131 (Canton) - Gunther, 1880: 55 (Hong Kong) - Sauvage, 1881: 107 [Swatow] - Wu, 1932: 148. - Fowler, 1934 b: 221 .- Chu, 1963:540, fig.406 - Shen, 1967:216.

Plagusia grandisquamis Cantor, 1850: 1214 [type - locality: seas of Penang].

Trulla grandisquamis - Kaup, 1858: 109

Cynoglossus grandisquamis - Gunther, 1862: 503 - Duncker, 1904: 169. - Weber and de Beaufort, 1929: 208

Plagusia potous [(not *potous* Cuvier] - Canter, 1850: 1217 [type locality: seas of Malay Peninsula and islands].

Plagusia macrolepidota Bleeker, 1851a:415 (type-locality: Batavia); 1852: 25.

Arelia macrolepidota - Bleeker, 1859: 184.

Cynoglossus macrolepidotus - Gunther, 1862: 496. - Bleeker, 1875: 34, pl. 242: fig. 2 - Day, 1877: 434, pl.96: fig. 3;1889: 455. - Alcock, 1889: 288. - Rutter, 1897: 89. - Scale,1910: 288. - Jenkins, 1910 a: 30.- Norman, 1928-202, fig. 18. Weber and de Beaufort, 1929: 205.- Herre, 1935: 5 (Sandakan).- Fowler, 1934 b: 219; 1937: 87. - Okada and Matsubarra, 1938: 437 (Formosa, Java, Banka).- Herre, 1941:392 (Andaman Islands). - Suvatti, 1950:327.- Herre, 1953:190.- Munro 1955: 265, pl.51: fig.770.- Fowler, 1956: 186, fig. 101.- De Silva, 1956: 97.- Scott, 1959: 43.- Kuronuma, 1961:32.- Saramma, 1963: 76.- Punpoka, 1964: 64.- Pradhan, 1964:458.- Chen and Weng, 1965: 95, fig. 66.- Shen, 1967: 215.- Krishnankutty, 1967: 97.- Krishnankutty and Qasim, 1967:17.- Ramanathan *et al* 1975: 533, 1977: 83.

Plagusia cantoris Bleeker, 1953 a: 153 ("Hindustan and Archipelagus, Indicum" based on two stuffed specimens of Cantor's *P. potus* from Singapore). - Gunther, 1862: 502.- Bleeker, 1875: 33.

Plaugusia oligolepis Bleeker, 1854 b: 445.

Arelio oligolepis Bleeker, 1859: 445.

Cynoglossus olegolepis.- Gunther, 1862: 496.- Bleeker, 1875: 34, pl.242: fig.3.- Steindachner, 1867: 587 (Ning - Pou) .-Bleeker, 1873: 134 (Ning - Pou).-Day, 1877: 433, pl.95: fig.4; 1889:455.- Alcock, 1887:280.-Johnstone, 1904: 209. -Weber, 1913 b: 441.

Cantoria pinangenensis Kaup, 1858: 106 (based on *Plagusia cantoris* [Bleeker].

Arelia kaupii Bleeker, 1860 a:73.

Cynoglossus kaupii.- Gunther, 1862: 497.- Bleeker, 1875:32, pl.244: fig.4.- Weber and de Beaufort, 1929: 196.

Cynoglossus elongatus Gunther, 1862: 501 (type - locality: East Indian Seas).- Bleeker, 1875: 34.

Description: Body flat and elongate, with dorsal and anal fins joined to caudal fin. Eyes on left side of the body, with a small scaly space between them. Depth of body 18.9 - 25.6, length of head 19.3-27.9 per cent of standard length. Eye diameter 6.2 - 10.4, anterior nostril tubular, posterior one lies on the anterior half of the inter orbital space. Snout obtusely pointed, 19.8-42.0 per cent of head length. Maxillary extends to beyond the fixed eye. Angle of mouth midway between tip of snout and branchial opening.

Scales: Ctenoid on ocular side, including scales on lateral line, those on head rather weakly serrated. Scales on blind side cycloid.

Lateral-line System: Two lateral-lines on ocular side with 57-72 scales, 7-9 transverse scales between lateral lines. No lateral line on blind side.

Fins: Dorsal with 118-128, and anal with 88-102 rays.

Vertebrae: 50-56; 9 abdominal and 41-47 caudal.

Colouration: Eyed side uniform brown, with dark patch on gill cover, blind side white.

Distribution: Malay Archipelago, seas of India to Persian Gulf and through South China sea to Philippines and Taiwan but not to New Guinea or Australia.

Cynoglossus bilineatus (Lacepede) (Plate 2)

Common Names	:	
Four lined tongue-sole	:	English
Lep	:	Marathi

Archirus blineatus Lacepede, 1802: 6 [type - locality: China and the East Indies].

Cynoglossus bilineatus.- Ogilby, 1910: 39.- Weber, 1913 b: 443. - Norman, 1926: 301 [Queensland]; 1928: 198.-Weber and de Beaufort, 1929: 194.- Herre, 1933: 5 (Sandakan, N. Borneo); 1934: 105 (Manila).- Roxas and Martin, 1937: 70 [Philadelphia].-Hardenberg, 1941:226 (Merauke, New Guinea).-Suvatti, 1950:326.-Herre,1953: 189 (Philippines).- Munro, 1955: 264, pl.50: fig. 767; 1958: 285 (Merauke).- Saramma, 1963: 75 [Kerala coast].-Pradhan, 1964:458 [Bombay coast].- Marshall, 1964: 468, pl.64: fig.454 (east coast of North Queensland).- Edwards *et al*, 1971: 280 [Kerala coast].- Seshappa, 1981: 144 (Calicut coast).- Hussain and Khan, 1981: 130 (Pakistan)

Plagusia quadrilineata Bleeker, 1851 a: 412., 1852: 21.

Arelia quadrilineata.- Kaup, 1858: 107 [Java, Sumatra].- Oshima, 1927: 198 (Tainan, Taihoku).

Cynoglossus quadrilineatus.- Gunther, 1862: 497.- Kner, 1867:295.- Bleeker, 1875: 32, pl.245: fig.3.- Klunzinger, 1871: 573.- Day, 1877 [in part]: 435; 1880: 409.-Macleay, 1884: 53.-Alcock, 1889 a: 288.- Day, 1889 [in part]: 457.- Smith and Pope, 1906: 498 (Kochi).-Jenkins, 1910 a: 30.- Wu, 1932: 144.

Cynoglossus lineolatus Steindachner, 1867: 588 (Hong Kong).- Bleeker, 1873: 133.- Rutter, 1897; 88 (Swatow).- Reeves, 1927: 14.- Chu, 1931: 95.- Wu, 1932: 150.- Fowler, 1934 b: 218 (Hong Kong, Swatow).

Cynoglossus quinquelineatus Day, 1877: 432, pl. 98: Fig.1 (type-locality: Madras); 1889-453.- De Silva, 1956: 198.- Norman, 1928, 197.

Cynoglossus sindensis Day, 1877: 434, pl.90: Fig.6 (type-locality: from Sind through the seas of India).-Jordan and Richardson,1908: 281.-Ogilby,1910: 37 (Croker Island, Northern Territory, Australia).- Norman, 1926:302.-De Silva, 1956:198.

Arelia diplasios Jordan and Evermann, 1903:367, fig. 29 (type-locality: Formosa).-Jordan and Richardson, 1909: 202,fig.25 (formosa).- Oshima, 1927: 204.

Description: Body flat and elongate, with dorsal and anal fins joined to caudal fin. Eyes on the left side of the body, with small scaly space between them. Depth of the body 23.1 - 29.2, head length 20.3 - 24.8 percent of standard length. Diameter of the eye 6.2 to 11.3 and interorbital space 4.8 to 10.1 percent of head length. Anterior nostril tubular and in front of the lower eye. The posterior nostril lies in the middle of the interorbital space. Snout, rounded, rostral hook short, reaching hardly before vertical through front border of anterior nostril. Maxillary extends beyond fixed eye. Angle of mouth extending to below vertical from posterior border of lower eye, slightly nearer to branchial opening than to tip of snout.

Scales: Ctenoid on ocular side except those on lateral lines, scales on blind side and those of lateral lines of ocular side cycloid.

Lateral-line System: Two lateral lines on ocular side and two on blind side. median lateral line on ocular side with 85-96 scales, 13-16 scales between the two lines.

Fins: Dorsal fin with 104-113 rays and anal with 80-88 rays, caudal rays generally 12.

Vertebrae: 51-53 comprising 9 abdominal and 42-44 caudal elements.

Colouration: Eyed side brownish with an irregular dark patch on opercular region, lower side whitish.

Size: Largest specimen examined 327 mm in TL from Quilon.

Distribution: From Malay Archipelago to the coasts of India and Pakistan and to New Guinea (Croker Island, Northern Territory) and coasts of Queensland and Taiwan and Japan (Kuchi).

Cynoglossus puncticeps (Richardson) (Plate 2)

Plagusia puncticeps Richardson, 1846: 280 (type locality: China). - Whitehead, 1969: 218, pl.29c.

Cynoglossus puncticeps.- Gunther, 1862: 500.- Bleeker, 1875: 37, pl.245: 15, fig.7.- Day, 1877: 437, pl.97: fig.1; 1889:459.- Alcock, 1889:289.- Jordan and Seale, 1907:46.- Jenkins, 1910:30.-Norman, 1928: 205.-Weber and de Beaufort, 1929: 198.-Chu, 1931: 94.- Herre, 1932: 433.-Wu, 1932: 151 [Amoy, Pehai, Canton, Hong Kong, and Hainan].-Smith, 1933:84.-Fowler, 1934 b: 220, fig.34.-Suvatti, 1950:328.- Herre, 1953:190.- Munro, 1955:265, pl.51: fig. 771.-Fowler, 1956: 135.- De Silva, 1956: 198 [Panadura].- Munro, 1958:285 (Kau Kau).- Kuronuma 1961:32.- Punpoka, 1964:69

(Thailand).-Pradhan, 1964:458.-Chen and Weng, 1965:91, fig.62 (Tainan and Tungkong).- Shen, 1967:214, figs. 138-141 (Lamma Island).- Edwards *et al*, 1971:280 (Kerala).- Seshappa, 1981:143 [Calicut].- Hussain and Khan, 1981: 130 (Pakistan).

Plagusia nigrolabeculatus Richardson, 1846:280 (coasts of China, Canton).- Kaup, 1858:110.- Whitehead, 1969:218, pl.29 b.

Cynoglossus nigrolabeculatus Bleeker, 1873: 131 (reference).

Plagusia aurolimbata Richardson, 1846: 280 (coasts of China).- Kaup, 1858: 110.-Whitehead, 1969: 218. pl.28 b.

Cynoglossus aurolineatus Bleeker, 1873: 130.

Plagusia javanica Bleeker, 1851a:414 [type-locality: Batavia]; 1852:24.

Arelia javanica Bleeker, 1859:184

Plagusia brachyrhynchos Bleeker, 1851a;414 [type-locality: Batavia]; 1852:24.

Arelia brachyrhymchos Bleeker, 1859: 184

Cynoglossus brachyrhynchus Gunther, 1862:499.-Bleeker, 1875:37 pl.243: fig.4.-Day, 1877:435, pl.96: fig.4; 1839:457.-Johnstone, 1904:206.-Weber, 1913b:443.

Cynoglossus brevis Gunther, 1862:500 [type-locality:Ganges].-Day, 1877:437, pl.97: fig.2.-Alcock, 1889:289.-Hora, 1923b: 760.-Norman, 1928:206.

Cynoglossus lida (not Bleeker).-Jenkins,1910a:31.

Cynoglossus lida var. punctatus.-Jenkins, 1910a:31.

Cynoglossus puncticeps immaculata Pellegrin and Chevy. 1940:154 (Vietnam).

Description: Body flat and elongate, with dorsal and anal fins joined to caudal fin. Eyes on the left side of the body with a narrow space between them. Depth of the body 12.3 to 46.1, length of head 11.1 to 29.8 percent in standard length. Eye diameter 6.4 to 15.8 and interorbital width 0.4 to 6.8 percent in head length. Two nostrils the anterior one tubular and lies in front of the lower eye, posterior nostril in front of the interorbital space. Snout rounded or obtusely pointed. Rostral hook short and ends in front of the anterior nostril. Maxillary reaching below middle of the posterior half of the fixed eye. Angle of mouth extending to below vertical from anterior half or middle of the fixed eye, usually nearer to the tip of the snout.

Scales: Ctenoid on both sides of the body including those of the lateral lines. Very rough to touch.

Lateral-line system: Two lateral lines on ocular side, dorsolateral line slightly undulating, running backward and entering dorsal fin along 5th - 6th ray, counted from the rear, mid lateral line with 78-99 scales and 14-18 scales between lateral lines. No lateral line on the blind side.

Fins: Dorsal with 90-100 rays, and with 73-80 rays.

Vertenbrae: 53-58, 9 abdominal and 44-49 caudal elements.

Colouration: Yellowish brown with dark brown blotches on head and body appearing as somewhat irregular cross bands that disappear with age, lower whitish. Some of the rays of the vertical fins marked with dark brown.

Size: Largest size 180 mm.

Distribution: From northwest Australia, Malay Archipelago to Philippines, through south China Sea to Taiwan, and westward to seas of India.

CHECK LIST OF ESTUARINE AND MARINE FLATFISHES ALONG KERALA COAST

Thirty seven species of flatfishes belonging to six families of Pleuronectformes are available along Kerala coast. Most species do not contribute to a fishery of commercial importance.

ORDER : PLEURONECTIFORMES

Family : Psettodidae (Halibuts)

Genus : *Psettodes* Bennett, 1831
Psettodes erumei (Schneider)

Family : Citharidae

Genus : *Brachypleura* Gunther, 1862
Brachypleura novazeelandiae Gunther

Family : Bothidae (Eyes sinistral)

Genus : *Pseudorhombus* Bleeker, 1862
: *Pseudorhombus duplioceIlatus* Regan
: *P triocellatus* (Bloch)
: *P.arsius* (Hamilton-Buchanan)
: *P.elevatus* Ogilby

Genus : *Bothus* Rafinesque, 1810
: *Bothus pantherinus* (Ruppell)
: *B.myriaster* (Temminck & Schlegel)

Genus : *Engyprosopon* Gunther 1862
: *Engyprosopon grandisquamis* (Temminck & Schlegel)

Genus : *Crossorhombus* Regan, 1920
: *Crossorhombus azureus* (Alcock)
: *C.valderostratus* (Alcock)

Genus : *Grammatobothus* Norman, 1926
: *Grammatobothus polyophthalmus* (Bleeker)

Genus : *Laeops* Gunther, 1880
Laeops guentheri Alcock
L.nigrescenes Lloyd

Genus : *Chascanopsetta* Alcock, 1894
Chascanopsetta lugubris Alcock

Family : Pleuronectidae (Eyes dextral)

Genus : *Samaris* Gray, 1831
Samaris cristatus Grey, 1831

Family : Soleidae (Soles) (Eyes dextral)

Genus : *Solea* Klein, 1775
Solea ovata Richardson
Solea elongata Day

Genus : *Euryglossa* Kaup, 1858
Euryglossa orientalis (Bloch)

Genus : *Synaptura* Cantor, 1850
Synaptura albomaculata Kaup
Synaptura commersoniana (Lacepede)
Synaptura aenea Smith
Synaptura orientalis (Bloch & Schn.)

Genus : *Zebrias* Jordan and Snyder, 1900
Zebrias quagga (Kaup)
Zebrias synapturoides (Jenkins)
Zebrias altipinnis (Alcock)

Genus : *Aesopia* Kaup, 1858
Aesopia cornuta Kaup

Genus : *Pardachirus* Gunther, 1862
Pardachirus pavoninus (Lacepede)

Genus : *Aseraggodes* Kaup, 1858
: *Aseraggodes cyaneus* (Alcock)

Genus : *Heteromycteris* Kaup, 1858
Heteromycteris oculus (Alcock)

Family : Cynoglossidae (Eyes sinistral)

Genus : *Cynoglossus* Hamilton-Buchanan, 1822
Cynoglossus macrostomus Norman
Cynoglossus semifasciatus Day
Cynoglossus arel Schneider)
Cynoglossus puncticeps (Richardson)
Cynoglossus bilineatus (Lacepede)
Cynoglossus lida (Bleeker)
Cynoglossus dubius Day

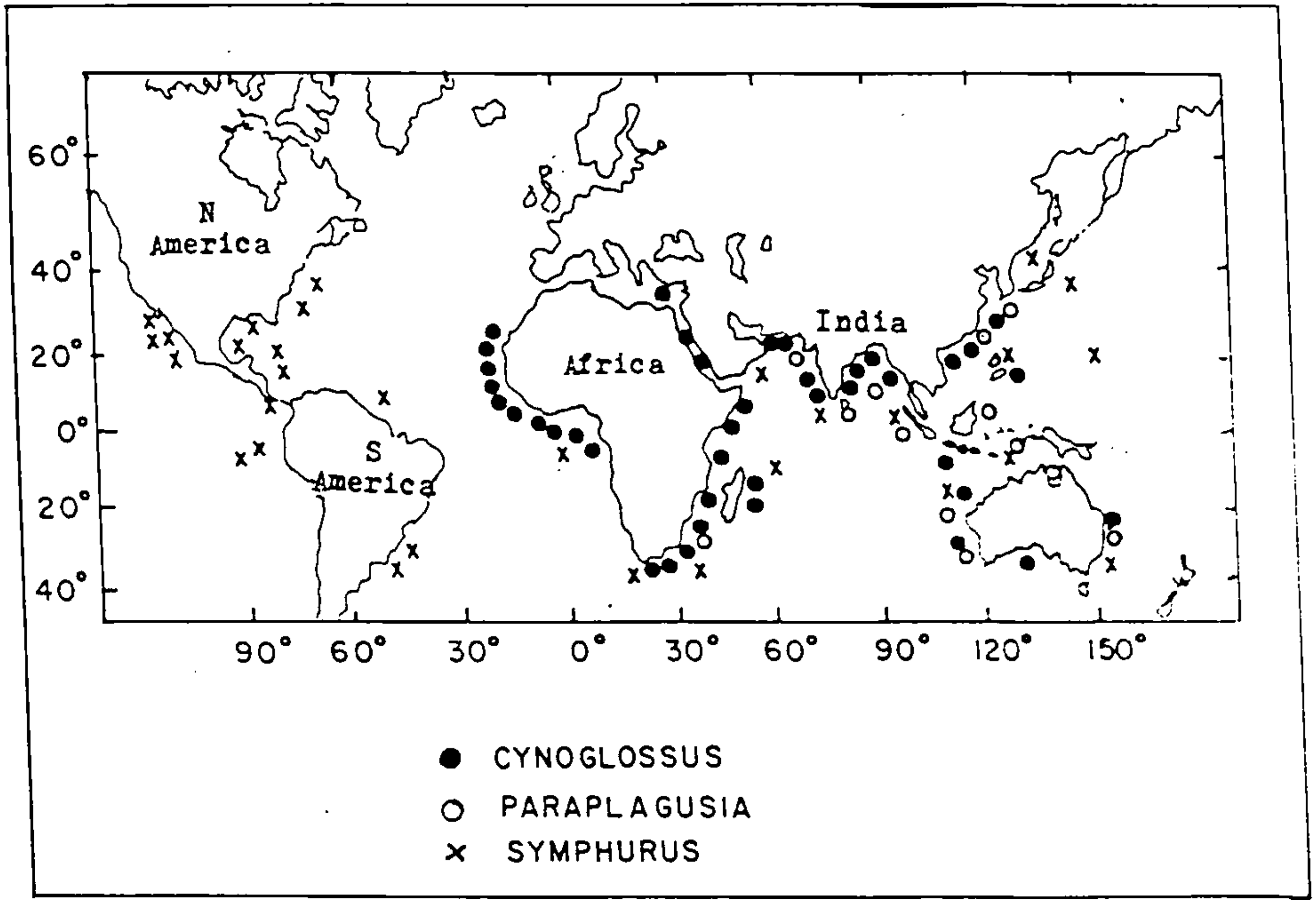

Fig. 2.1

Distribution of Cynoglossidae: <u>Cynoglossus</u>, <u>Paraplagusia</u> & <u>Symphurus</u>

Table 2.1 Comparison of the meristic and morphometric characters, their range and mean in different species of *Cynoglossus* selected for biological studies from along the Kerala coast.

	C. macrostomus	*C. arel*	*C. puncticeps*	*C. bilineatus*
No. examined	32	23	28	31
Standard length mm	122-147 (133.8)	144-311 (229.3)	107-169 (139.7)	122-324 (225.1)
Head length mm (HL) % S.L	24.2-30.71(26.45)	19.3-27.9(23.6)	11.1-29.8(22.3)	20.3-24.8(22.7)
Depth of body % SL	22.7-27.9(25.6)	18.9-25.6(22.8)	12.3-46.1(28.5)	23.1-29.2(26.0)
Eye diameter (% HL)	5.2-10.4(7.7)	6.2-10.4(8.2)	6.4-15.8(10.4)	6.2-11.3(8.9)
Interorbital Width (% HL)	1.2-3.3(2.1)	1.8-5.3(3.5)	0.4-6.8(3.1)	4.8-10.1(7.3)
Snout length (% HL)	20.7-29.7(25.3)	19.8-42.0(35.7)	24.1-41.3(32.3)	31.8-54.5(36.8)
Snout to corner of mouth (% HL)	34.7-46.8(39.7)	46.8-54.8(50.3)	33.8-52.0(44.1)	45.7-56.3(51.6)
Corner of mouth to gill opening (% HL)	42.8-62.3)(57.1)	46.1-53.2(48.9)	41.3-72.8(55.4)	47.1-54.9(49.5)
Lateral line scales	79-91(84)	57-72 (64)	78-99(88)	85-96
Scales between lateral lines	14-16(15)	7-9(8)	14-18(16)	13-16
Dorsal fin rays	100-107(104)	118-128(123)	90-100(98)	104-113
Anal fin rays	79-84(81)	88-102(95)	73-80(76)	80-88
Caudal rays	10	10	10	12
Vertebrae	48-51	50-56	53-58	51-53
a) abdominal	9	9	9	9
b) caudal	38-42	41-47	44-49	42-44

Figures in paranthesis is mean

PLATE I

Malabar sole, Cynoglossus macrostomus Norman

Large-scaled tongue sole Cynoglossus arel (Schneider)

PLATE II

Cynoglossus bilineatus (Lacepede)

Cynoglossus puncticeps (Richardson)

CHAPTER 3

FOOD AND FEEDING HABITS

CHAPTER 3

FOOD AND FEEDING HABITS

INTRODUCTION

Investigations on the food and feeding habits of fishes have traditionally been important in fishery biological studies since food is one of the important factors that may affect the shoaling, behaviour, migration, condition and even fishery. Hence considerable attention has been paid to the subject in recent years. Many authors discussed the food of fishes, their seasonal variations feeding in relation to availability of food organisms in the environment, feeding habits in relation to sexual cycle, condition of feed, selectivity in feeding and other related aspects and drawn general conclusions that bear upon the biology of the species concerned. Many have pointed out the correlation between availability of the food of a particular species and the occurrence of fishery for species. To mention a few instances, it was observed that the peak of fishery for the plankton feeders like mackerel and sardines along the Malabar coast is generally attained during September-December, when the inshore waters are rich in phyto and zooplankton. One of the factors governing the fluctuation in abundance of oil sardine is the availability of the diatom *Fragilaria oceanica* which is its favourite food. Similarly a relationship has been noticed between Malabar sole and a polychaete which is a preferred food item of this fish. A good fishery for the silver bellies and white baits during the monsoon month along the Malabar coast is said to be related with the abundance of their favourite food, *viz*; the copepods. Thus the study of food of a fish round the year might throw some light on the biology and fishery of the species, and such information is needed to adopt strategies for proper management of fish stocks and to make fishery forecasts.

The pleuronectids, comprising the flatfishes, by virtue of their body shape and bottom habitat have attracted the attention of many workers. Rathke (1824) made a comparative study on the alimentary tract of 56 species of plaice, flounders, dab and turbot. Kyle (1900) observed that differences in the alimentary tract and variation in number of pyloric appendages may not serve as taxonomic tools. But according to Norman (1934) the shape of the alimentary tract can be used for ascertaining the generic status. Wu (1932) noticed distinct differences in the alimentary tract of 11 species of Chinese flatfishes, but could not relate it to food habits. Suyehiro (1934, 1941) correlated the morphology of the digestive system with the type of food, and subdivided each group according to the morphology of the alimentary tract. Al-Hussaini (1947) broadly classified the flatfishes into plankton feeders, carnivores, omnivores and herbivores and subdivided the carnivores again into many groups according to their mode of feeding. Moisev (1953) grouped the pleuronectids into benthophagous flounders, omnivorous feeders, and predatory flounders based on the morphology of the alimentary tract and feeding habits. Matsubara and Ochiai (1963) and Amaoka (1964) reported on the relation between the morphology of the digestive tract and the feeding habits of few flatfishes from Japanese waters. Ochiai (1966) used the shape of the alimentary tract as a taxonomic character as did Norman (1934). De Groot (1969, 1971) and Braber and De Groot (1973) studied the morphology of the alimentary tract in relation to the feeding habits of flatfishes.

Our knowledge regarding the food and feeding habits of flatfishes in India is confined to the observations made by few authors. Along the west coast, Seshappa and Bhimachar (1955) while studying the fishery and biology of the Malabar sole *Cynoglossus semifasciatus* described its food and feeding habits. Pradhan (1959) gave a preliminary account of the food and feeding habits of *Pseudorhombus elevatus*. Later Pradhan (1969) and Abraham and Nair (1976) described the food and feeding of the Indian Halibut. Kuthalingam (1957) described the food and feeding habits of *Cynoglossus lingua*. Studies on the food and feeding habits of flatfishes from east coast are those of Devadoss and Pillai (1973), Devadoss *et al* (1977) and Ramanathan and Natarajan (1979). Ramanathan *et al*. (1977) studied the interrelationship between morphology of the alimentary tract and food of flatfishes from Porto Novo waters.

Eversince Seshappa and Bhimachar (1955) made a qualitative analysis of the food and feeding habits of the Malabar sole *Cynoglossus semifasciatus* (= *Cynoglossus macrostomus*) from West Hill in Calicut no information is available on various aspects of the biology of this species. Since the eighties the mechanization of the fishing craft and introduction of synthetic fibre for gears has resulted in increased access to deeper fishing areas, and monsoon fishing has become a regular activity. With these changes the exploitation of various fishery resources also have gone up including that of Malabar sole. Except for the availability of periodic catch statistics no information is available on this fish. Hence a study on the food and feeding habits of important flatfishes like the Malabar sole, *Cynoglossus macrostomus* and a few co-occurring *Cynoglossus* species was undertaken by collecting samples from three centres like Cochin, Neendakara and Ambalapuzha along the Kerala coast and the results are presented.

MATERIAL AND METHODS

Samples of Malabar sole *Cynoglossus macrostomus* were collected from the trawl landings at Cochin and Neendakara Fisheries Harbours and as well from the mini trawl landing at Ambalapuzha. Weekly trips were made to Cochin and fortnightly trips to the other two centres for observation and collection of samples. From Cochin, samples were collected from August 1994 to June 1995 and from August 1995 to August 1996. The samples consisted of 980 males comprising 335 immature and 645 adults, and 933 females consisting of 328 immature and 605 adult fishes during August 1994 to June 1995. During 1995-96 a total of 774 males (272 immature and 502 adults) and 727 females (253 immature and 474 adults) were studied.

From Neendakara 1862 specimens of *C.macrostomus* of the size range 45-165 mm were collected and analysed during the period from December 1994 to October 1996. From Ambalapuzha 1502 fishes were studied. From this centre, though the food items were studied, only the condition of feed is presented for comparing the results with that of Cochin and Neendakara.

Samples of other species of *Cynoglossus* were also collected for food analysis which include the following:

Cynoglossus arel A total of 294 fishes of the size range 124 mm to 338 mm were collected from the trawl landing at Neendakara Fisheries Harbour during September 1995 to August 1996.

C.bilineatus: This is a large growing species and a total of 93 specimens of the size range 193mm to 356 mm collected from Neendakara, have been studied for food and feeding habits.

C.puncticeps: The sample consisted of 105 specimens of the size range 93 to 172 mm collected from Neendakara.

ANALYSIS OF SAMPLE

Samples collected from the field were immediately put in ice box with sufficient quantity of ice. They were brought to the laboratory and were preserved in 5% formalin for two days and the detailed analysis was conducted thereafter.

Different workers have adopted various methods in studying the food of fishes. Hynes (1950) while studying the food of freshwater stickle back estimated the food items by points method and also reviewed the different methods. The same method was used by Swynnerton and Worthington (1940) and in a modified form by Frost (1943) for the study of the food of minnow. In a study of the food of the Indian mackerel Bhimachar and George (1952) followed both points and number method. Seshappa and Bhimachar (1955) adopted the occurrence method for the determination of relative importance of food items of the Malabar sole *Cynoglossus semifasciatus*. Pillay (1952) gave a critical review of the various methods used for the analysis of food of fishes. Natarajan and Jhingran (1961) have stated that individually either the occurrence method or a qualitative method is not suited for a proper analysis of food of fishes. They suggested an index that takes into consideration both the occurrence as well as the quantity of food item which is termed as the 'Index of Preponderance.' Accordingly

$$IP = \frac{V*O}{SUM\ V*O} * 100$$

where 'V' and 'O' are percentage volume and occurrence of a food item respectively. The Malabar sole *C.macrostomus* and *C.arel* are carnivores. Hence both the occurrence and volume were taken into account. The food analysis of these two species was done by the method of 'Index of Preponderance' as suggested by Natarajan and Jhingran (1961). After taking the total length of the fish in millimeter (mm) and the weight in grams (g) the specimens were cut open and the gut contents were carefully washed into a small petri dish. The various items were then sorted out using a binocular microscope and then identified upto the genus or species level as far as possible. The extent of feeding or the condition of feed was determined by the degree of distention of the stomach and the amount of food contained in it, and was expressed as 'gorged', 'full', '3/4 full', '1/2 full','1/4 full', 'trace'(or 1/8) and empty with 100, 80, 60, 40, 20, 10 and 0 points assigned respectively. Depending on the relative volume of the food items, points were allotted for each item. From these values,volume for each item was calculated. The percentage volume of each food item was found out from the total volume of all the stomach contents in each month separately for males and females. Similarly, the percentage occurrence of different items were determined from the total number of all items in each month. The index of preponderance was taken to indicate the food preference of *C.macrostomus* and *C.arel*. The percentage occurrence of various degrees of fullness was worked out from the total number of stomachs examined in a month. The food of the other two species such as *C.bilineatus* and *C.puncticeps* were analysed qualitatively by the occurrence method as these fishes were not commonly occurring in the landings.

RESULTS

QUALITATIVE AND QUANTITATIVE ANALYSIS

Qualitative analysis

The Malabar sole with its body shape and bottom habitat is essentially a bottom feeder. In general, the dietary components of this species can be grouped under major categories like polychaetes, amphipods, copepods, mysids, molluscs and detritus and hence the fish can be termed as a carnivorous detritus feeder.

Among polychaetes *Prionospia pinnata* was found to be the favourite food item of Malabar sole as this forage item was noticed in the stomach during all months in varying proportions. Other polychaetes like *Phyllochaetopterus* sp., *Pectinaria* sp. and *Clymene* sp. were also noticed at times.

Amphipods/mysids, though not encountered throughout the study, constituted an important food item during certain seasons. Among amphipods *Cheiriphotis megachelis* and *Grandidierella bonnieri* were the dominant species.

Copepods formed one of the important food items and were constituted by *Temora, Centropagus* and *Fabidocera* spp.

At times the stomach contained a variety of molluscs like young ones of bivalves and gastropods. Among bivalves *Tellina, Pholas orientalis, Cardium, Arca* and *Barnea* sp. were found. Young ones of gastropods were noticed almost through out the year except during few months.

Settled detritus constituted a major component in the diet of Malabar sole and was observed throughout the year except during one or two months. The other category of organisms encountered in the stomach consisted of heterogeneous elements of occasional occurrence, such as decapod remains (*Neptunus* sp. young ones of *Parapenaeopsis stylifera*. Diatoms like *Coscinodiscus* were more commonly observed compared to *Fragilaria oceanica, Thalassiothrix* and *Biddulphia.* Foraminifera were frequently encountered during most of the months. Most of them were smaller varieties and large forms like *Ammonia beccarii* also occurred during most of the period in varying numbers.

The above observations indicate that the Malabar sole is a typical bottom feeder, mostly feeding on detritus and the macrobenthos. They occasionally gravitate to feeding on small organisms like mysids and copepods in the column waters mostly depending on the availability of these forage organisms or whenever disturbance in the bottom habitat occurs during upwelling.

Quantitative analysis of the dietary components of Malabar sole from Cochin during August 1994 to June 1995

The stomach contents of the *C. macrostomus* from Cochin were analysed separately for males and females for each month and graded by the method of Index of Preponderance. The monthly data separately for males and females are presented in Tables 3.1 to 3.2 for the period August 1994 to June 1995. Samples from

Neendakara also have been analysed by the Index of Preponderance. But the males and females were not treated separately , and the results are presented in Tables 3.5 to 3.6 for the periods 1994-95 and 1995-96 for the periods 1994-95 and 1995-96.

Polychaetes: As a single food item the polychaetes occurred throughout the year in the diet of males. The index varied from a lowest 0.02 in May to 73.13 in August. It was the dominant item with higher index values during August, September and October 1994; and February and April 1995. Mostly, *Prionospia pinnata* constituted the diet. Other species like *Phyllochaetopterus* occurred only during August and October 1994 and April-May 1995 with percentage index ranging from 0.01 to 3.55. The highest value was in April 95.

In the females also *Prionospio pinnata* was observed in the diet of Malabar sole throughout the year. The highest index of 94.19 was in September compared to August in males. The item was dominant during August to October 1994 and then in April 1995. *Phyllochaetopterus* sp. occurred as in males only during October and December 1994; and then in April-May 95, with a highest index of 10.5 during April. *Pectinaria* sp. showed a low percentage index and was noticed during May.

Molluscs: Among molluscs, both gastropods and bivalves formed the food of Malabar sole. Mostly they appear to have been swallowed along with detritus. Gastropods occurred only during November 1994 to March 95 in both sexes. The species encountered were *Oliva* sp., *Architectonia* sp., *Turetella* sp. and *Dentalium*. Compared to the females, the gastropods were well represented in the diet of males. The percentage index of gastropods ranged from 0.01 to 1.98. *Turetella* sp. in both sexes was observed only during December. *Dentalium* was noticed to occur in December in the diet of males.

Among bivalves, species of *Nucula, Tellina, Arca, cardium, Pholas* and *Barnea* were observed. *Nucula* occurred during September to February and during April-May 1995. The index varied from 0.02 to 9.69. *Pholas sp.* was noticed during August and September in males and during August in females.

Crustaceans: The crustacean components in the diet of Malabar sole consisted of amphipods, mysids, copepods, young ones of squilla, prawns and crabs. Amphipods/mysids and copepods formed important dietary components during the post monsoon and premonsoon months mostly. In males amphipods/mysids were found to occur in good quantities during October, December, January to March and then in May-June. A high index of 98.33 was observed in June and 44.15 in January. The occurrence of amphipods as a dietary component in females was similar to that in males. The index value ranged from 0.49 to 98.46. The occurrence of a highest value in June was comparable to that in males.

Copepods also indicated the same pattern of seasonality in occurrence in both sexes of Malabar sole and may be grouped as forage item occurring during October to June. The pattern of occurrence of copepods as forage item in females compared well with that of males with higher index values of 42.47 and 85.74 respectively in March and May 1995.

Other crustaceans such as *Squilla* sp. with an index value of 0.06 occurred in March in males, where as in females this item was noticed during February and March with an index value of 0.28. Alima larva was also observed with a low index value during January in males. Small hermit crabs with an index value of 3.58 and 0.02 was observed in the males during December and January, whereas in females this item occurred during December with an index value of 1.8

Detritus: Detritus was observed in the diet in varying proportions throughout the year in both sexes. In males their index value ranged from 0.62 to 57.12 and in females 1.04 to 50.7 attaining high index values 57.12 and 47.67 during November and December 1994 respectively in males whereas in females it was a dominant item during November with an index of 50.74. The index value was above 20 during August, September, November, December, February and April in the case of females.

Foraminifera: A variety of foraminifera species were found to occur in the diet of the Malabar sole and the index value *Ammonia beccarii* ranged from 10.0 and 13.59 in males and females respectively during January. Mostly they occurred from November to May but was not found during August to October.

Quantitative analysis of the dietary components of Malabar sole from Cochin during August 1995 to May 1996.

The results of the analysis are given in Tables 3.3 to 3.4.

Polychaete: *Prionospia pinnata* was observed from October to May in the diet of both males and females and was the most dominant item with a percentage index of 97.16 and 96.59 respectively in October. This item was again a major constituent in the diet during February. In males the lowest values were observed during December, and March-April. Whereas in females it was during December, March to May. Other polychaetes like *Phyllochaetopterus* sp. occurred with higher index values of 41.32, 62.05 and 25.34 in males and 15.8, 62.12 and 45.70 in females during March, April and May respectively. As may be seen, it was the dominant food item in both sexes during April. *Pectinaria* sp. occurred in the diet of both sexes with low index value during March and in females this item was again noticed during April. *Clymene* sp. was encountered only in the males with a percentage index of 0.23 in November and 2.03 in April.

Molluscs: such as gastropods occurred mostly during November 1995 to March 1996 with low index values in both males and females. In males *Turetella* sp. was present during December 1995 and February 96 compared to December to February in females.

Bivalves occurred from September to May in males with percentage index ranging from 0.01 in February to a highest 18.08 in September. In females this item was absent during August, October and March, but in other months the index value ranged from 0.01 to 12.22. But in both sexes the high and low indices were during September and February respectively. Other food items like *Arca/Cardium* with low percentage index was recorded only during December in males compared to January and March in females. Bivalves like *Tellina* sp. was not encountered regularly, but was noticed during November in the diet of both sexes with an index value of 13.07 in males and 7.79 in females.

Crustaceans: Amphipods/mysids were observed in all the months with an index value ranging from 0.47 to 47.09, except during October and November. It formed the dominant item of food during September and January and was the second dominant item during December in males and females. But in females this food item was again noticed during March. Copepods were noticed in the diet except during September, October 1995 and May 1996. During the other months the percentage index varied from 0.01 to 99.01 in males and 0.05 to 64.23 in females. They were the dominant food item during August in both sexes with the highest index values. In males this forage item was second dominant among the dietary components during January and February, whereas in females it was during January.

Detritus: was observed in the diet from September to May with index values ranging from 2.32 to 59.73 in males and 0.66 to 64.43 in females. It was the dominant food item in males during November, February, March and May compared to November, March and May in females.

Other food items like foraminifera, *Coscinodiscus*, *Chaetoceros* spp. *etc*. occurred with low index values from September to May in the diet of both sexes. Large sized foraminifera (*Ammonia beccarii* occurred in low percentage in males compared to the previous year.

Comparison of the stomach contents of *C. macrostomus* from Cochin and Neendakara

A comparison of the dietary components of the Malabar sole at Cochin and Neendakara was made. The monthly relative index of food items of Malabar sole from Neendakara from August 1994 to October 1996 are presented in Tables 3.5 and 3.6.

The results of the study indicated that the food items could be grouped into polychaetes, amphipods/ mysids, copepods, molluscs and detritus as observed at Cochin. Among polychaetes *Prionospio pinnata* was one of the most commonest item that occurred throughout the year as at Cochin. Other polychaetes like *Phyllochaetopterus* sp., *Pectinaria* sp. and *Clymene* sp. were noticed occasionally during February to May.

The crustacean diet showed similarity in the seasonal pattern of occurrence and their availability in the environment at Cochin and Neendakara. Crustaceans like young ones of *Neptunus* sp., Hermit crabs and *Parapenaeopsis stylifera* were also encountered in minor quantities as in Cochin. The reults obtained at these two centres are given in Tables 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6.

Among molluscs, the gastropods noticed in the diet of Malabar sole at Neendakara were similar to that observed at Cochin. Bivalves like *Tellina, Nucula, Arca* and *Cardium* were noticed in the diet of the fish at Neendakara. But *Pholas* species was not seen in the diet.

Detritus as a food item was observed throughout the period of study as in Cochin. The percentage of index was highest (76.38) in May followed by 51.3 in March. During 1995-96 a highest percentage Index of 90.9 was noted during March followed by 74.69 in February and 73.6 in March.

Further, the monthly food item of male and females of *C.macrostomus* were pooled and the ranks obtained for various food items at Cochin were compared with the rankings obtained at Neendakara. There is good correspondence in the ranks obtained by the food items at these two centres. The ranks obtained by different food items with respect these two centres for the period 1994-95 and 1995-=96 are given in Tables 3.7, 3.8, 3.9 and 3.10.

The important food items at both the centres showed striking similarity. The minor differences in the ranks obtained were purely due to difference in the variability in abundance of the forage items or faunal changes in the two distantly placed centres during different months or due to a time lag in abundance of forage organisms.

FOOD ITEMS IN RELATION TO SIZE GROUPS IN MALABAR SOLE

The data on the food items consumed by the Malabar sole were further treated and analysed size groupwise based on the data at Cochin. The fishes were grouped into 5 mm size groups and percentage occurrence of various food items were worked out for the period August 1994 to June 1995 and August 1995 to May 1996. Separate analysis was made for males and the results are indicated in Tables 3.11, 3.12 and Figure 3.1; and for females in Tables 3.13, 3.14 and Figure 3.2. 3.12) and females (3.13 & 3.14) and also by pooling the data (Tables 3.15 & 3.16).

Polychaetes: The results of the analysis indicated that in males during 1994-95 polychaetes occurred in the length groups of 60 to 140 mm but were absent above this size from 145 to 155 mm. The highest percentage of 55.6 was in the 65 mm size fishes which gradually got reduced to 31.7% in 100 size mm group. The occurrence of polychaetes remained almost constant in 110,115 and 120 mm length groups, but was highest in 135 mm fishes.

During 1995-96 polychaetes were found to occur in males of 45 to 145 mm length fishes. In the size range 45 to 105 mm fishes the percentage occurrence was 40 with a highest of 77.8 and 79 in the 80 mm and 90 mm size fishes respectively. From 110 mm to 145 mm length fishes the percentage occurrence was lower. In the females, polychaetes were noticed in 60 mm to 155 mm size group during 1994-95 and 45-155 mm during 1995-96. The percentage occurrence was higher in the younger and in larger size groups.

Amphipods: were noticed from 75-130 mm and 60-145 mm in males compared to 70 - 150 mm and 70 - 110 mm in females during 1994-95 and 1995-96. Generally the percentage occurrence of Amphipods were less in the middle size groups.

Mysids: Mysids occurred from 55 - 135/140 mm length males and in 65 - 150 mm length range in females. In 55 mm size males they constituted 100% in 1994-95 which gradually got reduced to 13.4 in 95 mm size fishes and remained steady around 20% in higher size groups. A similar trend was seen in females also during that year. But during 1995-96 a fluctuation in their occurrence in various size group was noticed.

Copepods: Copepods also occurred in the diet of both males and females. In males they occurred from 50-55 mm during 1994-95 and 95-96, compared to 60-65 mm in females. In both sexes the percentage occurrence was comparatively higher in the smaller fishes, but in general showed a gradual reduction in the occurrence towards large sized fishes. But in the largest size fishes again an increase in intake of copepods was discernible. There was a clear cut reduction in their intake mostly around 100 mm size fishes in both sexes and in 110 mm females during 1994-95.

Bivalves: were observed in the diet of both males and females. During 1994-95 the bivalves were noticed from slightly larger size groups, compared to their occurrence from smaller size groups during 1995-96. The percentage occurrence in general was comparatively better in smaller and largest ones. Though there were fluctuations in the percentage occurrence of bivalves in various size groups particular reduction occurred around 95-100 mm size fishes of both sexes.

Gastropods: During 1994-95 gastropods occurred from younger size groups in males compared to slightly larger size groups in females. During 1995-96 their occurrence mostly started from 85/90 mm in males and females. But here again in both sexes there was a particular reduction or nil occurrence in fishes of length 90-105 mm.

Foraminifera: During 1994-95 in both sexes, foraminifera started occurring from 65 mm size fishes compared to their occurrence in 75 mm fish onwards during 1995-96. Here again, except in males during 1994-95 in both sexes the occurrence of foraminifera was less in the size groups around 100 mm.

Plant matter: In both sexes during the two year period plant matter (includes diatom, *Fragilaria*, *Thallasiothrix*, and algae) was observed in the middle size groups and were occurring irregularly. The percentage occurrence was higher in males during 1995-96 in the younger specimens (45 & 50 mm size fishes).

Detritus: Detritus formed a major food item in Malabar sole. This item was found to occur in 65-140 mm males during 1994-95 and 50-150 mm in 1995-96 compared to 60-155 mm and 45-155 mm in females during the respective years. During both the years the percentage occurrence in general was higher in the younger size groups and larger size groups.

FOOD PREFERENCE IN IMMATURE AND MATURE MALABAR SOLE

To find out the food preferences if any, the fishes were grouped into immature and mature. Since the size at maturity in both males and females has been found to be 97 mm (See Chapter spawning) fishes below 90 mm were treated as immature and those above as mature.

The food items of Malabar sole in both sexes were listed as polychaetes, amphipods, mysids, copepods, bivalves, gastropods, foraminifera, plant matter and detritus. The results of the study for the period 1994-95 and 1995-96 for males and females are given in Table 3.17. The pooled data for the two years are presented in Table 3.18.

During 1994-95, in immature males the dominant food items in the order of abundance were mysids (25.4%), polychaetes (20%), detritus (16.2%), copepods (11.4%), foraminifera (10.8%), bivalves (6.4%), amphipods (3.9%),gastropods (3.1%) and plant matter (2.8%). Whereas in mature fishes detritus (23.8%), polychaetes (23.5%), mysids (18.1%), copepods (13.3%), foraminifera (6.1%), bivalves (5.5%), amphipods (4.8%), gastropods (4.2%) and plant matter (0.7%) were encountered in that order of abundance.

In the immature females during 1994-95 polychaetes (27%) were dominant unlike mysids in males. Mysids in immature females occupied a second position which was followed by copepods (18.4%), detritus (14.7%), amphipods (6.7%) and other items like bivalves, gastropods and foraminifera occurring at a lower percentage. No plant matter was recorded in immature females. While polychaetes dominated the diet in immature fishes , in adult females detritus was a prominent. Polychaetes occupied a second position followed by mysids (19.3%), copepods (14.3%), foraminifera (6.2%), bivalves (5.2%) and gastropods (2.4%). Plant matter constituted 1.2% compared to its nil occurrence in immature females. Bivalves and gastropods showed a higher percentage in mature females than in immature fishes, whereas percentage of copepods were higher in immature ones.

During 1995-96, both in immature males and females, polychaetes dominated compared to their occurrence in mature fishes. Amphipods were dominant (8.3%) in immature males than in their mature counterpart. Contrary to the previous year (1994-95) the percentage of mysids were lower in immature fishes than mature ones of both sexes. Again the occurrence of mysids, copepods, bivalves, gastropods and detritus constituted a higher percentage in mature males and females. But foraminifera constituted a higher percentage in the immature fishes. The data for the two years on the percentage composition of major food items of males and females were pooled and the results are given in Table 3.18.

The results of this analysis indicated that the food items in both immature and mature fishes (male and females) in the order of dominance in percentage composition were 1) detritus, 2) polychaetes, 3) amphipods/mysids, 4) copepods and 5) molluscs.

CONDITION OF FEED IN MALABAR SOLE

To study the condition of feed the data from three centres were analysed and compared. From Cochin 3444 fishes collected during August 1994 to May 1996; Neendakara 1862 specimens from December 1994 to October 1996; and Ambalapuzha 1502 fishes collected during November 1994 to October 1996 were utilised. The stomachs from all these three centres, depending on their fullness were classified as 'full','3/4 full', '1/2 full', '1/4 full', trace and empty. The monthly distribution of state of fullness in males and females for 1994-95 and 96-96 at Cochin are given in Tables 3.19, 3.20, 3.21 and 3.22; for Neendakara 3.23 and Ambalapuzha 3.24.

Fishes with full, '3/4 full' and '1/2 full' were considered to have actively fed. The monthly pooled percentage contribution of the actively fed and those with poor feeding condition observed in males and females during August 1994 to May 1996 at Cochin are given in Table 3.25.

At Cochin, nearly 100% of the fishes, both males and females, were in poorly fed condition during August to October 1994 and 1995. Subsequently the percentage of poorly fed fishes showed a decrease with corresponding increase in the actively fed fishes till January 95. The percentage of actively fed group declined in February-March 1995, but further recorded an upward trend to 54.8% during April 1995 and then from May the monthly percentage of actively fed fishes plummeted subsequently. The trend observed was similar in both sexes during the said period. Figure 3.4 gives the monthly percentage of actively fed fishes at Cochin (male and females), Neendakara and Ambalapuzha.

During 1995-96 also the trend in the condition of feed was same at Cochin compared to that in 1994-95. It may be seen from the figure that the peak occurrence of actively fed fishes during 1995 were in December compared to January in 1996. Percentage of actively fed fishes increased from February '96 reaching a peak of 47.6% during March in the case of females and for males during April 96.

Condition of feed, comparison with other centres

A comparison of the feeding condition of Malabar sole at Ambalapuzha and Neendakara with that of Cochin indicated striking similarity with regard to active and poor feeding periods. But data from Ambalapuzha showed active feeding condition (96%) during August 1995 compared to very poor feeding condition observed at Cochin and Neendakara. Ambalapuzha area is known for 'Chakara' (Mud banks) during the south-west monsoon season. The food analysis of Malabar sole during August indicated that bivalves like *Barnea sp. Tellina sp.* and *Nucula* sp. dominated the diet, followed by copepods, detritus, polychaetes and gastropods. Upto 38 bivalves have been recorded in a stomach of Malabar sole during this month. The occurrence of bivalves, copepods and polychaetes in the diet of Malabar sole points out the existence or settlement of a rich faunistic composition in the area immediately after the cessation of mud banks (Regunathan *et al.* 1984). The general picture that evolved from the feeding condition at Cochin, Ambalapuzha and Neendakara was that December-January, February-March, April-May periods appeared to be the periods when active feeding was observed. Feeding was poor during other months and especially during August, September, and October. The active feeding of Malabar sole during August at Ambalapuzha is due to the availability of macrobenthic fauna settled there after the cessation of unconsolidated condition existed during mud banks.

FEEDING IN RELATION TO MATURITY

The variations in the feeding intensity were further studied in relation to the maturation of the fish and the volume points attained by each stomach. Since 50% of the of males and females mature at 97 mm (Chapter IV) fishes below 90 mm were grouped as immature and those above this size as mature. The average volume of the stomach contents of both males and females in each month and size groups were then calculated by dividing the total volume points gained by all stomachs by the total number of stomachs that contributed to this volume. The details of the average volume points in the immature and mature fishes during 1994-95 and 1995-96 are given in Tables 3.26 & 3.27 for females and 3.28 and 3.29 for males. During 1994-95 the annual average volume points for immature and mature males were 25.2 and 16.2 respectively. In the immature fishes the monthly volume points were higher than the annual average volume during January, March and April 1995. Whereas in the mature fishes the monthly volume points were higher during December 1994, January, February, April and May 1995. Figure 3.5 depicts the average volume points of stomachs in immature and mature males during 1994-95. During 1995-96 the monthly volume points in immature fishes were higher during February to May 1996 and in mature fishes November-December 1995 and February to May 1996 (Figure 3.6).

The analysis revealed that both in males and females the seasonal pattern in the volume points followed a similar pattern without much variation in immature and mature fishes. The feeding, it appears is influenced by the availability of forage organisms in the feeding grounds.

October-November and February-March is the peak spawning period of the Malabar sole (Chapter IV Reproduction). The period immediately following the spawning coincided with active feeding. It may be noted here that the immature fishes also showed almost the same periodicity in feeding activity as the mature ones. Hence, it may be assumed here that it is the availability of the forage organisms in the fishing ground that influence the feeding intensity.

Feeding intensity in relation to size groups

The condition of feed was further studied by finding out the average volume points in different size groups at Cochin The pattern of the average volume points in different size groups followed a similar pattern during 1994-95 and 1995-96.

In the size groups 55-90 mm in both sexes, the average volume points were higher. Slight reduction in the volume points was noticed in 95 mm group and also in 140 mm group. The size group wise volume points for males and females are given in Tables 3.30 and 3.31, and in Figure 3.7.

During 1995-96 the average volume was 17.1 for males and 20.3 for females. The volume points were lower in females in the size groups 45-75 mm and further in large size groups not much variation was seen till in large fishes of 145 mm, 155 mm and 160 mm. Males showed a higher volume points in 55 mm size fishes, then decreased and further in size group 70-95 mm the volume points were above average. From 100 mm to 140 mm size and in 150 mm fishes also the volume points were lower than the average. There was reduction in the volume points in males and females in the 90 to 100 mm and 55 to 65 mm fishes. Both these groups mostly occurred during March, a time when the feeding condition was comparatively poor.

FEEDING HABITS AND SELETIVITY

The Malabar sole *C. macrostomus* specialised to a bottom habitat mostly lie in the loose mud and its food and feeding is strongly influenced by the structure of the benthic fauna. Except during times when the bottom is disturbed , the sole resorts to feeding on the detritus and macrobenthos. The size of the macrobenthic organisms that form the forage items are important. Whole organisms that are encountered in the stomach include the amphipods, mysids, copepods, young bivalves like *Tellina* sp; *Arca* sp; *Cardium* sp; *Nucula* sp. and *Barnea* sp. and small gastropods and foraminifera. Sometimes as many as 35 numbers of pelecypods like *Barnea* sp. were noticed in the stomach mostly in the mid gut with detritus occupying the hind gut region. Sometimes the stomach contained detritus. While feeding on detritus and benthic organisms like molluscs, bivalves foraminifera are included and part of the detritus are passed to the hind gut to accommodate the molluscan items which are mostly found in the middle region of the gut. Polychaetes mostly browsed and chewed are found in the stomach region with detached chetae in most cases. The bottom conditions get disturbed at times during upwelling or due to other reasons when the fish resorts to off bottom and column feeding during vertical migrations. During this time the fish feeds on amphipods, mysids and copepods. But it seems that vertical migrations of the fish to feed on these organisms is mostly controlled by the availability of the forage items.

FOOD OF OTHER *CYNOGLOSSUS* SPECIES

The food and feeding of some of the other *Cynoglossus* species occurring along with the Malabar sole were studied. The species observed were *Cynoglossus arel, C. bilineatus* and *C.*

puncticeps. Since *C. arel* was found to occur more frequently than other species the food items of this fish were analysed by the Index of Preponderance. The food of other two species were analysed qualitatively.

Cynoglossus arel: A total of 294 speciemens in the size range 124-338 mm were examined from September 1995 to August 1996. The monthly details of percentage of occurrence, volume, relative Index and the ranking obtained by the different food items are given in Table 3.37. The important food items of *C.arel* in the order of importance and ranks obtained were detritus, polychaetes, hermit crabs, young ones of prawns like *Parapenaeopsis stylifera*, amphipods, gastropods, *Trachypenaeus curvirostris*, bivalves and fish remains and are indicated in Figure 3.8. The monthly percentage Index indicated that detritus was the most dominant food item during September 1995 to January '96. The percentage Index of polychaetes was found to increase from a low value in September to a high value of 48.4 during January, but declined thereafter and then increased to 33.9 during August '96. Bitten parts of hermit crabs were observed throughout with higher values during September 95 and during March to May 96. Among molluscs the gastropods occurred more abundantly than bivalves. The young ones of prawns like *Parapenaeopsis stylifera* dominated the diet during April and May. Fish remains showed a lower value. Active feeding was observed during December 95 to February, April, May and August

96 as may be seen from Figure 3.9.

Cynoglossus bilineatus: This is a large growing species. A total of 93 specimens in the size range 193 to 356 mm were examined. A qualitative analysis of the food was done (Table 3.33). The food items observed were detritus, young ones of crabs such as *Portunus sanguinolentus*, prawns such as *Parapenaeopsis stylifera* and *Trachypenaeus curvirostris* and remains of young fishes like *Upeneus* sp. Feeding was moderate during September, December, January and April. Active feeding months were October-November and March. Feeding was found to be poor during May.

Cynoglossus puncticeps : The sample consisted of 105 specimens of the size range 93 to 172 mm. The qualitative analysis of the dietary components showed that the fish feeds on detritus, small gastropods and bivalves, polychaetes, prawns like *Parapenaeopsis stylifera*, hermit crabs, amphipods, copepods and plant matter. Active feeding was observed during December, January and March moderate during October, February and April, and poor feeding during the rest of the period (Table 3.34).

The studies indicated that these four species of flatfishes are carnivores and detritus feeders. While amphipods, mysids, copepods, gastropods and bivalves were found common in the diet, the size of the food items appeared to be a limiting factor. The gastropods and bivalves found in the stomachs of larger growing species are bigger in size compared to those encountered in smaller growing fishes. Again large food organisms like prawns, crabs, Hermit crabs, small fishes *etc.* noticed in the diet of large growing flatfishes are conspicuously absent in the diet of smaller growing fishes. Hence there appears no inter species competition between these four species.

DISCUSSION

Based on the food preferences de Groot (1969,1973) grouped the flatfishes into belonging to the following food groups.

Type A, fish feeders- Psettodidae, Bothidae and Pleuronectidae

Type B, Crustacean feeders- Pleuronectidae and Cynoglossidae

Type C, Polychaete-mollusc-feeders- Pleuronectidae and soleidae

The role of visual and olfactorial factors in connection with the feeding behaviour in the North Sea flatfishes have been studied by de Groot (1969a). But information on the role of visual and olfactorial factors connected with feeding are lacking for the Psettodidae and Cynoglossidae. But from what is known of their food preference, de Groot (1973) drew some conclusions.

Psettodidae are very predacious fishes feeding nearly exclusively on fish. They possess brush like groups of teeth on the gill arches, which prevent the prey from struggling out. This indicates that they are visual feeders, and hence feed during the day time. Cynoglossids on the other hand feed mainly on polychaetes with crustaceans as a close second (Kuthalingam, 1957; Ochiai, 1966; Seshappa and Bhimachar,1955; Suyehiro, 1941; Edwards *et al*, 1970). However it is still unknown whether they feed during the day or night, as worms and crustaceans living in or near the bottom may be detected by smell and/or vision. But, from what is known about the development of certain parts of the brain it seems likely that they feed during the day as well. Lissner, Evans (1937) and Ochiai (1966) studied the comparative morphology of the brains of several flatfishes and reported that members of the Cynoglossidae have medium sized olfactory lobes and large optical lobes. It is generally agreed that swimming activity in flatfishes is largely confined to night (Boulenger, 1929; Harder and Hempel, 1954; Graham, 1956; de Groot, 1964; Woodhead, 1964). Diurnal cycles in the movement of the fish are often correlated with its feeding. The filling percentages of the stomach of turbot (Bothidae) are found maximum during the day time. In the sole (Soleidae) feeding has been known to occur during the well defined nocturnal activity cycle. In plaice (Pleuronectidae) on the other hand feeding is largely restricted to the day time. Data on the diurnal feeding behaviour of *Cynoglossus* species are lacking. It is still uncertain whether they feed during day or at night. In the present study samples were drawn from day time trawling operations as there was no night trawling. The results of the gut content analysis indicated the occurrence of a variety of food items and a clear cut periodicity in the condition of feed and intensity of feeding. The Malabar soles feed during day time and there is good correlation in the occurrence of various food item in the stomach of this species and their *in situ* abundance in the environment. The Malabar sole *Cynoglossus macrostomus* is a carnivorous detritus feeder. The dominant food items are detritus, polychaetes and crustaceans. Seshappa and Bhimachar (1955) observed that polychaetes formed the main constituent of the food of Malabar sole, *C. semifasciatus* (= *C. macrostomus*) De Groot (1971) in his studies on the food of 12 species of *Cynoglossus* observed that crustaceans formed the main constituents and concluded that the species of *Cynoglossus* are crustacean feeders. Studies on the food of *Cynoglossus lingua* and *Solea elongata* by Kuthalingam (1957,1960), *Pseudorhombus elevatus* by Pradhan (1959), *Psettodes erumei* by Pradhan (1969), Devadoss *et al* (1977) and Ramanathan and Natarajan (1979) indicated that the large growing species are voracious carnivores feeding on crustaceans and fishes.

The bottom fauna studies by Seshappa (1953) have shown that during the monsoon months, June to August, the inshore bottom is very poor in organisms that forms the food of Malabar sole. The return of the adult ones to the inshore coincides with this settlement of polychaetes and other benthic fauna. Large shoals appear during August/September and are popularly known as *Manthayilakkam*. These shoals feed on the abundant polychaetes. The seasonal change in the forage items of the malabar sole is a reflection of the availability of various forage organisms in the environment. The present study confirmed the earlier observations of Seshappa and Bhimachar (1955). Mathew *et al.* (1989) has indicated the seasonal abundance of mysids; Pillai (1989) and Rosama & Iyer (1979) have indicated the pattern of distribution of copepods in the Eastern Arabian Sea. The occurrence of mysids and copepods as dietary components of Malabar sole during different months reflected the *in situ* abundance of these forage organisms in the environment. Ortega-Salas (1950), Lande (1976) and Arntz (1971) while studying the seasonal change in the food of the North Sea dab *(Limanda limanda)* pointed out that the food composition is strongly influenced by the structure of macrobenthic fauna available as food resource.

As any other living organisms, the Malabar sole also has evolved suitable strategies by adhering to time schedules for feeding, reproduction and survival to meet the eventualities in a friendly or enimical environment. Variations in the time schedules of these activities seen are just reflections of such variations with in the ecosystem itself.

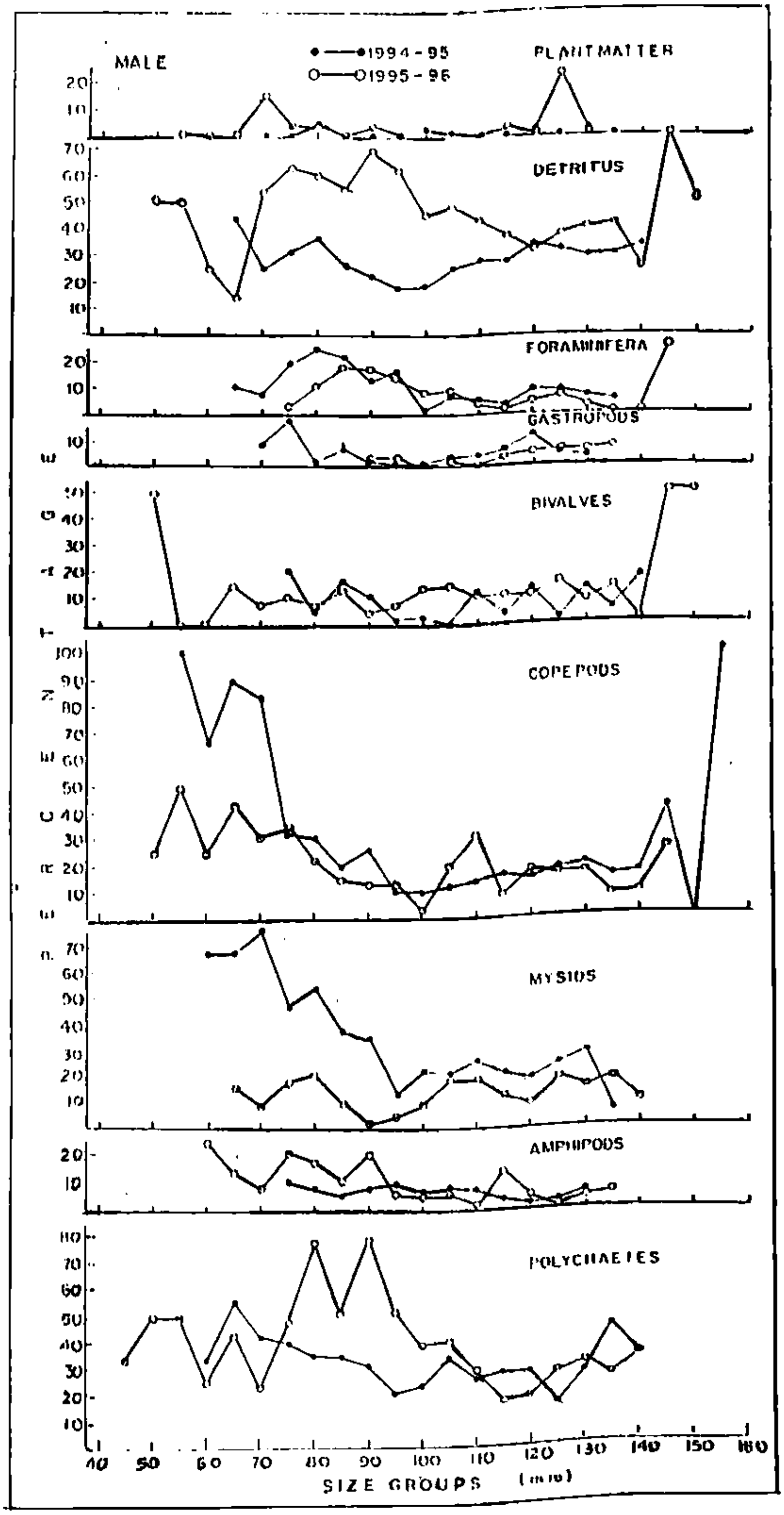

Fig. 3.1 Percentage occurrence of various food items in the stomachs of males of C.macrostomus in different size groups during 1994-95 & 1995-96

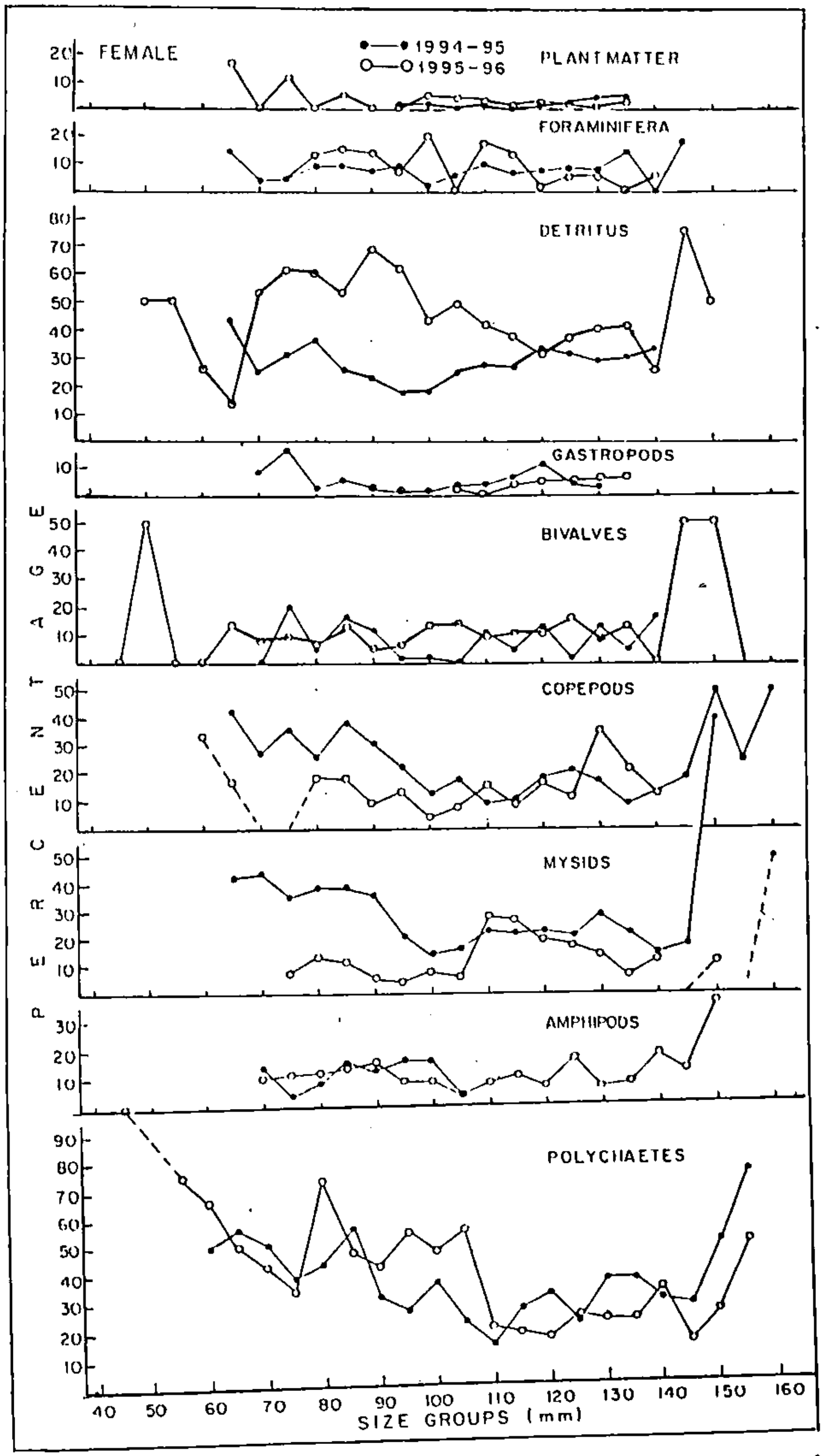

Fig. 3.2 Percentage occurrence of various food items in the stomachs of females of C.macrostomus in different size groups during 1994-95 and 1995-96

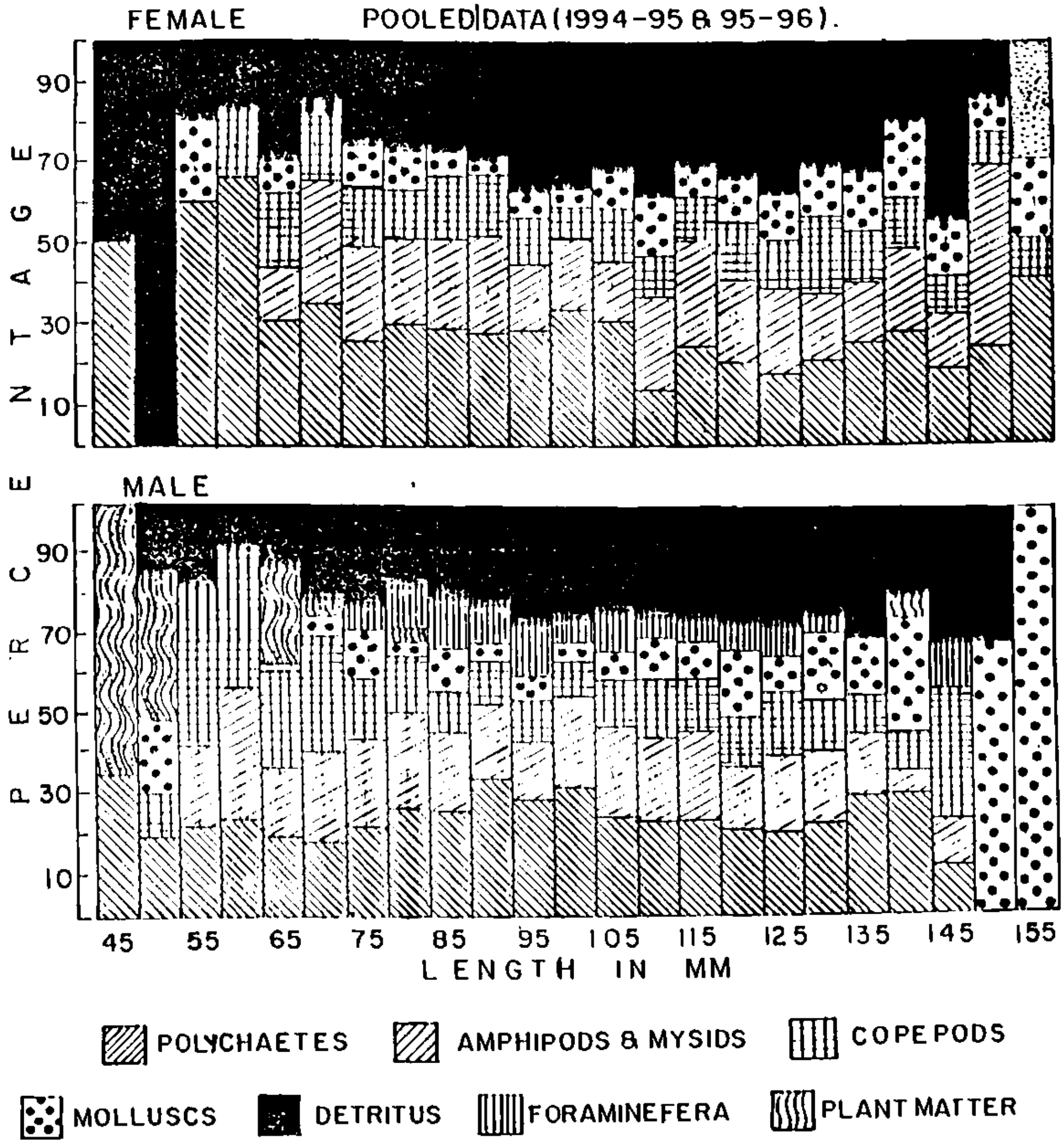

Fig. 3.3 Percentage occurrence (pooled for 1994-95 & 95-96) of food items of C.macrostomus in various size groups.
Upper panel - females & Lower panel - Males

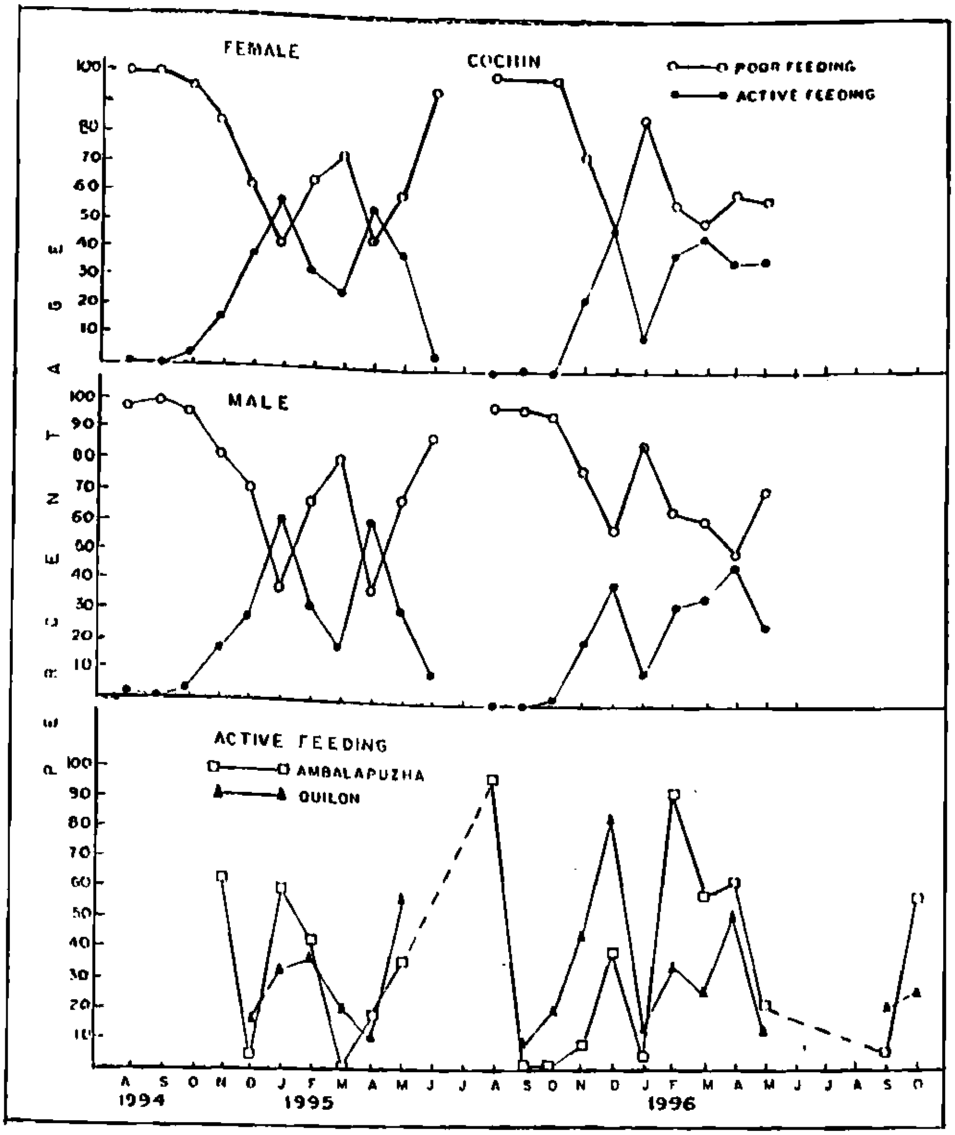

Fig. 3.4 Percentage occurrence of active and poor feeding in females (upper panel) and males (middle panel) of C.macrostomus at Cochin; and at Ambalapuzha and Neendakara (lower panel) during 1994, 1995 and 1996.

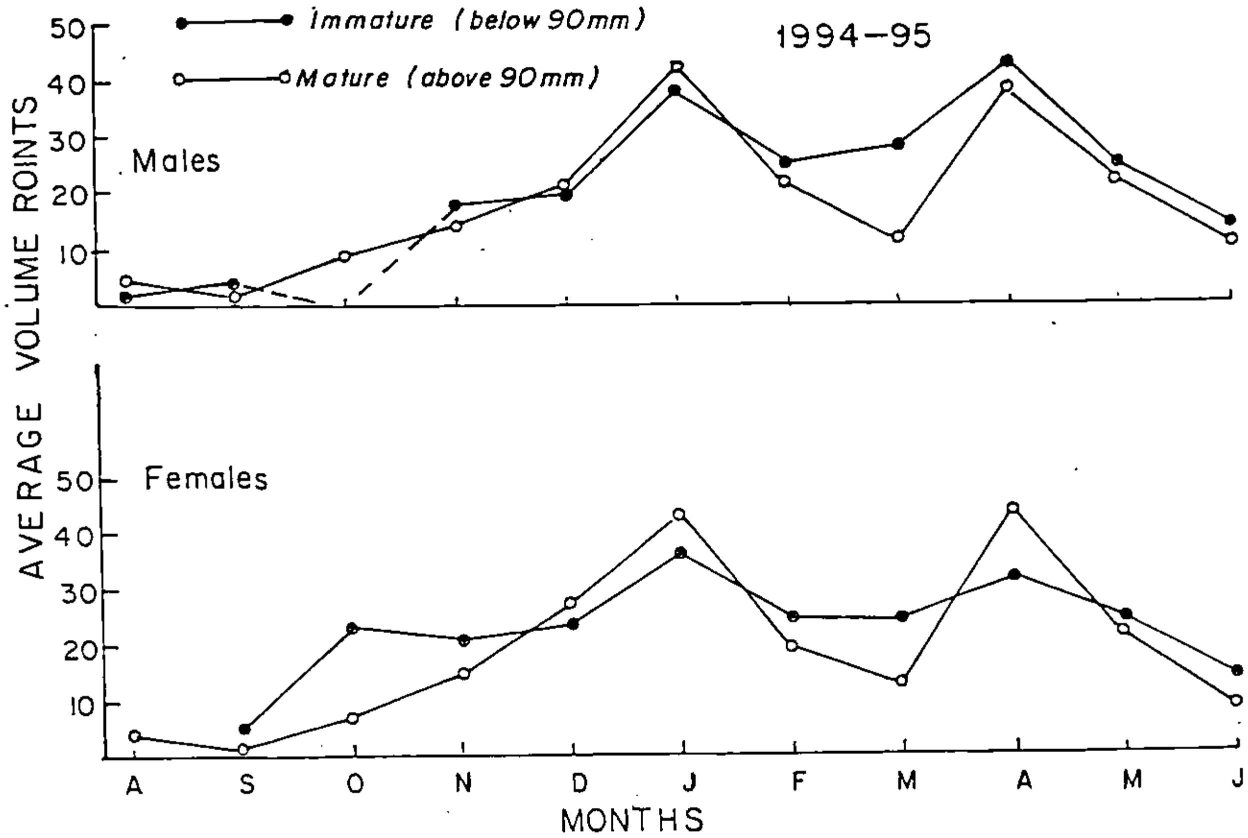

Fig. 3.5 Average volume points of stomachs in immature & mature males and females of C.macrostomus during 1994 - 1995

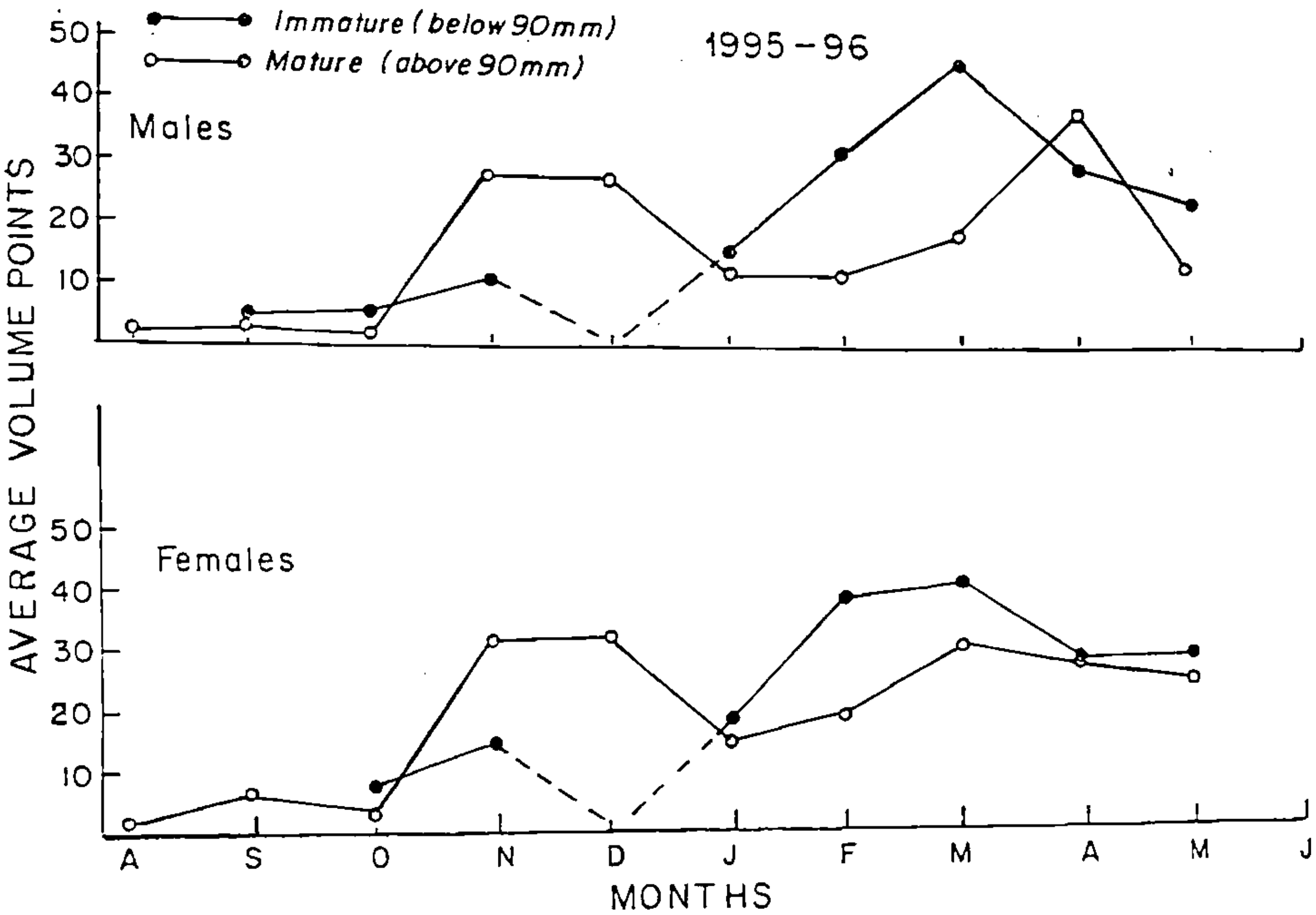

Fig. 3.6 Average volume points of stomachs in immature and mature males and females of *C. macrostomus* during 1995 - 1996

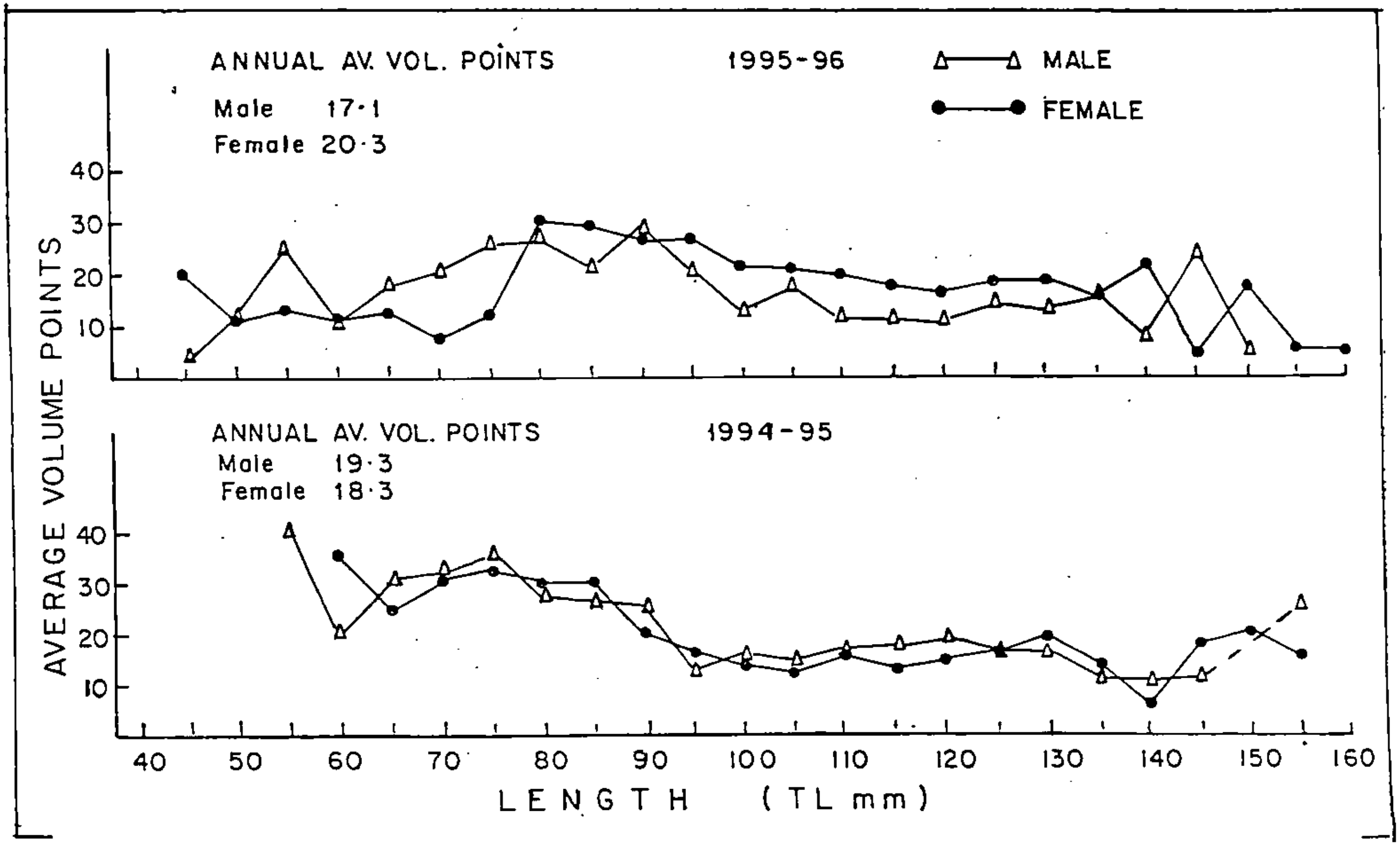

Fig. 3.7 Average volume points of stomachs in males and females of C.macrostomus in various size groups

Lower panel - 1994-95 & Upper panel - 1995-96

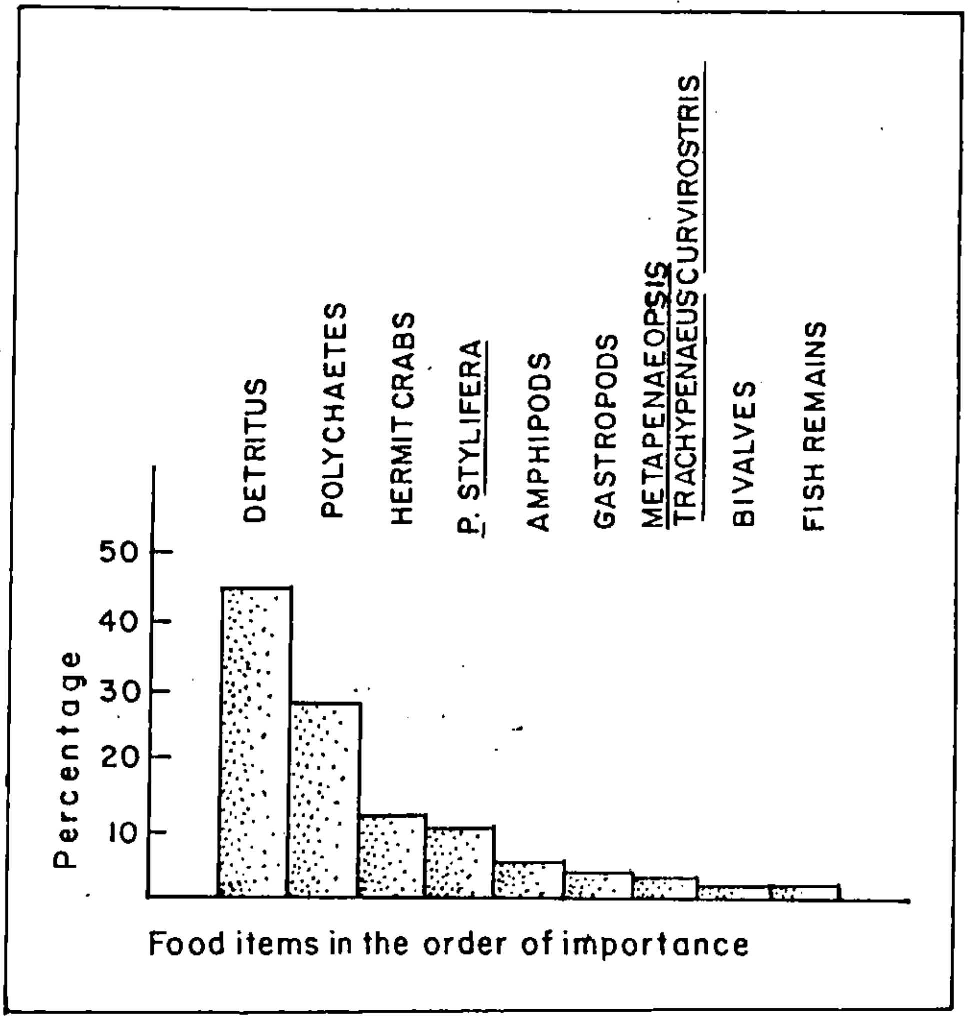

Fig. 3.8 Percentage occurrence of food items in the stomachs of Cynoglossus arel in the order of abundance

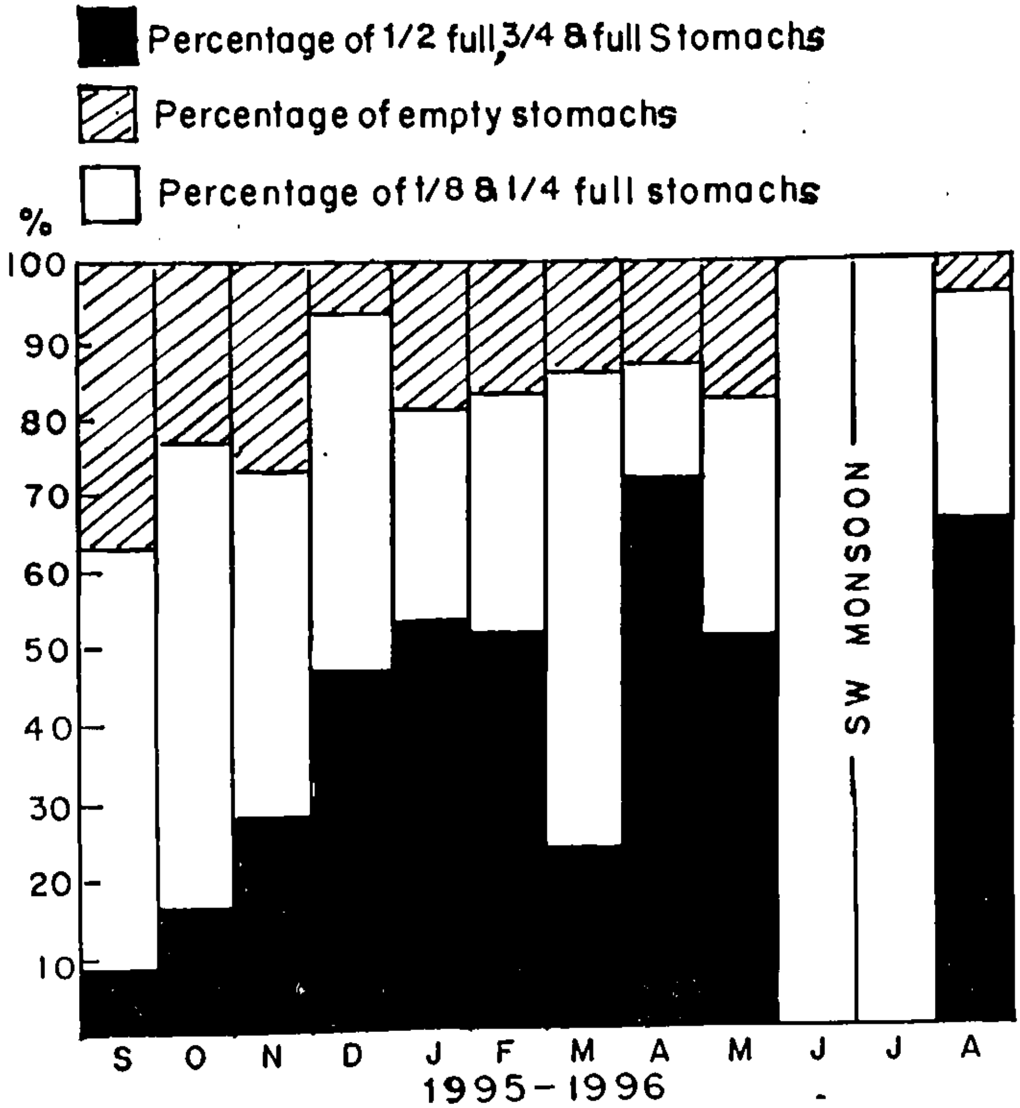

Fig. 3.9 Condition of feed in Cynoglossue arel
Percentage of 1/2 full, 3/4 full and full stomachs indicating active feeding

Table 3.1 Relative index of dietary components in males of *C.macrostomus* during August 1994 to June '95 at Cochin.

Contents	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.
POLYCHAETES											
P.pinnata	73.13	67.83	65.22	42.56	3.62	4.71	32.78	5.62	55.58	0.02	-
Phyllochaetopterus	0.37	-	0.99	-	-	-	-	-	3.55	0.01	-
Clymene sp.	-	-	-	-	-	-	-	-	0.02	-	-
MOLLUSCS											
Oliva sp				0.21	0.50	1.98	0.20	-	-	-	-
Tibia sp.	-	-	-	-	-	0.40	0.20	-	-	-	-
Architectonia sp	-	-	-	0.02	-	0.23	-	0.01	-	-	-
Turetella sp.	-	-	-	-	0.06	0.14	-	-	-	-	-
Dentalium	-	-	-	-	-	0.01	-	-	-	-	-
Gastropods	-	-	-	-	0.72	-	-	-	-	0.01	-
Arca/Cardium	-	-	-	-	0.06	0.01	-	-	-	0.01	-
Nucula sp	-	9.69	0.06	0.02	1.43	0.59	2.49	-	1.09	0.05	-
Pholas sp.	0.63	1.09	-	-	-	-	-	-	-	-	-
Bivalve remains	-	-	-	-	5.15	-	-	-	-	0.01	-
CRUSTACEANS											
Amphipods	-	-	-	-	-	-	-	-	17.53	-	-
Mysids	-	-	26.09	-	23.90	44.15	27.32	37.96	0.22	19.81	98.33
Copepods	-	-	0.60	-	6.51	29.77	6.75	49.67	-	79.01	0.92
Squilla	-	-	-	-	-	-	-	0.06	-	-	-
Alima larva	-	-	-	-	-	0.01	-	-	-	-	-
Hermit crabs	-	-	-	-	3.25	0.02	-	-	-	-	-
Crabs/prawns	-	-	-	0.02	-	-	-	-	-	-	-
OTHERS											
Mites	-	-	-	-	-	0.01	-	-	-	-	-
Large foraminifera	-	-	-	0.02	6.95	10.00	4.76	2.55	0.28	0.09	-
Foraminifera	-	-	0.02	0.02	0.18	-	0.01	-	0.20	0.01	-
Coscinodiscus	1.07	-	-	0.01	-	0.01	-	-	0.03	-	-
Chaetoceros	-	-	-	-	-	0.01	-	-	-	-	-
Fish eggs	-	-	-	-	-	-	-	-	-	-	0.03
DETRITUS	24.80	21.39	7.01	57.12	47.67	7.95	25.49	4.13	21.50	0.97	0.62

Table 3.2 Relative index of dietary components in females of *C.macrostomus* during August 1994 to June '95 at Cochin.

Contents	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.
POLYCHAETES											
P. pinnata	69.63	94.19	27.00	47.66	4.86	45.88	25.14	4.26	39.76	0.06	
Phyllochaetopterus	-	-	1.71	-	4.00	-	-	-	10.50	0.03	
Pectinaria sp	-	-	-	-	-	-	-	-	-	0.01	
GASTROPODS											
Oliva sp	-	-	-	0.05	-	0.13	-	-	-	-	-
Tibia sp	-	-	-	-	-	1.08	-	-	-	-	-
Architectonia sp	-	-	-	0.02	-	-	-	0.01	-	-	-
Turetella sp -	-	-	-	0.02	-	-	-	-	-	-	
Gastropod remains	-	-	-	-	-	-	-	-	-	0.01	-
Arca/Cardium	-	-	0.31	-	0.02	-	-	-	0.58	0.01	-
Nucula sp	-	0.12	-	0.05	0.49	0.67	1.01	-	-	0.11	-
Pholas sp	1.13	-	-	-	-	-	-	-	-	-	-
Bivalve remains	-	-	-	-	2.77	-	-	-	-	0.07	-
Planaria	-	-	-	-	0.14	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	-	-	-	-	-	-	-	-	10.92	-	-
Mysids	-	-	57.65	-	41.54	6.83	29.31	46.20	0.49	11.24	98.46
Copepods	-	-	7.54	-	1.64	26.57	13.93	42.47	-	85.74	0.50
Squilla	-	-	-	-	-	-	0.28	0.28	-	-	-
Hermit crabs	-	-	-	-	1.80	-	-	-	-	-	-
Mites	-	-	-	-	-	0.02	-	-	-	-	-
OTHERS											
* Large foraminifera	-	-	-	0.11	5.08	13.59	2.71	4.86	0.02	1.17	-
Foraminifera		0.85	-	0.16	=	0.01	-	0.48	-	-	-
Coscinodiscus	2.53	-	-	0.05	-	0.03	-	-	-	-	-
Chaetoceros	-	-	-	-	0.01	-	-	-	-	-	-
DETRITUS	26.71	4.84	5.79	50.74	37.63	5.21	27.90	1.44	37.73	1.55	1.04

* Large foraminifera is *Ammonia beccarii*

Table 3.3 Relative index of dietary components in males of *C.macrostomus* during August 1995 to June '96 at Cochin.

Contents	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.
POLYCHAETES											
P.pinnata	-	-	97.16	10.34	0.83	19.09	34.10	1.54	3.36	17.63	-
Phyllochaetopterus	-	-	-	-	-	-	-	41.32	62.05	25.34	-
Pectinaria sp	-	-	-	-	-	-	-	0.05	-	-	-
Clymene sp	-	-	-	0.23	-	-	-	-	2.03	-	-
GASTROPODS											
Oliva sp	-	-	-	-	0.82	-	-	0.04	-	-	-
Tibia sp	-	-	-	0.03	-	-	-	-	-	-	-
Turetella sp	-	-	-	-	0.08	-	0.02	-	-	-	-
Gastropod remains	-	-	-	-	0.12	-	-	-	-	-	-
Arca/Cardium	-	-	-	-	0.01	-	-	-	-	-	-
Nucula sp	-	18.08	0.26	4.47	0.20	0.24	0.01	0.19	0.04	0.01	
CRUSTECEANS											
Amphipods	-	47.09	-	-	-	-	-	-	4.08	0.47	-
Mysids	0.99	-	-	11.29	13.98	20.35	31.09	1.52	0.01	-	-
Copepods	99.01	-	-	11.29	13.98	20.35	31.09	1.52	0.01	-	-
OTHERS											
Large foraminifera	-	-	-	0.04	0.30	0.27	0.36	0.20	1.51	6.54	-
Foraminifera	-	-	-	-	-	0.03	0.01	0.18	0.12	-	-
Coscinodiscus	-	0.08	-	0.64	-	-	0.01	0.02	0.01	-	-
Fragilaria sp.	-	-	-	0.16	-	-	-	-	-	-	-
DETRITUS	-	34.75	2.32	59.73	43.56	16.35	27.87	45.98	56.79	50.01	-

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Table 3.4 Relative index of dietary components in females of *C.macrostomus* during August 1995 to June '96 at Cochin.

Contents	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.
POLYCHAETES											
P.pinnata	0.73	-	96.59	24.82	0.22	9.66	46.83	2.15	0.37	0.11	-
Phyllochaetopterus	-	-	-	-	-	-	-	15.80	62.12	45.70	-
Pectinaria sp	-	-	-	-	-	-	-	0.03	0.93	-	-
MOLLUSCS											
Oliva sp.	-	-	-	-	0.80	0.22	0.68	-	0.02	-	-
Architectonia sp	-	-	-	-	-	0.22	-	-	-	-	-
Turetella sp	-	-	-	-	0.06	0.04	0.01	-	-	-	-
Gastropod remains	-	-	-	-	0.47	-	-	-	-	-	-
Arca /Cardium	-	-	-	-	-	0.07	-	0.66	-	-	-
Nucula sp	-	12.22	-	2.51	0.18	0.27	0.01	-	1.05	0.04	-
Bivalve remains	-	-	-	7.79	-	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	35.04	55.18	-	-	-	-	-	-	0.43	1.15	-
Mysids	-	-	-	-	55.49	52.79	12.03	34.82	-	-	-
Copepods	64.23	-	-	0.41	5.45	32.53	12.88	2.76	0.05	-	-
Daphnia	-	-	-	0.01	-	-	-	-	-	-	-
OTHERS											
Large foraminifera	-	-	-	-	0.49	-	11.29	0.15	1.06	0.80	- Ranks
Foraminifera	-	-	-	0.01	-	0.13	0.01	-	0.06	0.01	-
Coscinodiscus	-	0.09	-	0.01	-	0.01	-	-	0.02	-	-
Chaetoceros	0.06	-	-	-	-	-	-	-	-	-	-
Fragilaria sp.	-	-	-	0.01	-	-	-	-	-	-	-
Algae	-	2.75	-	-	-	-	-	-	-	-	-
DETRITUS	-	32.45	0.66	64.43	36.84	4.26	16.26	43.63	33.89	52.19	-

Table 3.5 Relative index of dietary components of *C.macrostomus* during 1994 -'95 at Quilon

(Male and female combined)

Contents	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
POLYCHAETES											
P.pinnata	57.2	0.14	4.9	37.7	54.7	22.01	-	-	-	69.63	1.89
Phyllochaetopterus	-	-	14.9	-	-	-	-	-	-	-	-
GASTROPODS											
Oliva sp	-	-	0.8	-	-	-	-	-	-	-	0.12
Architectonia sp	-	-	-	-	-	-	-	-	-	-	0.01
Turetella sp	-	-	-	-	-	-	-	-	-	-	0.01
Dentalium	-	0.01	-	-	-	-	-	-	-	-	-
Gastropod remains	-	0.36	-	-	-	-	-	-	-	-	-
Nucula sp	-	0.02	0.1	-	-	-	-	-	-	-	0.06
Bivalve remains	-	0.16	0.5	1.0	0.1	0.06	-	-	-	0.03	-
Planaria	-	0.01	-	-	-	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	4.8	0.10	-	-	-	1.46	-	-	-	-	-
Mysids	-	0.89	33.8	5.2	2.9	-	-	-	-	0.87	81.18
Copepods	17.7	85.24	20.3	3.2	-	-	-	-	-	0.37	7.65
Hermit crabs	-	-	0.1	-	-	-	-	-	-	-	0.005
Prawns	-	-	-	-	-	0.09	-	-	-	-	0.005
OTHERS											
Large foraminifera	-	1.19	6.2	1.6	-	-	-	-	-	-	-
Foraminifera	-	0.63	0.2	-	-	-	-	-	-	-	0.02
Coscinodiscus	-	-	-	-	-	-	-	-	-	-	0.01
Algae	-	0.01	-	-	-	-	-	-	-	-	-
Fish eggs	-	0.01	-	-	-	-	-	-	-	-	0.04
DETRITUS	20.3	11.23	18.2	51.3	42.3	76.38	-	-	-	29.10	8.99

Table 3.6 Relative index of dietary components of *C.macrostomus* during 1995 -'96 at Quilon

(Male and Female combined)

Content	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
POLYCHAETES												
P.pinnata	5.57	23.75	0.80	8.08	20.78	15.75	7.64	-	-	-	11.84	15.24
Phyllochaetopterus	0.28	0.61	-	3.89	-	0.57	1.43	-	-	-	-	-
MOLLUSCS												
Oliva sp	-	-	-	0.01	-	0.32	-	-	-	-	-	0.01
Tibia sp	-	-	-	-	-	-	0.02	-	-	-	-	-
Architectonia	0.11	-	-	-	-	-	-	-	-	-	-	-
Turetella sp	0.03	-	0.16	-	-	-	-	-	-	-	-	0.01
Gastropod remains	-	-	2.63	-	-	-	-	-	-	-	-	-
Arca/Cardium	0.08	0.14	0.01	-	-	-	-	-	-	-	-	-
Nucula sp	0.17	-	0.64	-	-	-	-	-	-		0.08	-
Bivalve remains	-	-	0.02	0.01	0.43	0.86	0.02	-	-	-	-	0.80
CRUSTACEANS												
Amphipods	78.53	-	-	-	-	-	-	-	-	-	-	-
Mysids	-	42.22	2.71	6.99	12.92	5.92	55.45	-	-	-	15.63	-
Copepods	0.17	0.96	1.82	1.43	11.44	0.02	-	-	-	-	-	-
Hermit crabs	0.06	-	-	-	-	-	0.02	-	-	-	-	-
Prawns	-	-	-	-	-	-	0.02	-	-	-	-	0.03
Mites	-	0.01	-	-	0.03	-	-	-	-	-	-	-
OTHERS												
Large foraminifera	-	0.01	0.30	4.90	1.54	18.72	-	-	-	-	-	0.01
Algae 0.02	-	-	-	-	-	-	-	-	-	-	-	-
Fish eggs	-	-	-	-	-	-	-	-	-	-	-	-
DETRITUS	14.98	32.30	90.90	74.69	73.6	57.84	35.40	-	-	-	72.45	84.0

Table 3.7 Ranking of the dietary components of *C.macrostomus* (male & female) at Cochin during 1994-95

Contents	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
POLYCHAETES											
P.pinnata	1	1	1	2	4	3	1	3	1	6	-
Phyllochaetopterrus	5	-	5	-	-	-	-	-	4	7	-
Pectinaria sp	-	-	-	-	-	-	-	-	-	9	-
Clymene sp	-	-	-	-	-	-	-	-	-	9	-
GASTROPODS											
Oliva sp	-	-	-	-	8	6	7	-	-	-	-
Tibia sp	-	-	-	4	-	7	7	-	-	-	-
Architectonia sp	-	-	-	8	15	9	-	8	-	-	-
Turetella sp	-	-	-	-	13	10	-	-	-	-	-
Dentalium	-	-	-	-	-	12	-	-	-	-	-
Gastropod remains	-	-	-	-	10	-	-	-	-	8	-
Arca/Cardium	-	-	-	-	14	12	-	-	-	8	-
Nucula sp	-	3	6	8	9	8	6	-	-	5	-
Pholas sp	4	4	-	-	-	-	-	-	-	-	-
Bivalve remains	-	-	-	8	6	-	-	-	5	6	-
Planaria	-	-	-	8	12	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	-	-	-	-	-	-	-	-	3	-	-
Mysids	-	-	2	-	2	2	2	2	6	2	1
Copepods	-	-	4	-	5	1	4	1	-	1	3
Squilla	-	-	-	-	-	-	-	7	-	-	-
Alima larva	-	-	-	-	-	12	-	-	-	-	-
Hermit crabs	-	-	-	-	7	11	-	-	-	-	-
Prawns	-	-	-	3	-	-	-	-	-	-	-
Mites -	-	-	-	-	-	11	-	-	-	-	-
OTHER ITEMS											
Large foraminifera	-	-	-	6	3	4	5	4	7	4	-
Foraminifera	-	5	8	5	11	-	8	6	8	9	-
Coscinodiscus	3	-	-	7	-	11	-	-	9	-	-
Chaetoceros	-	-	-	-	15	12	-	-	-	-	-
Algae	-	-	7	-	-	-	-	8	-	-	-
Fish eggs	-	-	-	-	-	-	-	-	-	-	4
DETRITUS	2	2	3	1	1	5	3	5	2	3	2

Table 3.8 Ranking of the dietary components of *C.macrostomus* (male & female) at Cochin during 1995-96

Contents	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
POLYCHAETES											
P.pinnata	3	-	1	2	4	3	1	5	3	3	-
Phyllochaetopterus	-	-	-	-	-	-	-	2	1	2	-
Clymene sp	-	-	-	7	-	-	-	-	4	-	-
Pectinaria sp.	-	-	-	-	-	-	-	9	-	-	-
MOLLUSCS											
Oliva sp	-	-	-	10	3	7	6	-	9	-	-
Architectonia sp	-	-	-	-	-	11	-	-	-	-	-
Turetella sp	-	-	-	-	8	10	7	-	-	-	-
Gastropod remains	-	-	-	-	-	-	-	10	-	-	-
Arca/Cardium	-	-	-	-	9	9	-	-	-	-	-
Nucula sp	-	-	4	5	7	-	7	6	-	-	-
Bivalve remains	-	3	4	3	6	5	-	-	6	6	-
CRUSTACEANS											
Amphipods	-	1	-	-	-	-	-	-	3	5	-
Mysids	2	-	-	-	1	1	4	3	-	-	-
Copepods	1	-	-	4	3	2	3	4	8	-	-
Daphnia	-	-	-	10	-	-	-	-	-	-	-
OTHERS											
Large foraminifera	-	-	-	9	5	6	5	7	5	4	-
Foraminifera	-	-	-	10	-	8	7	8	7	7	-
Coscinodiscus	-	5	-	6	-	11	7	11	9	-	-
Chaaetoceros	-	6	-	-	-	-	-	-	-	-	-
Algae -	-	4	2	-	-	-	-	-	-	-	-
Fragilaria sp	-	-	-	8	-	-	-	-	-	-	-
DETRITUS	-	2	3	1	2	4	2	1	2	1	-

Table 3.9 Ranking of dietary components of *C.macrostomus* at Neendakara during 1994-95

Components	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
POLYCHAETES											
P.pinnata	1	8	6	2	1	2	-	-	-	1	4
Phyllochaetopterus sp.	-	-	4	-	-	-	-	-	-	-	-
MOLLUSCS											
Oliva sp	-	6	7	-	-	-	-	-	-	-	5
Tibia sp	-	-	-	-	-	-	-	-	-	-	-
Turetella sp	-	-	-	-	-	-	-	-	-	-	8
Dentalium	-	11	-	-	-	-	-	-	-	-	-
Gastropod remains	-	-	-	-	-	-	-	-	-	-	-
Arca/Cardium	-	-	-	-	-	-	-	-	-	-	-
Nucula sp	-	10	6	6	4	5	-	-	-	-	-
Pholas sp	-	-	-	-	-	-	-	-	-	-	-
Bivalve remains	-	7	8	-	-	-	-	-	-	5	5
Planaria	-	11	-	-	-	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	4	9	-	-	-	3	-	-	-	-	-
Mysids	-	4	1	3	3	-	-	-	-	3	1
Copepods	3	1	2	4	-	-	-	-	-	4	3
Squilla sp	-	-	-	-	-	-	-	-	-	-	-
Alima larva	-	-	-	-	-	-	-	-	-	-	-
Hermit crabs	-	-	10	-	-	-	-	-	-	-	9
Mites	-	-	-	-	-	-	-	-	-	-	-
OTHERS											
Large foraminifera	-	3	5	5	-	-	-	-	-	-	-
Foraminifera	-	5	9	-	-	-	-	-	-	-	7
Coscinodiscus	-	-	-	-	-	-	-	-	-	-	8
Chaetoceros	-	-	-	-	-	-	-	-	-	-	-
Algae	-	11	-	-	-	-	-	-	-	-	-
Fish eggs	-	-	-	-	-	-	-	-	-	-	-
DETRITUS	2	2	3	1	2	1	-	-	-	2	2

Table 3.10 Ranking of dietary components of *C.macrostomus* at Neendakara during 1995-96

Components	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
POLYCHAETES												
P.pinnata	3	3	3	3	3	3	3	-	-	-	3	2
Phyllochaetopterus	4	5	-	5	-	6	4	-	-	-	-	-
MOLLUSCS												
Oliva sp.	-	-	-	7	-	7	-	-	-	-	-	-
Tibia sp.	-	-	-	-	-	-	-	-	-	-	-	-
Turetella sp	9	-	8	-	-	-	-	-	-	-	-	5
Dentalium	-	-	-	-	-	-	-	-	-	-	-	-
Gastropod remains	-	-	3	-	-	-	5	-	-	-	-	5
Arca/Cardium	7	-	10	-	-	-	-	-	-	-	-	-
Nucula sp.	-	-	6	7	6	-	-	-	-	-	4	-
Pholas sp.	-	-	-	-	-	-	-	-	-	-	-	-
Bivalve remains	5	6	9	-	-	5	5	-	-	-	-	3
CRUSTACEANS												
Amphipods	1	-	-	-	-	4	-	-	-	-	-	-
Mysids	-	1	2	3	3	-	1	-	-	-	2	-
Copepods	5	4	4	6	4	8	-	-	-	-	-	-
Squilla	-	-	-	-	-	-	-	-	-	-	-	-
Alima larva	-	-	-	-	-	-	-	-	-	-	-	-
Hermit crabs	8	-	-	-	7	-	5	-	-	-	-	-
Prawns	-	-	-	-	-	5	-	-	-	-	-	4
Mites	-	7	-	-	-	-	-	-	-	-	-	-
OTHERS												
Large foraminifera	-	7	7	4	5	2	-	-	-	-	-	5
Coscinodiscus	-	-	-	-	-	-	-	-	-	-	-	-
Chaetoceros	-	-	-	-	-	-	-	-	-	-	-	-
Algae	10	-	-	-	-	-	-	-	-	-	-	-
DETRITUS	2	2	1	1	1	1	2	-	-	-	1	1

Table 3.11 Percentage occurrence of food items in various size groups of *C.macrostomus*

Males Cochin 1994-95

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastropods	Foraminifera	Algae	Detritus
55	1	-	-	100.0	100.00	-	-	-	-	-
60	3	33.3	-	66.7	66.7	-	-	-	-	-
65	9	55.6	-	66.7	88.9	-	-	11.1	100.0	44.4
70	12	41.7	-	75.0	83.3	-	8.3	8.3	-	25.0
75	45	40.0	11.1	46.7	33.3	20.0	17.8	20.0	-	31.1
80	63	34.9	7.9	53.9	30.2	4.8	1.6	25.4	6.3	36.5
85	75	34.7	5.3	37.3	20.0	16.0	5.3	22.7	-	26.7
90	60	31.7	8.3	35.0	26.7	11.7	1.7	13.3	-	23.3
95	67	20.8	10.4	13.4	10.4	1.5	1.5	16.4	-	17.9
100	69	23.9	7.0	21.1	9.9	2.8	1.4	1.4	1.4	18.3
105	82	33.7	8.4	20.5	12.0	-	3.6	8.4	1.2	25.3
110	101	27.7	8.0	25.0	14.3	11.6	3.6	5.4	-	27.7
115	133	27.5	3.5	20.4	16.2	4.2	5.6	4.2	-	27.5
120	107	27.4	1.8	18.6	15.0	12.4	10.6	9.7	1.8	33.6
125	68	15.9	2.9	24.6	18.8	1.4	4.3	6.7	-	31.9
130	53	27.8	5.6	27.8	20.4	12.9	3.7	5.6	1.9	29.6
135	19	45.0	-	5.0	15.0	5.0	-	5.0	-	30.0
140	6	33.3	-	-	16.7	16.7	-	-	16.7	33.3
145	5	-	-	-	40.0	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
155	2	-	-		100.0	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-

Table 3.12 Percentage occurrence of food items in various size groups of *C.macrostomus*

Males Cochin 1995-96

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastropods	Foraminifera	Algae	Detritus
45	3	33.3	-	-	-	-	-	-	-	66.7
50	5	50.0	-	-	25.0	50.0	-	-	100.0	50.0
55	2	50.0	-	-	50.0	-	-	-	-	50.0
60	4	25.0	25.0	-	25.0	-	-	-	-	25.0
65	7	42.9	14.3	14.3	42.9	14.3				14.3
70	13	23.1	7.7	7.7	30.8	7.7	-	-	15.4	53.8
75	29	48.3	20.7	17.2	34.5	10.3	-	3.4	3.4	62.1
80	45	77.8	17.8	20.0	22.2	6.7	-	11.1	4.4	60.0
85	55	50.9	10.9	9.1	16.4	12.7	-	18.2	-	54.5
90	62	79.0	20.9	1.6	12.9	4.8	1.6	17.7	3.2	69.4
95	47	51.1	6.4	4.3	12.8	6.4	2.1	14.9	-	61.7
100	36	38.9	5.6	8.3	2.8	13.9	-	8.3	-	44.4
105	35	40.0	5.7	17.1	20.0	14.3	2.9	8.6	-	48.6
110	47	29.8	2.1	17.0	31.9	10.6	-	4.3	-	42.6
115	81	18.5	13.6	12.3	8.6	11.1	2.5	2.5	2.5	37.0
120	81	19.8	4.9	9.8	17.3	11.1	4.9	4.9	1.2	33.3
125	97	27.8	1.0	18.6	18.6	15.5	4.1	8.2	22.2	37.1
130	67	31.3	4.5	14.9	17.9	8.9	4.5	2.9	1.5	40.3
135	39	25.6	5.1	17.9	7.7	12.8	5.1	-	-	41.0
140	12	33.3	-	8.3	8.3	8.3	-	-	-	25.0
145	5	25.0	25.0	-	25.0	50.0	-	25.0	-	75.0
150	2	-	-	-	-	50.0	-	-	-	50.0

Table 3.13 Percentage occurrence of food items in various size groups of *C.macrostomus*

Females Cochin 1994-95

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastropods	Foraminifera	Algae	Detritus
55	-	-	-	-	-	-	-	-	-	-
60	4	-	-	-	-	-	-	-	-	-
65	7	57.1	-	42.9	42.9	14.3	-	14.3	-	42.9
70	29	51.7	10.3	44.8	27.6	3.4	-	3.4	-	24.1
75	54	38.9	11.1	35.2	35.2	9.3	3.7	3.7	-	22.2
80	61	42.6	11.5	39.3	26.2	11.5	4.9	9.8	-	29.5
85	61	55.7	14.8	39.3	37.7	4.9	4.9	9.8	-	22.9
90	56	31.0	15.5	36.2	31.0	3.4	-	6.9	-	12.1
95	56	25.9	9.3	20.4	22.2	9.3	-	9.3	1.9	27.8
100	57	37.0	9.3	14.8	13.0	3.7	-	1.9	1.9	24.1
105	55	22.2	3.7	16.7	16.7	3.7	7.4	5.6	-	24.1
110	78	13.5	1.4	23.0	9.5	4.1	6.8	9.5	1.4	31.1
115	131	26.0	-	22.0	10.2	2.4	-	5.5	-	20.5
120	91	31.6	-	23.2	18.9	6.3	2.1	7.4	1.1	46.3
125	74	22.1	-	20.8	20.8	5.2	6.5	7.8	2.6	38.9
130	41	36.6	-	29.3	17.1	4.9	7.3	7.3	4.9	36.6
135	42	36.6	-	21.9	9.8	14.6	2.4	14.6	4.9	26.8
140	19	28.6	-	14.3	14.3	23.8	-	-	-	14.3
145	12	27.3	-	18.2	18.2	9.0	-	18.2	-	45.5
150	1	50.0	-	100.0	50.0	-	-	-	-	50.0
155	4	75.0	-	-	25.0	50.0	-	-	-	25.0

Table 3.14 Percentage occurrence of food items in various size groups of *C.macrostomus*

Females Cochin 1995-96

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastropods	Foraminifera	Algae	Detritus
45	1	100.0	-	-	-	-	-	-	-	100.0
50	1	-	-	-	-	-	-	-	-	100.0
55	4	75.0	-	-	-	25.0	-	-	-	25.0
60	3	66.7	-	-	33.3	-	-	-	-	-
65	6	50.0	-	-	16.6	16.7	-	-	16.7	33.3
70	7	42.9	14.3	-	-	-	-	-	-	14.3
75	27	33.3	3.7	7.4	-	11.1	-	3.7	11.1	51.9
80	37	73.0	8.1	13.5	18.9	16.2	-	13.5	-	59.5
85	65	47.7	16.9	12.3	18.5	7.7	1.5	15.4	4.6	55.4
90	51	43.1	7.8	5.9	9.8	3.9	-	13.7	-	50.9
95	51	54.9	11.8	3.9	13.7	5.9	1.9	7.8	-	62.7
100	25	48.0	12.0	8.0	4.0	4.0	-	20.0	4.0	60.0
105	27	55.6	3.7	7.4	7.4	11.1	-	-	3.7	48.0
110	45	20.0	8.9	28.9	15.6	11.1	17.8	17.8	2.2	37.8
115	55	18.2	10.9	27.3	9.1	20.0	3.6	12.7	1.8	30.9
120	85	16.5	7.1	20.0	17.6	14.1	3.5	1.2	1.2	25.9
125	82	23.2	17.1	17.1	11.0	10.9	3.7	4.9	1.2	45.1
130	62	22.6	6.5	14.5	35.5	8.1	8.1	6.5	-	35.5
135	53	22.6	9.4	5.7	20.8	9.4	7.5	-	1.9	32.1
140	21	33.3	19.0	14.3	14.3	14.3	4.8	4.8	-	28.6
145	7	14.3	14.3	-	-	-	28.6	-	-	42.9
150	8	25.0	37.5	12.5	-	12.5	-	-	-	12.5
155	2	50.0	-	-	-	-	-	-	-	100.0
160	2	50.0	-	-	-	-	-	-	-	50.0

Table 3.15 Percentage occurrence of food items in the stomach of *C.macrostomus* in various size groups

Males (Pooled data 1994-95 & 1995-96) Cochin

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastrods	Foraminifera	Algae	Detritus
40	-	-	-	-	-	-	-	-	-	-
45	3	33.3	-	-	-	-	-	-	66.7	-
50	4	50.0	-	-	25.0	50.0	-	-	100.0	50.0
55	3	33.3	-	33.3	66.7	-	-	-	-	33.3
60	7	28.6	14.3	28.6	42.9	-	-	-	-	14.3
65	16	50.0	6.3	43.8	68.8	6.3	-	6.3	68.8	31.3
70	25	32.0	4.0	40.0	56.0	4.0	4.0	4.0	8.0	40.0
75	74	43.2	14.9	35.1	33.8	16.2	10.8	13.5	1.4	43.2
80	108	52.8	12.0	39.8	26.9	5.6	0.9	19.4	5.6	46.3
85	130	41.5	7.7	25.4	18.5	14.6	3.1	20.8	-	38.5
90	122	55.7	14.8	18.0	19.7	8.2	1.6	15.6	1.6	46.7
95	114	33.3	8.8	9.6	11.4	3.5	1.8	15.8	-	35.9
100	107	28.9	6.5	16.8	7.5	4.7	0.9	3.7	-	35.9
105	118	27.1	7.6	19.5	14.4	4.2	3.4	8.5	-	32.2
110	159	28.3	6.3	22.6	19.5	11.3	2.5	5.0	-	32.1
115	223	24.2	7.2	17.5	13.5	4.9	4.5	3.6	0.9	30.9
120	197	24.2	3.1	14.9	15.9	11.9	8.2	7.7	1.5	33.5
125	166	22.9	1.8	21.1	18.7	6.0	4.2	8.4	1.2	34.9
130	121	29.8	4.9	20.7	19.0	18.2	4.1	4.1	1.7	35.5
135	59	32.2	3.4	13.6	10.2	11.9	3.4	1.7	-	37.3
140	18	33.3	-	5.6	11.1	33.3	-	-	5.6	27.8
145	9	11.1	11.1	-	33.3	-	-	11.1	-	33.3
150	2	-	-	-	-	100.0	-	-	-	50.0
155	2	-	-	-	-	50.0	-	-	-	50.0
Total	1784	32.5%	7.0%	20.7%	18.4%	9.2%	3.7%	9.1%	2.1%	35.5

Table 3.16 Percentage occurrence of food items in various size groups of *C.macrostomus*

Females (Pooled data 1994-94 & 1995-96) Cochin

Size groups (mm)	No.examined	Polychaetes	Amphipods	Mysids	Copepods	Bivalves	Gastropods	Foraminifera	Algae	Detritus
45	1	100.0	-	-	-	-	-	-	-	100.0
50	1	-	-	-	-	-	-	-	-	100.0
55	4	75.0	-	-	-	25.0	-	-	-	25.0
60	7	80.0	-	-	20.0	-	-	-	-	20.0
65	13	53.8	-	23.1	30.8	15.4	-	7.7	7.7	38.5
70	36	49.9	11.1	36.1	22.2	2.8	-	2.8	-	22.2
75	81	37.0	8.6	25.9	23.5	9.9	2.5	3.7	3.7	32.1
80	98	54.1	10.2	29.6	23.5	13.3	3.1	11.2	-	40.8
85	126	51.6	15.9	25.4	27.8	6.3	3.2	12.7	2.4	39.7
90	107	36.7	11.9	22.0	21.0	3.7	-	10.1	-	30.3
95	107	39.9	10.5	12.4	18.1	7.6	0.9	8.6	0.9	44.8
100	82	40.5	10.1	12.7	10.1	3.8	-	7.6	2.5	35.4
105	82	33.3	3.7	13.6	13.6	6.2	4.9	3.7	1.2	32.1
110	123	15.9	4.2	25.2	11.8	6.7	10.9	12.6	1.7	33.6
115	186	23.6	3.3	23.6	9.9	7.7	1.1	7.7	0.5	23.6
120	176	24.4	3.3	21.7	18.3	9.9	2.8	4.4	1.1	36.7
125	156	22.6	8.8	18.9	15.7	8.2	5.0	6.3	1.9	42.1
130	103	28.2	3.9	20.4	28.2	6.8	7.8	6.8	1.9	35.9
135	95	28.7	5.3	12.8	15.9	11.7	5.3	7.6	6.4	29.8
140	40	30.9	9.5	14.3	14.3	19.0	2.3	2.4	-	21.4
145	19	22.2	5.6	11.1	11.1	5.6	11.1	11.1	-	44.4
150	9	30.0	30.0	30.0	10.0	10.0	-	-	-	20.0
155	6	66.7	-	-	16.7	33.3	-	-	-	49.9
160	2	-	-	25.0	25.0	-	-	-	-	-
Total	1660	32.8%	7.5%	20.7%	17.9%	7.9%	3.5%	7.4%	1.4%	34.2%

Table 3.17 Percentage composition of dietary components in immature and mature *C.macrostomus* at Cochin

Food items	1994 - 95				1995 - 96			
	Male		Female		Male		Female	
	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature
Polychaetes	20.0	23.5	27.0	23.8	31.6	23.1	48.2	20.7
Amphipods	3.9	4.8	6.7	2.7	8.3	4.3	4.8	8.2
Mysids	25.4	18.1	22.2	19.3	5.1	10.5	4.3	11.6
Copepods	11.4	13.3	18.4	14.3	10.9	12.3	6.2	11.8
Bivalves	6.4	5.5	4.5	5.2	4.6	9.4	4.3	8.3
Gastropods	3.1	4.2	2.2	2.4	0.3	2.5	0.2	4.2
Foraminifera	10.8	6.1	4.3	6.2	6.2	4.6	5.5	4.9
Algae	2.8	0.7	-	1.2	3.0	0.9	1.7	1.0
Detritus	16.2	23.8	14.7	24.9	30.0	32.4	24.8	29.2

Table 3.18 Percentage composition of major food items in *C.macrostomus* pooled 1994-95 and 1995-96.

Food items	1994 - 95 and 1995 - 96			
	M A L E		F E M A L E	
	Immature	Mature	Immature	Mature
Polychaetes	24.6	22.8	28.7	22.6
Amphipods/Mydids	21.0	19.4	22.9	20.1
Copepods	14.0	12.8	14.7	12.6
Molluscs	7.1	10.8	6.0	10.2
Detritus	33.3	34.2	27.7	34.5

Table 3.19 Percentage occurrence of various degrees of fullness of stomachs of *C.macrostomus*

Males 1994-95 Cochin

Condition of feed & sample size	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	129	58	96	98	96	108	87	107	114	80	40
Full	-	-	-	1.0	3.1	13.0	3.4	4.7	12.3	1.3	-
3/4	-	-	1.0	4.1	9.4	25.9	6.9	4.7	24.6	10.0	2.5
1/2	1.6	-	2.1	13.3	15.6	23.1	21.8	9.3	24.6	20.0	7.5
1/4	8.5	1.7	5.2	7.1	14.6	18.5	14.9	19.6	14.0	21.3	5.0
1/8	7.0	10.3	25.0	42.9	24.0	11.2	40.2	37.4	15.8	32.4	67.5
Empty	82.9	88.0	66.7	31.6	33.3	8.3	12.6	24.3	8.7	15.0	17.5

Table 3.20 Percentage occurrence of various degrees of fullness of stomachs of *C.macrostomus*

Males 1995-96 Cochin

Condition of feed & sample size	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	57	72	78	99	87	87	75	79	72	69	-
Full	-	-	-	1.0	5.7	-	4.0	16.5	9.7	1.5	-
3/4	-	-	-	5.1	12.6	2.3	10.7	12.7	12.5	8.7	-
1/2	-	-	1.3	15.2	21.8	8.0	19.9	7.6	25.0	17.4	-
1/4	-	4.2	1.3	15.2	20.7	12.6	17.3	17.7	22.2	18.8	-
1/8	17.5	38.9	14.1	35.3	19.5	46.0	17.3	31.6	19.5	30.4	-
Empty	82.5	56.9	83.3	26.2	19.5	31.1	30.8	13.9	11.1	23.2	-

Table 3.21 Percentage occurrence of various degrees of fullness of stomachs in *C.macrostomus*

Females 1994-95 Cochin

Condition of feed & sample size	Aug 111	Sep 69	Oct 76	Nov 114	Dec 87	Jan 124	Feb 72	Mar 101	Apr 73	May 78	Jun 24
Full	-	-	-	-	6.9	12.1	-	2.9	8.2	11.5	4.2
3/4	-	-	2.6	6.1	11.5	20.2	12.5	4.0	19.2	10.3	-
1/2	-	-	1.3	10.5	19.5	25.0	20.8	18.8	27.4	17.9	-
1/4	9.9	-	1.3	10.5	19.5	16.1	12.5	8.9	16.4	28.2	8.3
Trace	10.8	20.3	35.6	43.0	17.3	21.0	33.4	39.6	15.1	21.8	75.0
Empty	79.3	79.7	59.2	29.9	25.3	5.6	20.8	25.8	13.7	10.3	12.5

Table 3.22 Percentage occurrence of various degrees of fullness of stomachs in *C.macrostomus*

Females 1995-96 Cochin

Condition of feed & sample size	Aug 43	Sep 78	Oct 74	Nov 78	Dec 95	Jan 73	Feb 61	Mar 84	Apr 75	May 66	Jun -
Full	-	-	-	1.3	10.5	1.4	8.2	13.1	13.3	3.0	-
3/4	-	-	-	6.4	16.8	5.5	14.8	22.6	5.3	13.6	-
1/2	-	-	-	16.7	22.1	5.5	18.0	11.9	20.0	22.7	-
1/4	4.7	2.6	6.8	15.4	15.8	20.5	14.8	7.2	14.7	16.7	-
Trace	14.0	46.2	21.6	44.9	14.8	46.6	19.7	36.9	33.3	36.4	-
Empty	81.3	51.2	71.6	15.3	20.0	20.5	24.5	8.3	13.4	7.6	-

Table 3.23 Percentage occurrence of various degrees of fullness of stomachs in *C. macrostomus*

Centre: Neendakara Period 1994-95 and 1995-96

Month	No. examined	Full	3/4	1/2	1/4	Trace	Empty	Active feeding
Dec.94	215	0.9	3.7	11.2	20.9	36.7	26.6	15.8
Jan.95	106	1.9	6.6	23.6	26.4	33.9	7.5	32.1
Feb	90	3.3	5.6	27.8	15.5	36.7	11.1	36.7
Mar	28	3.5	7.1	10.7	21.5	17.8	39.4	21.3
Apr	62	-	3.3	6.7	6.7	66.7	16.6	10.0
May	89	6.7	22.5	28.1	22.5	15.7	4.5	57.3
Jun	-	-	-	-	-	-	-	-
Jun	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-
Sep	245	-	2.9	4.1	3.3	41.2	48.5	7.0
Oct	141	5.7	2.8	10.6	12.8	51.8	16.3	19.1
Nov	50	6.0	10.0	28.0	22.0	26.0	8.0	44.0
Dec	136	25.7	23.5	33.1	7.4	5.9	4.4	82.3
Jan.96	97	1.0	5.2	5.2	9.3	46.4	32.9	11.4
Feb	75	4.0	14.7	14.7	18.7	14.7	33.2	33.4
Mar	50	-	14.0	10.0	14.0	52.0	10.0	24.0
Apr	53	16.9	13.2	20.8	15.1	24.5	9.5	50.9
May	106	0.9	2.8	6.6	6.6	27.4	55.7	10.3
Jun	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-
Sep	41	2.0	7.1	8.9	20.3	26.5	35.2	18.0
Oct	278	-	3.7	8.9	12.2	52.2	23.0	12.6

Table 3.25 Feeding intensity in *C.macrostomus* during different months
Centre: Cochin Period: 1994-95 and 1995-96

Month	Female		Male	
	Percentage		Percentage	
	Empty, Trace & 1/4 full	1/2 full & above	Empty, Trace & 1/4 full	1/2 full & above
Aug.94	100.0	-	98.4	1.6
Sep	100.0	-	100.0	-
Oct	96.1	3.9	96.9	3.1
Nov	83.4	16.6	81.7	18.3
Dec	61.1	37.9	71.9	28.1
Jan.95	42.7	57.3	38.0	62.0
Feb	66.7	33.3	67.9	32.1
Mar	74.3	25.7	81.3	18.7
Apr	45.2	54.8	38.5	61.5
May	60.3	39.7	68.7	31.3
Jun	95.8	4.2	90.0	10.0
Jul	-	-	-	-
Aug	100.0	-	100.0	-
Sep	100.0	-	100.0	-
Oct	100.0	-	98.7	1.3
Nov	75.6	24.4	79.7	21.3
Dec	50.6	49.4	59.9	40.1
Jan.96	87.6	12.4	89.7	10.3
Feb	59.0	41.0	65.4	34.6
Mar	52.4	47.6	63.2	36.8
Apr	61.4	38.6	52.8	47.2
May	60.7	39.3	72.4	27.6

Table 3.26 Average volume (points) of stomach contents in
C.macrostomus Centre: Cochin 1994-95 **Females**

Month	Immature			Mature		
	No.of fish	Total volume points	Av. volume points	No.of fish	Total volume points	Av. volume points
Aug.94	22	-	-	88	340	3.9
Sep	11	50	4.5	58	90	1.6
Oct	4	90	22.5	72	360	5.0
Nov	2	40	20.0	112	1580	14.1
Dec	13	310	23.8	74	1940	26.2
Jan	109	3930	36.1	15	640	42.7
Feb	38	910	23.9	34	650	19.1
Mar	46	1060	23.0	55	660	12.0
Apr	58	1790	30.9	16	680	42.5
May	7	170	24.3	74	1620	21.9
Jun	18	250	13.9	7	50	7.1
Total	328	8600	26.2	605	8610	14.2

Table 3.27 Average volume (points) of stomach contents in *C.macrostomus* during different months
Centre: Cochin 1995-96 Females

	Immature			Mature		
Month	No.of fish	Total volume points	Av. volume points	No.of fish	Total volume points	Av. volume points
Aug.95	-	-	-	42	100	2.38
Sep	3	-	-	75	400	5.3
Oct	26	180	6.9	48	80	1.7
Nov	54	750	13.9	24	740	30.8
Dec	-	-	-	96	3050	31.8
Jan	13	230	17.7	60	890	14.8
Feb	28	1080	38.6	33	590	17.9
Mar	29	1190	41.0	55	1660	30.2
Apr	59	1640	27.8	16	440	27.5
May	41	1160	28.3	25	600	24.0
Total	253	6230	24.6	474	8550	17.8

Table 3.28 Average volume (points) of stomach contents in *C.macrostomus* during different months
Centre: Cochin 1994-95 Males

	Immature			Mature		
Month	No.of fish	Total volume points	Av. volume points	No.of fish	Total volume points	Av. volume points
Aug.94	36	30	0.83	93	360	3.8
Sep	17	50	2.9	41	30	0.7
Oct	7	-	-	57	480	8.4
Nov	3	50	16.7	95	1310	13.8
Dec	21	400	19.0	74	1490	20.1
Jan.95	80	3000	37.5	28	1160	41.4
Feb	40	990	24.8	47	980	20.9
Mar	45	1230	27.3	62	620	10.0
Apr	51	2160	42.4	62	2260	36.5
May	7	170	24.3	74	1620	21.9
Jun	28	370	13.2	12	120	10.0
Total	335	8450	25.2	645	10430	16.2

Table 3.29 Average volume (points) of stomach contents in *C.macrostomus* during different months
Centre: Cochin 1995-96 Males

Month	Immature			Mature		
	No.of fish	Total volume points	Av. volume points	No.of fish	Total volume points	Av. volume points
Aug.95	-	-	-	57	100	1.8
Sep	8	40	5.0	64	250	3.9
Oct	13	60	5.0	65	110	1.7
Nov	64	690	10.8	35	960	27.4
Dec	-	-	-	86	2350	27.3
Jan.96	16	240	15.0	71	780	10.9
Feb	36	1160	32.2	39	430	11.0
Mar	34	1560	45.9	45	850	18.9
Apr	57	1690	29.6	15	590	39.3
May	44	1060	24.1	25	330	13.2
Total	272	6500	23.9	502	6750	13.4

Table 3.30 Average volume (points) of stomach contents in *C.macrostomus* of different size groups

Centre: Cochin 1994-95

Size groups (mm)	MALE No.of fish	MALE Total volume points	MALE Av. volume points	FEMALE No.of fish	FEMALE Total volume points	FEMALE Av. volume points
55	1	40	40.0	-	-	-
60	3	60	20.0	4	140	35.0
65	9	280	31.1	7	170	24.3
70	12	380	31.6	29	890	30.7
75	45	1580	35.1	54	1740	32.2
80	63	1770	28.1	61	1820	29.8
85	75	1950	26.0	61	1800	29.5
90	60	1530	25.5	56	1110	19.8
95	67	860	12.8	56	930	16.6
100	69	1010	14.6	57	760	13.3
105	82	1160	14.1	55	660	12.0
110	101	1590	15.7	78	1210	15.5
115	133	2300	17.3	131	1700	12.9
120	107	2080	19.4	91	1360	14.9
125	68	1030	15.1	74	1160	15.7
130	53	860	16.2	41	790	19.3
135	19	230	12.1	42	550	13.0
140	6	60	10.0	19	120	6.3
145	5	60	12.0	12	220	18.0
150	-	-	-	1	20	20.0
155	2	50	25.0	4	60	15.0
160	-	-	-	-	-	-
Total	980	18880	19.3	933	17210	18.4

Table 3.31 Average volume (points) of stomach contents in *C.macrostomus* of different size groups

Centre: Cochin 1995-96

Size groups (mm)	MALE			FEMALE		
	No.of fish	Total volume points	Av. volume points	No.of fish	Total volume points	Av. volume points
45	3	10	3.3	1	20	20.0
50	5	60	12.0	1	10	10.0
55	2	50	25.0	4	50	12.5
60	4	40	10.0	3	30	10.0
65	7	130	18.6	6	80	13.3
70	13	280	21.5	7	50	7.1
75	29	760	26.2	27	330	12.2
80	45	1230	27.3	37	1090	29.5
85	55	1150	20.9	65	1870	28.8
90	62	1850	29.8	81	1330	26.1
95	47	940	20.0	51	1370	26.9
100	36	480	13.3	25	530	21.2
105	35	630	18.0	27	570	21.1
110	47	590	12.6	45	920	20.4
115	81	940	11.6	55	1010	18.4
120	81	930	11.5	85	1390	16.4
125	97	1450	14.9	82	1550	18.9
130	67	880	13.1	62	1120	18.0
135	39	630	16.1	53	830	15.7
140	12	90	7.5	21	440	20.9
145	5	120	24.0	7	30	4.3
150	2	10	5.0	8	140	17.5
155	-	-	-	2	10	5.0
160	-	-	-	2	10	5.0
Total	774	13250	17.1	727	14780	20.3

Table 3.32 Relative index of food items of *C.arel*, based on the Index of Preponderance
Centre: Neendakara Period: 1995-96

Food items	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
POLYCHAETES												
Neires sp.	7.1	25.5	22.7	24.1	34.1	48.4	27.2	1.9	11.0	-	-	33.8
P.pinnata	-	-	-	-	-	-	-	-	-	-	-	2.8
Parapenaeopsis stylifera	-	9.3	8.1	-	1.2	2.5	-	38.2	35.3	-	-	24.3
Trachypenaeus curvirostris	-	-	-	-	4.8	-	-	-	10.3	-	-	-
Amphipods	-	-	-	205	-	12.2	11.7	9.4	2.1	-	-	7.5
Copepods	-	-	-	-	-	7.0	4.3	-	-	-	-	0.9
Hermit crabs & crab remains	17.2	2.3	6.0	20.9	8.2	2.8	18.2	16.7	21.3	-	-	4.2
Squilla	-	-	-	-	0.2	2.5	7.6	-	-	-	-	0.7
Gastropods	14.1	0.8	4.0	5.3	0.8	3.3	-	-	2.4	-	-	0.2
Bivalves	1.8	1.2	-	-	0.6	1.9	2.4	-	1.0	-	-	0.1
Fish remains	1.8	1.1	4.7	-	1.4	-	-	-	-	-	-	0.6
Detritus	58.0	59.8	54.5	47.2	48.7	19.4	28.6	33.8	16.6	-	-	24.9

Table 3.33 Qualitative analysis of the stomach contents of *Cynoglossus bilineatus* from Neendakara during 1995-96

Month	No. of fish	Size range (mm)	Food items in the order of abundance	Condition of feed
Sep.95	11	193-291	Detritus, gastropods, bivalves, *Portunus sanguinolentes*, polychaetes & fish remains	Moderate
Oct	9	224-305	Detritus, fish remains (*Upeneus* sp), gastropods, bivalves & polychaetes	Active
Nov	15	182-283	Detritus, fish remains, *Neptunus sp* hermit crabs, gastropods, polychaetes, bivalves.	Active
Dec	17	211-356	Detritus, fish remains, crab remains, gastropods, bivalves and polychaetes.	Moderate
Jan 96	8	226-297	Prawn remains, detritus, fish remains, crabs, gastropods, bivalves, Squilla	Moderate
Feb	5	231-254	prawn remains,detritus, fish remains, squilla, hermit crabs, bivalves	Poor
Mar	7	207-313	Prawn remains , detritus, hermit crabs, fish remains amphipods, gastropods, bivalves	Active
Apr	12	197-286	Prawn remains, *Portunus* sp, polychaetes gastropods, bivalves, fish remains.	Moderate
May	9	273-311	Prawn remains, fish remains, *Portunus* sp hermit crabs, amphipods, detritus, gastropods.	Poor

Table 3.34 Qualitative analysis of the stomach contents in *Cynoglossus puncticeps* from Neendakara during 1995-96

Month	No. of fish	Size range (mm)	Food items in the order of abundance	Condition of feed
Sep.95	7	96-172	Polychaetes, detritus, crab remains (*Portunus* sp) gastropods, bivalves, algae.	Poor
Oct	12	102-169	Detritus, polychaetes, crab remains, gastropods, bivalves, amphipods	Moderate
Nov	18	106-171	Detritus, polychaete, hermit crabs, fish remains (*Upeneus* sp),gastropods, foraminifera, bivalves.	Moderate
Dec	18	113-163	Detritus, polychaetes, prawns (*P. stylifera*), crab remains, gastropods, bivalves, foraminifera.	Active
Jan.96	16	102-156	Polychaetes, detritus, hermit crabs, gastropods, bivalves, foraminifera.	Active
Feb	11	93-141	Polychaetes, detritus, amphipopds, copepods, hermit crabs, bivalves.	Moderate
Mar	9	98-152	Detritus, polychaetes, amphipods, copepods, hermit crabs, prawn remains foraminifera.	Active
Apr	17	103-164	Polychaetes, amphipods, copepods, detritus, crab remains, foraminifera.	Moderate
May	15	85-131	Amphipods,copepods, prawn remains, hermit crabs and detritus.	Poor

CHAPTER 4

REPRODUCTION

CHAPTER 4

REPRODUCTION

INTRODUCTION

The success of any fish population is ultimately determined by the ability of its members to reproduce successfully in a fluctuating environment and thereby to maintain viable populations. Each fish species occurs under a unique set of ecological conditions and therefore has a unique reproductive strategy, with special anatomical, behavioral, physiological and energetic adaptations. Knowledge on the basic biological factors such as maturation cycle, size at first maturity, sex ratio, spawning, fecundity and ponderal index of the fish species is a prerequisite for the successful management of their fisheries.

Among the classic works in these aspects , mention has to be made about Clark(1934) who studied the ova diameter measurements, the maturity and spawning of California sardine *Sardina caerulea*. Hickling and Rutenberg (1936) studied the spawning periods in hake, haddock and pilchard and other fishes; and de Jong (1940) determined the spawning periods of a number of tropical fishes by ova diameter measurements. Prabhu (1956) based on ova diameter studies indicated four types of spawning periodicities in fishes. Significant contributions on aspects like fecundity are those of Hickling (1940) on the herring of southern North Sea; MacGregor (1957) on the Pacific sardine

Sardinops caerulea and Bagenal (1957 & 1963) on the long rough dab *Hippoglossoides plattessoides* and the Plaice.

During the last fifty years , in India, many accounts have been published on the maturity, spawning behaviour and fecundity of commercially important fishes. Qasim (1973) made an appraisal of the studies on maturation and spawning in marine teleosts in Indian seas enlisting the work done so far during 1957 to 1970 on different species, the number of maturity stages followed and the periodicity of spawning in different fishes. James and Baragi (1980) opined that in majority of the tropical marine fishes maturation is a continuous process resulting in the occurrence of mature fishes through out the year. Literature on the maturation, spawning, reproduction and eggs and larvae of flatfishes are scanty. Seshappa and Bhimachar (1955) while studying the fishery and biology of the Malabar sole *Cynoglossus semifasciatus (= C. macrostomus* Norman) described the maturation and spawning in this species. Kuthalingam (1957 & 1960) gave an account of the life history and feeding habits of *Cynoglossus lingua* and *Solea elongata.* Pradhan (1964) made observations on the spawning of *Psettodes erumei.* Ramanathan *et al* (1977) while studying the biology of the large scaled tongue sole *Cynoglossus macrolepidotus* described the maturation and spawning in this species. Published accounts on the eggs and larvae of flatfishes are available from the works of John (1951), Jones and Menon (1951), Nair (1952a, b), Kuthalingam (1957), Balakrishnan and Devi (1974) and Ramanathan and Natarajan (1979). Seshappa and

Bhimachar (1955) described the eggs , larvae and the metamorphosis in the Malabar sole *Cynoglossus semifasciatus*.

During the last 50 years, the the landings of Malabar sole, *Cynoglossus macrostomus* have considerably increased due to exploitation all along the Kerala coast. In view of the importance of this species a detailed study on the reproduction in Malabar sole, *C.macrostomus* was undertaken from August 1994 to October 1996 to update our information on this species. In addition a study on the reproduction in another co-occurring species *Cynoglossus arel* also was undertaken and the results presented and discussed.

MATERIAL AND METHODS

DATA BASE

Centre	Gear	Period	Sample size Nos.	Size range (mm)
Cynoglossus macrostomus				
Cochin	Trawl	Aug.1994-Jun.95	3399	55-165
" "		Aug.95 to Aug.96	4348	45-170
Neendakara	Trawl	Aug.94 to May 95	2614	60-160
" "		Sep.95 to Oct.96	5337	40-165
Ambalapuzha	Mini trawl	Oct.94 to Sep.95	4267	55-150
		Oct.95 to Oct.96	4627	55-150
Cynoglossus arel				
Neendakara	Trawl	Aug.95 to Sep.96	347	141-323

Samples of Malabar sole *Cynoglossus macrostomus* were collected from the trawl landings at the Fisheries Harbours at Cochin and Neendakara and from the minitrawl landings at Ambalapuzha as indicated above. Weekly samples were collected from Cochin and fortnightly sampling was carried out at other two centres. Samples of *C.arel* were collected from the trawl landings at Neendakara. Soon after the collection the samples were packed in ice box with sufficient quantity of ice, brought to the laboratory and preserved in 5% formalin for further studies. Sample collected during a trip was analysed after two days of preservation in 5% formalin and this practice was followed during the course of the study. The total length in mm and the weight in grams were noted. The fishes were cut open and the maturity stages as defined by Lovern and Wood (1937) were recorded. For observing the colour of the ovaries and testes during the various stages of maturity, fresh specimens were also cut open and examined. The length of the ovaries and testes in mm and their weight in milligram were recorded. The gonads were further preserved in 2% formalin in small specimen tubes with all details for further studies on the ova diameter measurements and fecundity.

Since the problem of spawning habits has to be largely approached by such indirect method like the analysis of growth of ova by measuring their increase in diameter, the method as described by Thompson (1915) and successfully employed by subsequent workers like Clark (1934), Hickling and Rutenberg

(1936), de Jong (1940) and Prabhu (1956) was followed. Further, it was noticed during the present study that 5% formalin hardens the ovary and ova too much, rendering it a bit tedious to tease out individual ova from the ovigerous lamellae. It was found that 2% formalin was ideal both for proper preservation with minimum distortion and for easier removal of ova. In addition at the time of examination a drop of Guilson's fluid with double the amount of glacial acetic acid (*i.e.*, 16 cc instead of 9 cc in normal Guilson's fluid) placed on the material facilitated more rapid and easier separation of intraovarian eggs. The method described by Clark (1934), June (1953), Yuen (1955) and others having a micrometer fixed in the eye piece of a monocular microscope and taking the diameter parallel to the two horizontal guide lines on the slide in whatever axis the ovum lies by moving the slide slowly was followed. The parallel guide lines prevented duplication in measurements of the same ovum. In addition to the parallel lines on the micrometer, the squares of the plankton counting chamber on which the ova were spread were found to be helpful in avoiding duplicate measurements of the same ova. Thus the diameter of the ovum may be defined as the distance between two parallel lines running along the two extremities of the ovum perpendicular to the guide lines (Antony Raja, 1964). The magnification gave a value of 0.012857 mm to each micrometer division (Objective 10 X, eye piece 10 X). For easier presentation the diameter of ova is described in micrometer divisions (m.d.) along with the millimeter conversions.

Various authors have maintained different views regarding the number of ova to be measured from an ovary. Although Clark (1934) drew her observations based on measurements of 200 ova. Prabhu (1956) considered that measurements of atleast 1000 ova was necessary to mitigate the probable error in the representation of various groups of ova. Bunang (1956) was of opinion that at least 2000-2500 ova are to be measured in the advance maturing and mature ovaries. However, in the investigations involving the examination of large number of ovaries, workers seem to have resorted to measuring lesser number of ova, roughly from 100 to 300 (June, 1953; Yuen, 1955; Horward and Landa, 1958). Antony Raja (1964) compared the frequency distribution obtained from the measurements of 1000 ova and the first 300 of the same ovary of the oil sardine, *Sardinella longiceps* and found no statistically significant difference between these samples in any of the ovaries to which the tests were applied. Hence in the present study it was found reasonable to take 400 to 500 ova per ovary, in view of the large number of ovaries collected for examination. Ova diameter measurements of 75 ovaries in different stages of maturity were taken for the study. These measurements were then grouped into 2 m.d. class intervals.

For fecundity studies 88 mature females of *C.macrostomus* belonging to stages IV and V were analysed. Determination of absolute fecundity in the Malabar sole was based on gravimetric method (MacGregor, 1957; Bagenal, 1957) by counting the number of ripe ova from a piece of known weight of the middle region of both the ovarian lobes and their average value raised to the total ovary weight as:

$$F = 1/2\ (n_1/w_1 + n_2/w_2)\ W$$

where F = absolute fecundity, W = total weight of the ovary in gram, w_1 and w_2 are weight of subsamples of either lobes of ovary and n_1 and n_2 represent ova from the sample weighing w_1 and w_2 respectively.

From known weight of the ovary a portion was removed and weighed on an electronic balance. The ova in this subsample were carefully teased out into a plankton counting chamber. All the yolked ova above 24 m.d. (0.31 mm.) diameter were counted under the microscope using the same micrometer and magnification adopted in the ova diameter studies. From the number of ova in the subsample the total number of ova in the ovary were estimated by multiplying the number of ova in the subsample by the ratio of the subsample weight to ovary weight.

For sex ratio studies the entire samples collected monthwise from Cochin, Quilon and Ambalapuzha amounting to 7747, 7978 and 8894 fishes respectively were analysed.

STRUCTURE OF GONAD

Sexes in Malabar sole, *Cynoglossus macrostomus* are separate and the fish does not exhibit any sexual dimorphism. But in Malabar sole and other *Cynoglossus* species the body cavity is restricted to the anterior part of the body and and contains only the digestive system and the kidneys. The ovaries and testes, though paired are not suspended in the body cavity as in other teleosts, but lie embedded in the musculature behind the body cavity on either side of the haemal spines. They run parallel to the body towards the posterior region and are tightly packed in the musculature. Dissecting out the gonads require patience as they are enmeshed in the musculature. The ovaries develop as two small elongated cylindrical lobes and with advancement of maturation these lobes gradually push backwards along both sides of the haemal spines. This pattern is seen in the testes also. But the testes are very small in size compared to the ovaries a fact which has not been reported by earlier workers. In a fully grown fish of 150 mm in total length the ovaries may measure upto 40-47 mm compared to a maximum of 7 mm length attained by the testes.

The ovaries are long, slender, cylindrical in the early stages, but increase in length, breadth and thickness with advancement of maturity. As the ovaries mature, they get distended due to changes in the intraovarian eggs and attain an yellow or slightly orange colour as a result of yolk deposition. The ovaries as they grow and mature attain a triangular appearance towards the anterior end but towards the posterior side the lobes are cylindrical and slightly flattened. The testes are oval and bud like in the juveniles and in the adults they get a little elongated and look like a grain of rice. The ovy duct originate from the triangular anterior end of the ovaries and the two oviducts join to open on the blind side of the fish. The vas deferens also originates from the anterior side of the testes and they unite anteriorly to form the vasa deferentia and open on the blind side of the fish.

Sexes are recognisable in the Malabar sole of 60 to 70 mm in total length on examination after dissection. There are no external marks to distinguish between the two sexes, but in the case of females in advanced stage of maturity the ovaries can be easily seen through the body wall when the fish is held against light.

CLASSIFICATION OF MATURITY STAGES

The system of classification of the maturity stages in teleosts by many of the workers in Indian waters is diverse. Generally the trend of opinion is to follow the ICES scale (quoted by Lovern and Wood, (1937) as far as possible with suitable modifications. Seshappa and Bhimachar (1955) adopted the ICES scale with slight modifications in describing the maturity stages of the Malabar sole *Cynoglossus semifasciatus*. In the present study on the Malabar sole (*C.macrostomus*) 9 maturity stages have been distinguished based on the macroscopic and microscopic examination of the ovary and ova respectively. The description given below relates to fresh as well as preserved specimens. In the frequency polygons the diameter measurements were grouped into 2 m.d (microdivisions) intervals as 1-2, 3-4, 5-6 etc. and the modes represented by the second number in the size groups *viz.*, 2, 4, 6 etc., or the corresponding millimeter conversions are used for description. The maturity stages for the males were classified depending only on macroscopic examination of testes. The various maturity stages recognised in Malabar sole *Cynoglossus macrostomus* are as follows:

STAGE I - IMMATURE

The ovaries are 3.5 mm in length, slender, cylindrical but tapering posteriorly and forms 6.6 % of the total length of the fish. The left lobe is slightly small. Ovary is flesh coloured and transparent. Ova are not visible to the naked eye. Under microscope the ova are transparent, each with a nucleus. The size of the ova ranges from 0.025 to 0.051 mm in diameter (2 to 4 m.d.). The average Gonado-somatic Index (GSI) is 0.21. The testes are very small, oval, bud like, thick, flesh coloured and opaque. Both the testes are of the same size and measure upto 1 mm.

STAGE II- DEVELOPING IMMATURE

The ovaries get slightly enlarged, transparent and amber coloured. Ova are small and transparent with large nucleus. Yolk formation has started in a few ova. Externally ova are not visible to the naked eye. Majority of the ova are in between 6 to 10 m.d (0.077 to 0.13 mm) with a mode at (0.103 mm) 8 m.d. The average GSI is 0.342. The testes show slight enlargement and measures upto 2 mm in length, oval, flesh coloured and bud like.

STAGE II b RECOVERING SPENT

The ovary is slightly flattened and thread like in appearance. There is no change in the length of the ovary compared to the previous stage *i.e.,* the spent stage, but considerable reduction in the volume is noticed and contains only the immature ova of the size range 2 m.d. to 20 m.d. A small mode is seen at 12 m.d. The average GSI is 0.511. The ovary becomes light grayish in colour after recovering from the fully spent stage. This stage differs from the immature II a in that stage II b is found in specimens above the minimum size at maturity (97 mm). More-over, the ovary is longer compared to the stage II a. The testes also are large in size compared to stage IIa. The wringles noticed in the spent condition disappear,become muscular and flesh coloured.

STAGE III- MATURING

The ovaries are greatly enlarged compared to stage II and constitute 21% to 40% of the total body length of the fish. They are broader anteriorly and tapering posteriorly. The ovarian membrane is transparent and ova are visible to the naked eye. The advancing ova has a mode at 18 m.d. (0.23 mm). The maximum size of the ovum is 26 m.d (0.33 mm). Another developing mode may be seen at 12 m.d (0.15 mm). Both these sets of ova are opaque, thickly yolked and hence yellowish in colour. The ovary also is yellowish. The average GSI is 1.2. The testes are larger, thick , flesh coloured and more longer than oval. Measures on an average 3 mm. Vas deferens are well developed.

STAGE IV- MATURE

The ovaries appear yellow to yellowish orange. They are enlarged with increase in dimension and occupy about 30 to 35% of the total body length. Ova are visible to the naked eye and measure upto 32 m.d. (0.41 mm). The most advancing group of ova are seen with a mode at 28 m.d (0.36 mm) and another mode at 22 m.d (0.28 mm). The average GSI is 5.5 . The yolked ova are completely opaque with a thick transparent egg membrane. The testes show slight increase in length and measures on an average 4 mm. The flesh colour is reduced, becomes whitish, but the muscular nature is retained.

STAGE V - ADVANCED MATURE

Ovaries occupy 37% of the body length and looks swollen and there is little reduction in the yellowish colouration. The ovarian cyst is very thin , transparent and the individual eggs are visible externally. A few fully mature transparent ova may be noticed externally through the cyst in fresh condition as colourless dots. The maximum diameter of the ova observed was 48 m.d. (0.62 mm). The mode of advanced group of ova is at 32 m.d. (0.41 mm). Another mode, though not prominent, is seen at 16 m.d (0.21 mm). Among the mature ova some are completely opaque, some with transparent periphery, some partly transparent and a few fully transparent. The partly transparent ova are light yellow in colour. The average GSI is 6.44. The testes is elongated, but oval at both ends. The average length is 6 mm. They are whitish and retains the muscular nature.

STAGE VI - RIPE

Ovaries show only slight increase in length compared to the previous stage and on an average constitute 40% of the total length of the fish, but are expanded and turgid with increase in number of colourless dots representing the transparent eggs. In fresh condition if slight pressure is applied on the belly a gelatinous mass of transparent ova will be extruded. The largest ova are transparent and jelly-like reaching a maximum of 62 m.d (0.8 mm). The mode of the ripe eggs is at 42 m.d (0.54 mm). The transparent ova have several oil globules. A less prominent mode is seen at 20 m.d (0.26 mm). The average GSI is 7.13. The testes is swollen and whitish and on applying pressure on the belly extrudes the sperms. The maximum length of testes recorded is 7 mm.

STAGE VII a - PARTIALLY SPENT

The ovaries turn light grayish than yellowish. Though decreased in dimension there is no reduction in the length of the ovary. The frequency distribution of ova shows only two categories of yolked ova, one at 26 m.d (0.33 mm) and another at 16 m.d (0.21 mm). Some of the unspawned eggs are seen at 60 m.d and 64 m.d (0.77 & 0.82 mm). The lumen of the ovaries is filled with ruptured tissues, yolk fragments, scattered oil droplets which indicate the degeneration of ova. The ova undergoing resorbtion are sometimes translucent. The perivitelline becomes very thin and brittle. On slight pressure the oocyte breaks and the yolk granules flow out in spurts in fresh specimens.

STAGE VIIb FULLY SPENT

Ovary very thin flat and grayish in colour. Most of the eggs have been resorbed and the remaining ova have a size range of 2 m.d to 20 m.d. The mode is at 4 m.d. There is no reduction in the length of the ovaries which still remain embedded in the musculature on both sides of the haemal spines. The average GSI is 0.5. The testes have shrunken and show wrinkles, but muscular in appearance. There is no reduction in length of the testes. The average length is 5 mm.

DISTRIBUTION OF OVA IN THE OVARY

To find out the distribution of ova in the different regions of the ovary of *C.macrostomus* samples from anterior, middle and posterior regions of the right and left lobes of a mature ovaries (Stage IV) from a specimen 137 mm in total length (wt. 9.0 g) were cut out and teased on a plankton counting chamber and ova diameter measurements of nearly 500 ova from each portion were noted separately. Frequencies were plotted as in figure 4.1 a,b. which indicated a similar pattern in the distribution of the maturing and mature ova and hence the diameter frequency polygon of the three regions of the right lobe of ovary were pooled (fig. 4.1 c,d). Similarly the distributional pattern of ova in the left lobe of the ovary was also found to be uniform and comparable to that of the right ovary. It was thus evident that the distribution of number of ova and their diameter in the three regions of both the lobes of ovaries were uniform.

Ovaries in all stages of maturity contained immature ova measuring up to 0.15 mm. Though several workers while studying the ova diameter frequency polygons have considered only the maturing and mature ova, in the present study all stages have been included.

DEVELOPMENT OVA TO MATURITY

Ova diameter measurements of as many as 75 ovaries in different stages of maturity were taken for this study. The nine maturity stages described earlier are based on the macroscopic appearance supported by the microscopic study of the ova. Ovaries typical of 9 stages described earlier have been utilised for ova diameter measurements and the frequency polygons are presented in Figure 4.2.

In stage I, majority of the ova were in the size range of 1-4 m.d with mode at 2 m.d. In stage II the maturing ova were noticed and the first batch of developing ova was found withdrawn from the general stock with a mode *(A)* at 8 m.d (0.1 mm). As the ova undergo further maturation from stage II to III a second group of ova *(B)* representing a mode at 12 m.d (0.15 mm) got separated from the original immature stock. The earlier group shown as *(A)* progressed further to give a mode at 18 m.d (0.2 mm). In the IV stage, the mode *(A)* at 32 m.d represented the mode *(A)* of the stage III which has progressed during maturation. So also the mode at 12 m.d represented by *(B)* in the Stage III was traced to the IV stage. These groups of ova showed a faster growth and were seen almost merging with the mode *(A)* in the IV stage. In this stage, in addition, another group of maturing ova (14 m.d) represented by the mode *(C)* was seen segregated from the immature stock. In the V stage the mode at 32 m.d (0.41 mm) shown as *(AB)* represented the groups of ova *(A)* and *(B)* of the IV stage that have grown during maturation. The mode *(AB)* of the V stage further progressed to mode *(AB)* in the VI stage and showed a modal value of 42 m.d (0.54 mm). A growth of 10 m.d (0.13 mm) was noticed during the transition from V to VI stage. In the VIIa stage the group of ova represented by *(AB)* appeared almost completely shed with only few unspawned ova left in the ovary. But apart from this the mode *(D)* seen appear at 16 m.d. consisted of ova which were not completely opaque indicating the process of resorbtion. Further, in stage VII b all ova upto 20 m.d are found resorbed and the ovary is grayish in colour, thin flat and thread like. In the spent resting stage the size of the ova ranged from 2 to 20 m.d. A group that separated from the immature stock represented by the mode *(E)* has a diameter of 12 m.d. Such an ovary is noticed only in the fish above 97 mm. The frequency distribution of ova from such ovaries may resemble stage IIa. But the ovary differs morphologically in appearance and size. It may be assumed that the maturing yolked eggs left over after the spawning is degenerated and absorbed, resulting in an ovary of stage IIb. This may pass through a resting phase before further maturation starts for the next spawning. The studies indicated that the ova destined to be spawned are determined in the third stage itself. The immature ova represented by the smaller modes in the spent stage (VIIa) will not undergo further yolk deposition, grow and mature to be released in the same season. Hence they are absorbed. This is clear from the frequency polygon of the fully spent stage (VIIb) which definitely occurs by December/January and again by April/May every year soon after the first and second spawning respectively.

SPAWNING

A total of 3232 fishes were examined during August 1994 to June 1995 and 3613 specimens during August 1995 to August 1996. The details of the results are given in Tables 4.1 & 4.2. In this study the maturity stages as defined by the International Council for the Exploration of the Sea (ICES) (quoted by Lovern and Wood, 1937) was followed. Here, stage II included both virgin IIa and recovering IIb and stage VII b was included in the spent fishes. While some authors include only the maturing and mature stages to find out the spawning season, in the present study all stages have been included to give a complete picture of the maturity stages in the population as a whole.

The percentage occurrence of the ovary in different stages of maturity are presented in Figure 4.3 & 4.4. During August and September 1994 the stages II to IV were present, stage IV being more dominant. During October all stages were present, but mature and spent specimens dominated. By November the mature and gravid stages were less, but there was an increase in spent stage. By January 1995 no spent stages and gravid ones were encountered but correspondingly there was an increase in the percentage of immature fishes. During February gravid and spent stages started appearing again in low percentages. Further, by March their percentages were higher. In May gravid stages were not observed, but spent fishes were seen in good percentage. Only immature followed by maturing fishes were encountered during June 1995. During the subsequent period of study from August 1995 to August 1996 the monthly occurrence of maturity stages presented almost a similar picture compared to the previous period. By August 1995 stage IV ranked first with a higher percentage, but by September the V stage was dominant and the IV stage ranked second. By October gravid and spent stages were noticed whereas in November V stage was absent as this stage has further advanced to VI stage. In the subsequent months, mature and gravid fishes were absent but spent fishes dominated during January 1996. The percentage occurrence of spent fishes was low during February. By March the mature, gravid and spent fishes were noticed to occur again. During August 1996, again the IV stage was dominant and this cycle is repeated.

MATURITY STAGES AND SPAWNING OFF NEENDAKARA:

For comparison of the spawning time of Malabar sole along the Kerala coast samples were also collected from Neendakara (Quilon) in southern Kerala. Since there was no difference between the occurrence of various stages of males and females at Cochin, the maturity stages of females only were considered from Neendakara for the analysis and comparison. The monthly percentage distribution of maturity stages from this centre are based on 1336 females collected during December 1994 to October 1996. The monthly percentage occurrence of various maturity stages are presented in Table 4.3. The analysis showed that the distribution of monthly percentage occurrence of maturity stages were comparable to that of Cochin. This indicated that the spawning time of the Malabar sole is almost the same at Cochin and Neendakara.

These studies showed that when the commercial fishery starts immediately after the southwest monsoon the predominant maturity class is stage IV. The immature group is absent or poorly represented. During the period upto December the smaller individuals become scarce in the samples and there is an increase in the appearance of the spent fishes. Again, from February advanced maturity stages occur and further by May spawning ceases and only spent individuals are encountered.

A comparison of the data for two successive years from Cochin and Neendakara indicated that there are two spawnings in an year. The first spawning is during the postmonsoon (September-October-November) and the second during the premonsoon (February-March-April). The new recruits of the spawning during postmonsoon grow, mature and are ready to spawn when they are nearly one year old by next postmonsoon season. Whereas the new recruits of premonsoon period will not be able to grow, mature and spawn during the ensuing postmonsoon season. The commercial catches consists of fishes that undergo various maturation process and belong to the two recruitment period mentioned above. Thus there are two broods. That is why the III and IV stages are seen during most of the months. The occurrence of these stages is no indication of multiple spawning as many workers have concluded (James and Baragi, 1980). The III and IV stage fishes that occur in increasing percentage immediately after a spawning do not belong to the fishes that have spawned. But they represent fishes of a subsequent recruits undergoing maturation and are readying for spawning in the next favourable time slot. It appeared that the spawning is synchronised with the favourable conditions existing in the environment. The primary and secondary productions are high during the post monsoon and after the north east monsoon. The Malabar sole selects these productive periods for spawning to ensure the survival of the new recruits. Also the adults will have sufficient food items in the environment and they actively feed and recover from the spawning stress. This aspect has been highlighted in Chapter on food and feeding.

FREQUENCY OF SPAWNING

According to Clark (1934), Hickling and Rutenberg (1936), de Jong (1940) and Prabhu (1956) the multiplicity of modes in the frequency curve of ova diameters from mature fishes can indicate the spawning periodicity. The ova diameter studies in Malabar sole indicated no multiple modes. When the immature group of ova are shed during the spawning season, their place is not taken by the advancing groups of eggs as may be seen in some of the multiple spawners. In the ripe ovary only two groups of ova could be noticed in addition to the immature stock. The first group (fully mature) ranges in size from 34 m.d (0.44 mm) to 62 m.d (0.80 mm). This group is clearly separated from the second group of ova of the size range 12 m.d to 34 m.d. The mode of this group is at 20 m.d (0.26 mm) which corresponds to a size slightly more than the III rd stage. Ova of size below 12 m.d (0.15 mm) is the immature stock. In the spent ovary apart from residual eggs a small mode is seen at 26 m.d (0.33 mm) and 16 m.d (0.21 mm). These two sets of ova, though yolked have advanced only a quarter of the maturation process. The chances may be rather remote for this group of ova to complete their maturation process to be shed in the same season. These observations confirm that Malabar sole spawns once in an year. But there are two groups that spawn at different timings.

RELATIVE NUMBER OF OVA IN DIFFERENT GROUPS

It has been pointed out by Clark (1934) that analysis of ratios between the number of ova in most advanced group and the lesser advanced groups would give an idea of number of ova that would be spawned in the same season and that if there is any progressive decrease in the proportionate number of smaller ova during the spawning season, it indicates that spawning takes place in batches. (Jhingran, 1961; Antony Raja, 1964; Devaraj, 1973; Somavanshi, 1980). To know the relative number, the ova from mature ovaries were grouped as : A - ova ranging from 2 m.d to 11 m.d; B - ova from 12 m.d to 21 m.d; C-ova from 22 m.d to 29 m.d and D-ova from 31 m.d and onwards. Since the group A represented immature ova, the remaining three groups were considered in ratio calculations. The average values of the two sets of ratios B+C/D and C/D are given in Table 4.4. During September the B+C/D ratio varied from 0.75 to 7.3 and C/D ratio from 0.29 to 5.2. In October the B+C/D ratio ranged from 0.6 to 1.8 and C/D ratio from 0.21 to 1.01, whereas during December the B+C/D ratio ranged from 0.57 to 1.94 and that of C/D 0.51 to 1.18. The monthly average ratio of B+C/D and C/D were 2.5 and 1.6 in September, 1.3 and 0.69 and October, and 1.76 and 1.14 in November. The ratio between B+C/D and C/D were 1.6:1 in September, 1.9:1 in October and 1.8:1 in November.

The monthly averages indicated that there was no appreciable decrease in the ratios through time lapse. The decline in some cases noticed was more due to advancement of maturity from stage IV to stage V. Since there exist a constant ratio between ova of different diameters during the breeding season, it may be concluded that the Malabar sole is not a multiple spawner.

GONADO-SOMATIC INDEX

In addition to the method of ova-diameter measurements, the state of maturity of a fish may as well be determined from the size of ovaries. June (1953) and Yuen (1955) have found that the relative ovary weight (ovary weight x 10^3/fish weight) is more suitable to explain the state of maturity of the Hawaiian yellowfin and Central Pacific big-eye tuna respectively. This relative ovary weight, otherwise known as gonado-somatic index was calculated to study the relationship between the gonad index and maturity. This study was confined to females, since the testes of this fish was very small and the difference in weight between stages was negligible. The index was calculated for individual fish in different months using the formula, gonado-somatic index = ovary weight x 10^2/fish weight.

The gonado-somatic index of individual fish thus obtained was plotted against the largest mode of the egg diameter as indicated in Figure 4.5. Based on this regression of modal values of ova diameter on gonad index, the gonad indices were classified into 3 categories of maturity. (1) The immature ovaries of stage I and II having an index below 1.0 (2) stage III (maturing) ovary having an index between 1.0 and 1.5, (3) mature and ripe ovaries of stage IV,V and VI having an index above 1.5. The study revealed that the increase in the ovary weight of Malabar sole is associated with the progress of maturity of the ovary.

To find out the correlation between the gonad index and the spawning season, the percentage occurrence of different categories in various months were calculated and the details are presented in Table 4.5. The results indicated that the first group (immature fishes with gonad index below 1.0) occurred in November 94 to June 95 and again in November 95 to May 96. The maturing (1.0 to 1.5) also showed the same pattern during the period. The mature group with index above 1.5 showed higher indices during August, September, October and November 1994 and during April-May 1995. Further, the indices were higher during August-September-October and November 1995 and again during March-April-May 1996.

The average gonado-somatic index for each month for the period August 1994 to September 1996 was calculated from the index of individual fish by dividing the total value of the indices for each month by the number examined. The results are given in Table 4.6. and Figure 4.6.

The curves representing the values for both years showed a similar pattern. The high values observed during September and a decline in the value by October indicated spawning of the first batch. The second spawning was observed during April/May. All these observations clearly indicate that the species has two spawning seasons. But by considering the growth of the new recruits to attain maturity, the sequence of occurrence of various maturity stages and ova diameter studies it may be concluded that spawners of September-November are different from that of the spawners during February to April.

RELATION BETWEEN THE SIZE OF THE OVARY AND SIZE OF THE FISH

If the size of the gonads show a constant relation with the size of the fish, it may be useful as an index of maturity of the species. It is generally observed that the length of the gonad increased with the length of the fish. A total of 257 females of ***C.macrostomus*** comprising 69 immature fishes of the size range 55-94 mm and 188 mature speciemens of the size range 97-159 mm were studied for this purpose.

The total length of the fish and the length of the ovary were noted with accuracy along with the stage of maturity for each specimen. Immature fishes (less than 97 mm) and mature specimens (above 97 mm) were treated separately. The length of the ovary was plotted against the length of the fish in a scatter diagram as in Figure 4.7 which showed a linear relationship. The equation was fitted to the data by the least square method and the values of 'A' and 'B' were obtained by using the formula $Y = A+B\,X$, where 'A' and 'B' are two constants and 'Y' represents the length of the ovary and 'X' the length of the fish. The equation for immature and mature fishes were found to be:

Immature: $Y = -8.16475 + 0.192690\,X$

Mature $Y = -5.31728 + 0.378713\,X$

SIZE AT MATURITY

The size at maturity of Malabar sole *Cynoglossus macrostomus* was determined by analysing 1754 males and 1516 females during August 1994 to June 1995, and 1945 males and 1543 females during August 1995 to September 1996.

For this purpose the fish collected were grouped sex-wise into 5 mm size groups and percentages of the fish in different stages of maturity in various size groups were calculated separately for the two years for both sexes. The fishes belonging to stages I and II were grouped under immature category and stages III to VII under mature category for the calculation of the size at maturity. The details for males are given in Tables 4.7 and 4.8; females 4.9 and 4.10; and pooled data in Table 4.11.

From Tables 4.7 to 4.8 it could be noticed that during August 1994 to June 1995 all the females upto 70 mm were immature and belonged to stage I. From 75 mm onwards they pass on to stage II and a few of them (1%) were found to be in the maturing stage (stage III). Mature fishes were first noticed in 80-84 mm size group (0.4%). Spent fishes were recorded for the first time in 100 mm size group. In the 95-100 mm size group majority (55.6%) were immature. But in the 100-105 mm size group the immature fishes formed only 24.1% and in the next size group they comprised only 17.2%. From the size group 125 mm onwards the mature fishes formed 100%. Hence it may be noted that more than 50% passed on to maturity within the 95-100 mm size and a plot of this data as indicated in figure 4.8 revealed the length at maturity as 97 mm.

The percentage occurrence of males in different stages of maturity during August 1994 to June 1995 and August 95 to September 96 are presented in Tables 4.9 and 4.10. Here also all males upto 70 mm were immature. By 75 mm onwards the maturing constituted 1%. Gradually the percentage of mature fishes increased and by 120 mm size group all were mature. In the size group 95 mm , immature males formed 53.7% compared to 23.6% in the next size group. Hence the size at maturity lie at a size between these two size groups. A plot of this data revealed that the size at maturity for males also was 97 mm (Figure 4.8). The data sets for males and females for 1995-96 also revealed the size at maturity as 97 mm. Based on the pooled data for both the years the size at maturity was found to be 97 mm for males and females (Figure 4.9).

FECUNDITY

In the present study, fecundity in Malabar sole was determined from the total number of mature ova destined to be shed in the current spawning season. The fecundity was calculated from 88 fishes of the size range 76 mm to 159 mm in total length and weight ranging from 2.5 g to 21.9 g. The ova diameter studies indicated that the main mode was at 18 m.d in the third stage, 28 m.d in the IV stage, 32 m.d in the V stage and 45 m.d in the VI stage. In the VI stage the second mode was at 20 m.d. In the spent stage this mode further advanced to 26 m.d and it appeared that ova below this stage are resorbed. Hence it was considered to count all eggs above 24 md. Determination of absolute fecundity in Malabar sole was based on the gravimetric method (Mac Gregor, 1957; Bagenal, 1957) as mentioned earlier.

The fecundity of 88 fishes examined are presented in Table 4.12 along with the total length and weight of the fish, length and weight of the ovary and stages of maturity. The lowest fecundity was 5021 ova in a fish of total length 76 mm weighing 2.5 g. The highest fecundity of 64,434 ova was observed in a fish of 156 mm total length and weighing 20 g. Though there were variations within size groups and between size groups, the fecundity increased with increase in length. Further, the average fecundity was calculated for each size group. The lowest fecundity of 5110 ova was in the 75-80 mm size group and the highest of 62,921 ova in the 155-160 mm size group. Tables 4.13. According to Seshappa and Bhimachar (1955) ripe and full ovaries of specimens measuring 156 and 159 mm were found to have 42,200 and 65,900 ripe and ripening ova respectively.

RELATIONSHIP BETWEEN FECUNDITY AND LENGTH OF THE FISH

Many workers have reported a non-linear relationship between length of the fish and fecundity as that between length and weight of the fish. Pioneering workers like Franz (1910), Kiselevich (1923) and Clark (1934) on their studies on *Pleuronectes platessa*, and *Sardina caerulea* respectively showed that fecundity of fish increases in a proportion to the square of its length. Hickling (1940) found that the fecundity of the herring in the southern North sea increases at a rate above the cube of length. Smith (1947) reported a straight line relationship between fecundity and length in the eastern trout. Simpson (1951) observed that the fecundity is related to the volume of ovary and consequently to the cube of the length in *Pleuronectes platessa.* James (1967) observed the same relation in *Enpleurogrammus intermedius.* Prabhu (1955 b) in his studies on *Trichiurus haumela* noted that the fecundity increased with the length of the fish at a rate substantially greater than the fourth power. Pillay (1958) found an exponential relationship between fecundity and length of the fish in *Hilsa ilisha.* Parulekar and Bal (1971) reported that fecundity in *Sillago sihama* increased at a rate of fourth power its length. Varghese (1973) observed that the fecundity of Rohu, *Labeo rohita* increased at a rate of 3.96 times the length. Varghese (1980) reported that in *Coilia dussumieri* the fecundity increased at a rate of 4.82 times the length increase. Horwood (1993) found that in the Bristol channel sole *Solea solea* the fecundity and length showed a linear relationship and increased at a rate of 4.3 times with increment in length.

To find out the relationship between the length of the fish and fecundity in *Cynoglossus macrostomus* the absolute fecundity estimated for 88 fishes were plotted against their total length in a scatter diagram in Figure 4.10. The relationship was calculated by the least square method (logarithmic values) based on the formula

$$\log F = a + b \text{ Log } L$$

where F = Fecundity, L = total length in mm, 'a' and 'b' are two constants. The fecundity (F) and length (L) relationship can be expressed as:

$$\log F = -3.2406 + 3.6942 \log L.$$

The expected fecundity for length was calculated based on the above formula and a regression line was fitted to the scatter diagram which showed a linear relationship between these two variables. The correlation coefficient was r = 0.917908. The r value was tested for significance and was found to be highly significant.

In the length-weight relationship of *C. macrostomus* the exponential value was found to be 3.10734 for the mature females. This value is lower than that observed in fecundity-length relationship (3.6942). This indicates that the fecundity in this fish increased at a rate greater than the rate of increase of body weight, in relation to length.

RELATION BETWEEN FECUNDITY AND WEIGHT OF THE FISH

In order to study the relation between fecundity and fish weight the values were plotted as in Figure 4.11. The arithmetic values of fish weight and fecundity were converted to log values and could be expressed as

$$\log F = 3.36981 + 1.15698 \log W$$

where F = fecundity, W = total weight of fish. A straight line relationship was observed between these two variables. The correlation coefficient was found to be 'r' = 0.902415. The exponential value 1.15 is above unity (unity = 1). Hence the fecundity increases at a rate more than that of the body weight in relation to length.

RELATION BETWEEN FECUNDITY AND WEIGHT OF OVARY

In order to study the relation between ovary weight and fecundity, the fecundity values were plotted against the respective weights of ovaries in a scatter diagram (Figure 4.12). The relationship between these two variables can be expressed as

$$\log F = 4.59765 + 0.83282 \log OW$$

where F = fecundity, OW = ovary weight, a = constant and b = the exponential value. The exponential value (0.83282) which was less than 1 which indicated that fecundity increased at a rate less than that of body weight and ovary weight in relation to total length.

FECUNDITY IN RELATION TO LENGTH OF OVARY

To find out the relation between fecundity and length of the ovary the scatter diagrams of the above values were plotted (Figure 4.13). The relationship was found to be curvilinear of the form $F= al^{b}$, which may be expressed in the logarithmic form as

$$\log F = 0.41209 + 2.475196 \log OL.$$

where a = constant, b= the exponential, F = fecundity and OL = the ovary length. The correlation coefficient was 0.83205.

FECUNDITY FACTORS

Varghese (1973) calculated the average number of ova per gram body weight and per gram ovary weight for Rohu *Labeo rohita* to study whether the fecundity factors are influenced by the size of the fish. Madan Mohan and Velayudhan (1986) estimated the number of ripe ova per gram of body weight in *Nemipterus delagoae* and observed considerable variations in the fecundity of individual fish of same length.

In the Malabar sole the number of ova per gram body weight and per 0.1 gram ovary weight were calculated. Since majority of the ovary weighed less than one gram, 0.1 gram was taken as the unit for ovary weight. The averages of total length, weight, length of ovary, weight of ovary, fecundity and number of ova per 0.1 g weight of ovary are given in Table 4.13. The absolute and relative fecundity of *C.macrostomus* for various length ranges are given in Table 4.14. Though the minimum size at maturity is 97 mm, some of the younger fishes less than this size with IV stage ovary noticed also have been considered in this study. And the size of fishes considered ranges from 83 mm to 157 mm. The overall average fecundity per gram body weight and per 0.1 g ovary weight was 3243 and 4465 ova respectively. Number of eggs per 1 gram body weight (1770 ova) and 0.1 gram ovary weight (4102 ova) were lowest in the smallest size group. The number of ova per 0.1 g weight of ovary was highest (7484 ova) in fish of total length 92 mm and again in 106 mm and 113 mm. Further, in large size groups the number of ova per 0.1 g weight of ovary were lower than the overall average. The number of ova per 1 gram body weight was highest (3924 ova) in fishes of length 113 mm. Here also the values in higher size groups were less than the value in fishes of 113 mm. The lowest value of 3010 ova per 1 gram body weight was in 155-160 mm size group. The size group 110-115 mm represented the one year old fishes and are first time spawners and the ova per 1 gram weight of fish is higher than the 2nd and 3rd time spawners. In the second and third time spawners though the fecundity is more, the number per 1 gram body weight is less than the first time spawners. Hence it may be concluded that the one year old and first time spawners have a high fecundity and are more productive compared to the old and larger fishes.

SEX RATIO

Sex ratio studies in Malabar sole *C. macrostomus* is based on samples collected from the trawlers at Cochin, Neendakara and from the mini trawlers at Ambalapuzha. This was done mainly to ascertain whether there existed any difference in sex ratio in various size groups, between centres, and during seasons.

From Cochin 1697 preadults and 1472 adults during August 1994 to June 1995 and 1308 preadults and 2991 adults during August 1995 to August 1996 of the size range 45 mm to 170 mm were analysed. From Neendakara 2641 fishes during 1994-95 and 5337 specimens during 1995-96 of the size range 40 mm to 165 mm; and from Ambalapuzha 4267 fishes during 1994-95 and 4627 fishes during 1995-96 of the size range 55 mm to 160 mm have been considered for studies on sex ratio.

The samples were grouped monthwise as well as size group wise. Data from Cochin were further grouped into immature and adults. At other two centres the monthly distribution of sex ratio of adults only were worked out and comparison between the three centres were made. The observed sex-ratios were tested against an expected ratio 1:1 by the method of chi-square (Snedecor, 1946).

SEX RATIO DURING DIFFERENT MONTHS: The monthwise sex-ratio in the immature Malabar sole at Cochin during 1994-95 and 1995-96 are given in Tables 4.15 & 4.16. The overall sex ratio of M:F was 1.3:1 during 1994-95 and 1.2:1 during 1995-96. During both the years the males dominated except during September October 1994 and November 1995 and April 1996. The sex ratio was significant at 5% level in December '94, June 1995, February and May '96.

In the adults, at Cochin during 1994-95 and 1995-96 males dominated except during September 1994, April/May 95, September 95, January February, April and August 1996 (Tables 3.17 & 3.18). The domination of males was noticed also at Neendakara and Ambalapuzha. At Neendakara, females were dominant during December 1994, February May, November, December 1995 and May 1996, whereas at Ambalapuzha females dominated during April, July and September 1995 and January to May 1996.The sex ratio of malabar sole at

Cochin is presented in Tables 4.17 & 4.18; for Neendakara Tables 4.19 & 4.20; and Ambalapuzha Tables 4.21, & 4.22. The annual sex ratio at these three centres for 1994-95 and 1995-96 showed that males were dominant except at Ambalapuzha during 1995-96.

The monthly sex ratio was significant at Cochin during December 94, June, August and December 1995, March, April, May and August 1996. At Quilon it was during August, September, October '95 and January, February and May '96. Sex ratio was significant at Ambalapuzha during November 94, April, May and September '95; January, and March to May '96.

SEX RATIO IN DIFFERENT SIZE GROUPS: During 1994-95 at Cochin females dominated in size groups 55 and 60 mm. But from 65 to 85 mm and 95 to 130 mm size groups the males dominated. But in fishes of 135 to 145 mm length the females were dominant. Again from 150 mm size onwards males were found dominating (Tables 4.23 & 4.24). At Ambalapuzha, except in 65 mm size fishes males were dominant in all size groups upto 125 mm and in the next two size groups females and further from 140 mm onwards males again dominated (Tables 4.27 & 4.28). At Neendakara, the younger size groups upto 70 mm were absent. Mostly in the middle size groups of 95 to 115 mm males dominated except in 120 mm size fishes (Tables 4.25 & 4.26). A comparison of the sex ratio in the adults of *C.macrostomus* at Cochin, Neendakara and Ambalapuzha is given in Table 4.29. During 1995-96 also at all these centres the males dominated in most of the size groups with minor variations.

The above analysis indicated that males were fished more than the females in both the years and the sex ratio was often statistically significant. Mostly, though not regularly, during the spawning season the sex ratio 1:1 (male:female) was maintained. During both the years at Cochin the sex ratio was significant in December, indicating an increase in male population. In the next one or two months the sex ratio was again nearer to 1:1 ratio *i.e.*, during the second spawning. At Neendakara the sex ratio was significantly high during the spawning season in August to october and also during the second spawning season around April/May. A somewhat similar trend was noticed at Ambalapuzha also.

The size group wise analysis revealed that the sex ratio was significant in the maturing first time spawners. There may occur a congregation of first time male spawning population near to the female population. It may be one of nature's ways to ensure spawning and thereby recruitment of a successful and healthy progenies from the younger generation, as such offsprings may be efficient by way of better survival and growth compared to the progenies from the older generation. Sex ratio in different size groups from Cochin, Neendakara and Ambalapuzha for the period 1994-95 and 1995-96 are given Table 4.30.

MATURITY, SPAWNING AND FECUNDITY IN A RELATED SPECIES

Among these, other *Cynoglossus* species *C.arel* was common in the flatfish landings. Hence the maturity, spawning, size at maturity and fecundity of this species also were studied. A total of 347 specimens of the size range 141 to 323 mm collected from Neendakara during August 1995 to September 1996 were analysed. The percentage occurrence of various maturity stages are given in Table 4.31 and Figure 4.14. The study indicated that mature, ripe and spent specimens mostly occur during the post monsoon and premonsoon period indicating two spawning seasons, as in Malabar sole. The maturity stages were grouped size group wise and the size at maturity was found to be 197 mm and is shown in Figure 4.15. Table 4.32 gives the size group wise distribution of maturity stages.

For fecundity studies 35 mature fishes of the size range 201 to 322 mm were examined. The lowest fecundity of 24,325 was in a fish 201 mm and a highest 289,823 in a fish of 322 mm in total length (Table 4.33). There was variation in the fecundity among individuals as noticed in Malabar sole. The relation between length of the fish and fecundity was calculated by the least square method

$$\log F = a + b \log L$$

where F = fecundity, L = length of fish, a = a constant, b = the exponent. The formula obtained was

$$\log F = -6.97275 + 5.002121 \log L$$

DISCUSSION

Seshappa and Bhimachar (1955) reported that spawning of the Malabar sole *Cynoglossus semifasciatus* takes place in the offshore area and hence the spent and spent resting fishes were not encountered in the catch. Qasim (1973) while reviewing overall implications of the problems related to the quantification of maturity stages in fishes of tropical waters proposed that the classification of gonads should be limited to about 5 maturity stages. James and Baragi (1980) opined that in majority of the marine fishes from tropical waters maturation is a continous process resulting in the occurrence of mature fishes through out the year. The study period of Seshappa and Bhimachar (1955) pertains to 1949-51 when the fisheries sector was in its infant stage of development. Fishing was carried out by the indigenous craft and gear in the inshore waters. It was natural during those days to miss the complete maturity stages of Malabar sole as this resource was not fished or exploited from its entire commercial range of distribution. Hence the absence of spent and spent recovering stages in the landings during those days does not mean that the fish after spawning reverts to stage III and get ready for the next spawning immediately. Mechanisation of the fishing craft has resulted in increased access to deeper areas exploiting almost the entire range of commercial distribution of various resources which were not so during the pre-mechanisation period. The present study has taken care to collect all stages of maturity in Malabar sole.

Seshappa and Bhimachar (1955) observed that the spawning season of the Malabar sole starts by September-October and ceases by June, There are no different batches of eggs maturing at different periods in the same season. But different individuals mature at different times, thus prolonging the breeding season. But the present study indicated that there are two spawning seasons and accordingly two broods also could be distinguished.

The studies on the spawning habits of the large scaled tongue sole *Cynoglossus arel* indicated that this species also spawns during the post monsoon and during the premonsoon season. Ramanathan *et al* (1977) while studying the the biology of *C.macrolepidotus* observed that the spawning season of this species in Porto Novo waters appear to be from August to October. Based on the size distribution of ova they concluded that the spawning takes place once a year, during a definite short period. The size at maturity was estimated as 191 mm compared to 197 mm in the present study.

According to Seshappa (1974 b) the spawning season in *Cynoglossus dubius* is a little later than or roughly the same as that of Malabar sole. Devadoss *et al* (1977) reported that the spawning season of the Indian Halibut *Psettodes erumei* in Porto Novo waters is a prolonged one extending over a period from November to May. Horwood (1993) showed that the Bristol channel sole *Solea solea* is a determinate spawner and the duration of the spawning spans about 90 days but an individual fish may not be there through out the period. Most of the flatfishes in India especially the Malabar sole also is determinate spawner. In flatfishes apart from the studies on maturity stages and ova diameter measurements the occurrence of fish eggs and larvae also confirm two spawning periods. Seshappa and Bhimachar (1955) recorded the eggs and larvae of the Malabar sole from the plankton collections at Calicut during October. John (1951) mentioned the occurrence of young ones of *Psettodes erumei* of 25 mm in total length during July. Basheeruddin and Nayar (1961) mentioned the incidence of larval forms of about 30 mm in Madras during March-April. Devadoss and Pillai (1973) also reported the occurrence of young ones of 41 mm to 78 mm during May in Porto Novo waters. Further, the ratios between the number of ova in most advanced group and the lesser advanced do not indicate any decrease suggesting that the Malabar sole is not a multiple spawner. This has been observed by Antony Raja (1964) in the oil sardine *Sardinella longiceps* and by Parameswaran and Sinha (1966) in *Notopterus notopterus*.

In the present study on the sex ratio in the Malabar sole (*C.macrostomus*), males mostly dominated during most of the period. The chi-square test showed significant values during the two spawning seasons around October/November/December and in March/April/May. It is interesting to note that the testes in this species is significantly small compared to the ovaries, a fact which has not been reported so far. It appeared that one male alone may not be sufficient to fertilise the eggs that are discharged during the spawning and in all probability more than one male, each at a time, and at different times may be taking part in the spawning activity. Seshappa and Bhimachar (1955) also reported that the two sexes in Malabar sole were not equally represented. Instances of domination by one sex have been reported in *Cynoglossus dubius* by Seshappa (1974 b), in *Sardinella longiceps* Antony Raja (1972), in *Garra mullya* by Somavanshi (1980) and in *Dussumieria acuta* by Nair (1983). Eltink (1987) found that the male/female ratio in mackerel *(Scomber scombrus)* of maturity IV was 56/44, which indicated a longer duration in maturity stage VI for males than female.

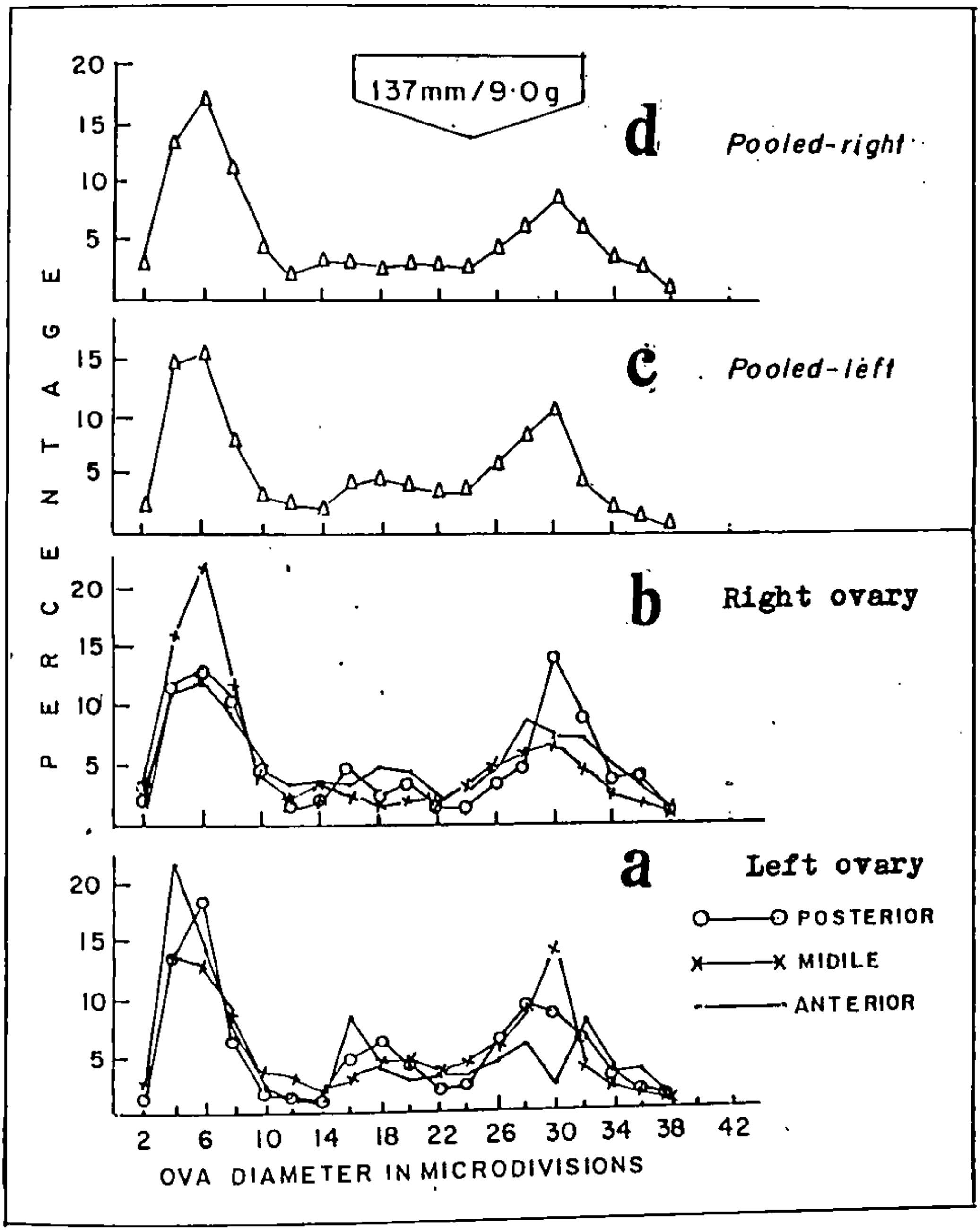


Fig. 4.1 Ova diameter frequency polygons of the anterior, middle and posterior regions of a mature left (A) and right (B) ovary of C.macrostomus.

C & D represent the pooled ova diameter frequency

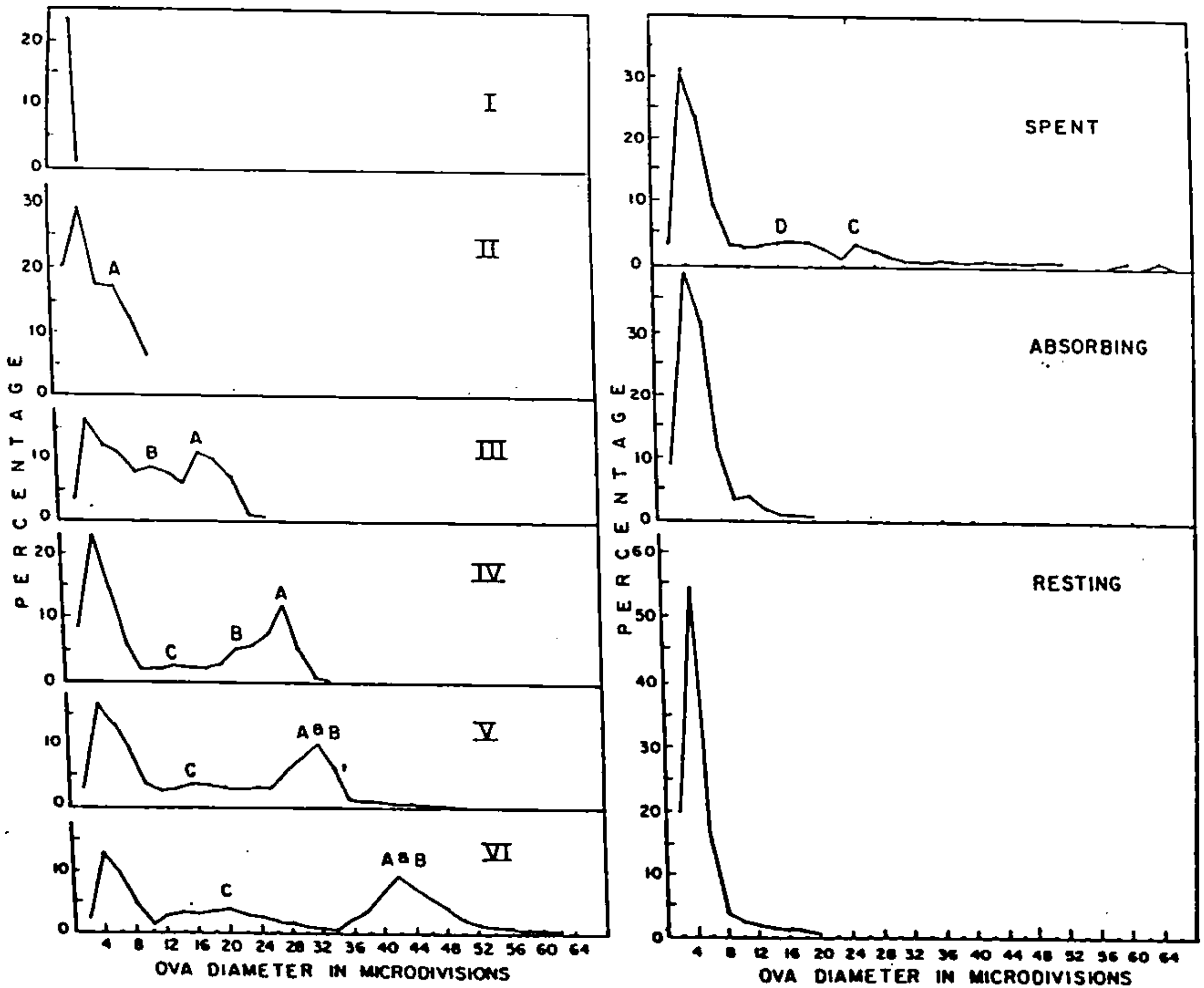


Fig. 4.2 Ova diameter frequency polygons of the ovaries of *C.macrostomus* in various stages of maturity

Fig. 4.3 Percentage occurrence of maturity stages in C.macrostomus Females 1994-95

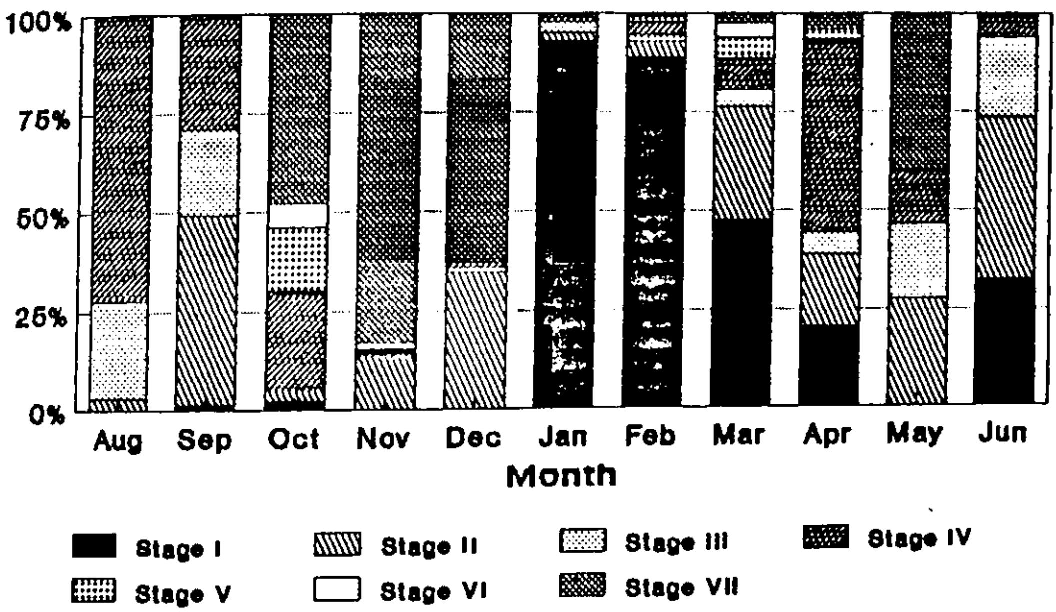
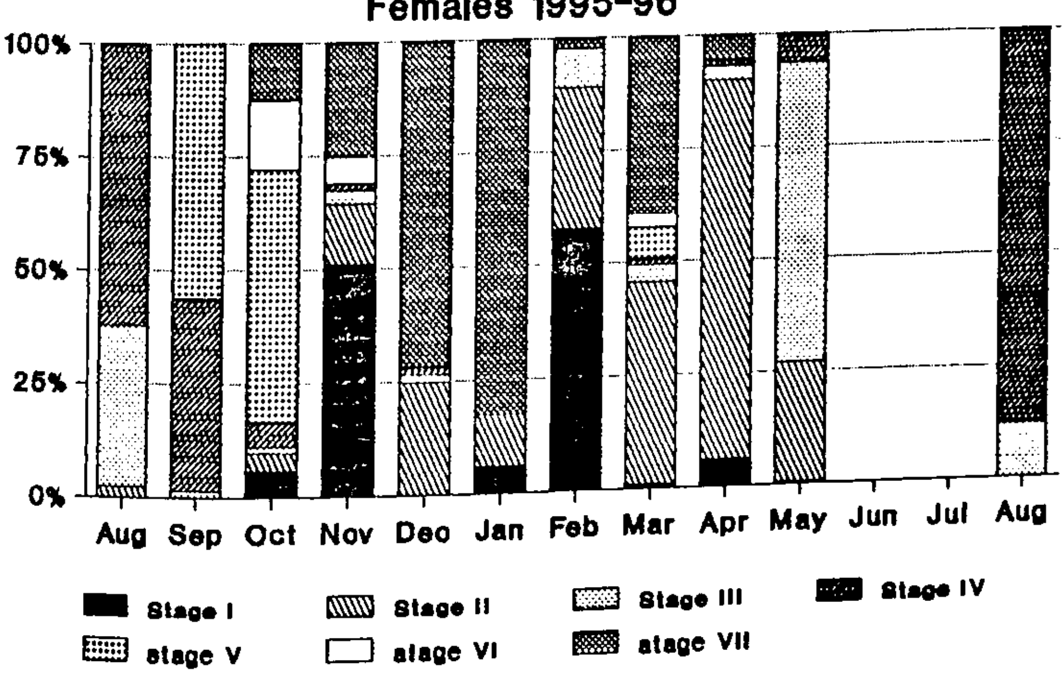


Fig. 4.4 Percentage occurrence of maturity stages in C.macrostomus Females 1995-96



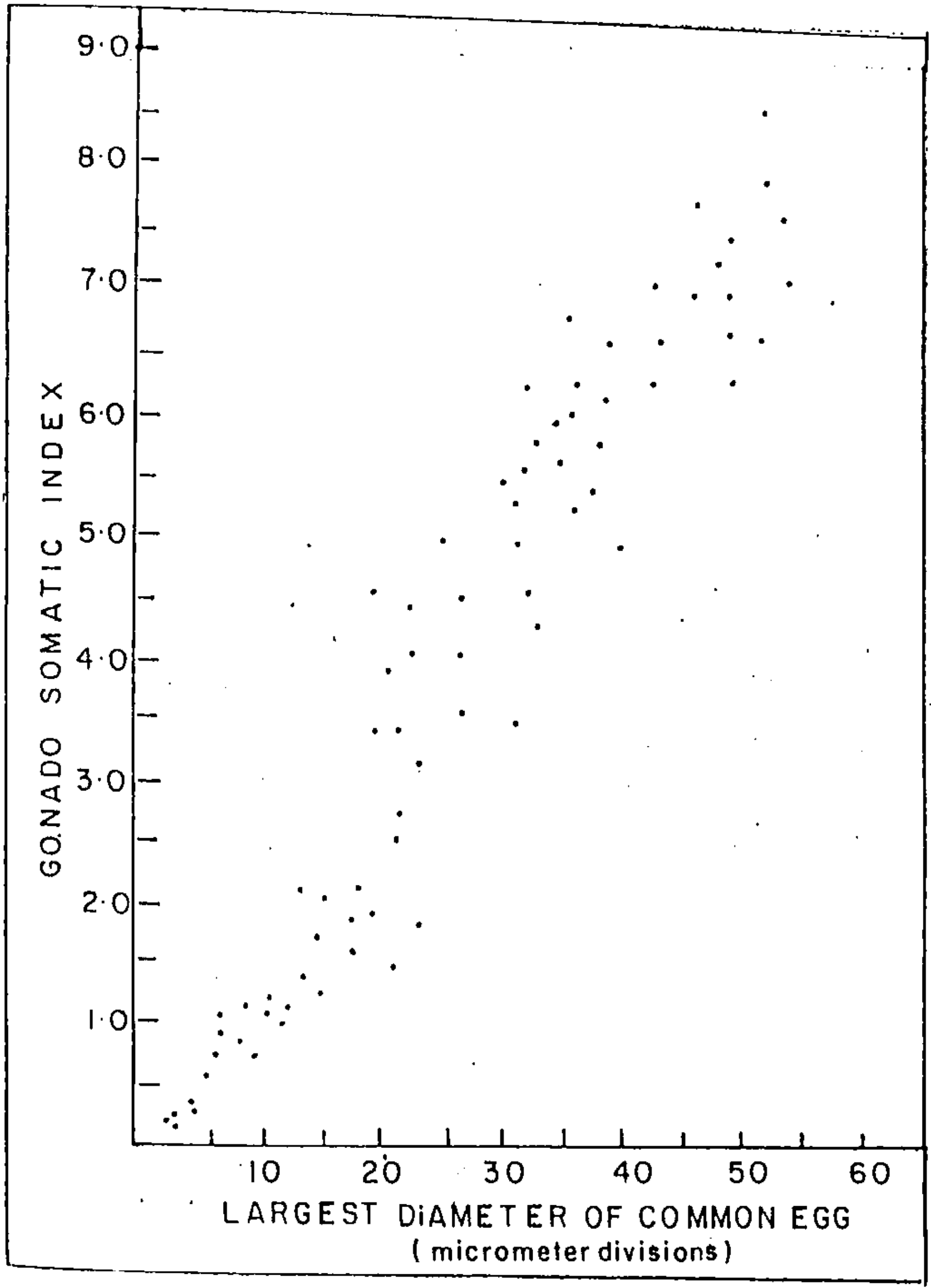


Fig. 4.5 Gonado-somatic index of individual fish (C. macrostomus) plotted against the largest mode of the egg diameter

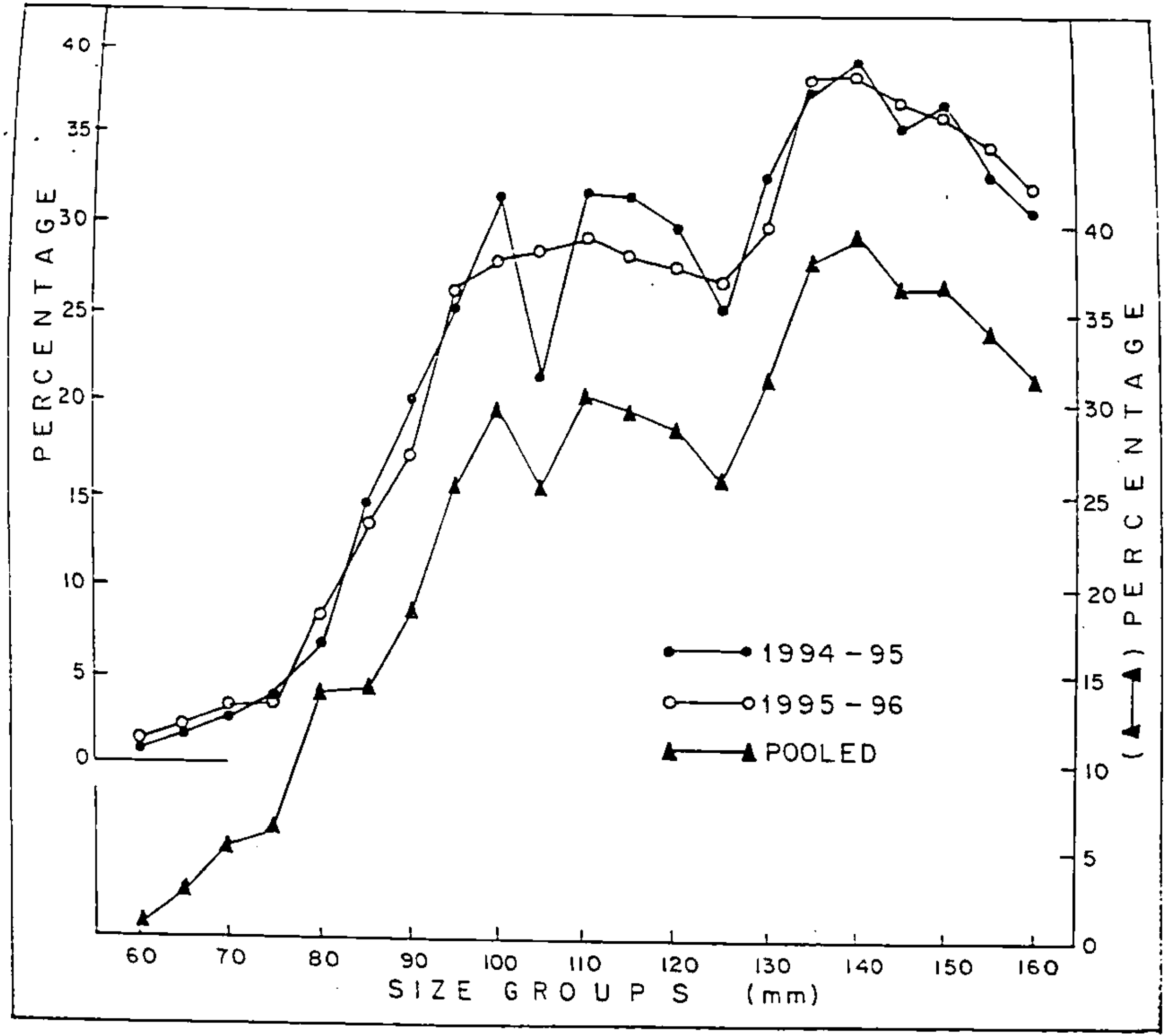


Fig. 4.6 Gonado-somatic index in different size groups of <u>C.macrostomus</u> during 1994-95 and 1995-96 and pooled for the two years at Cochin.

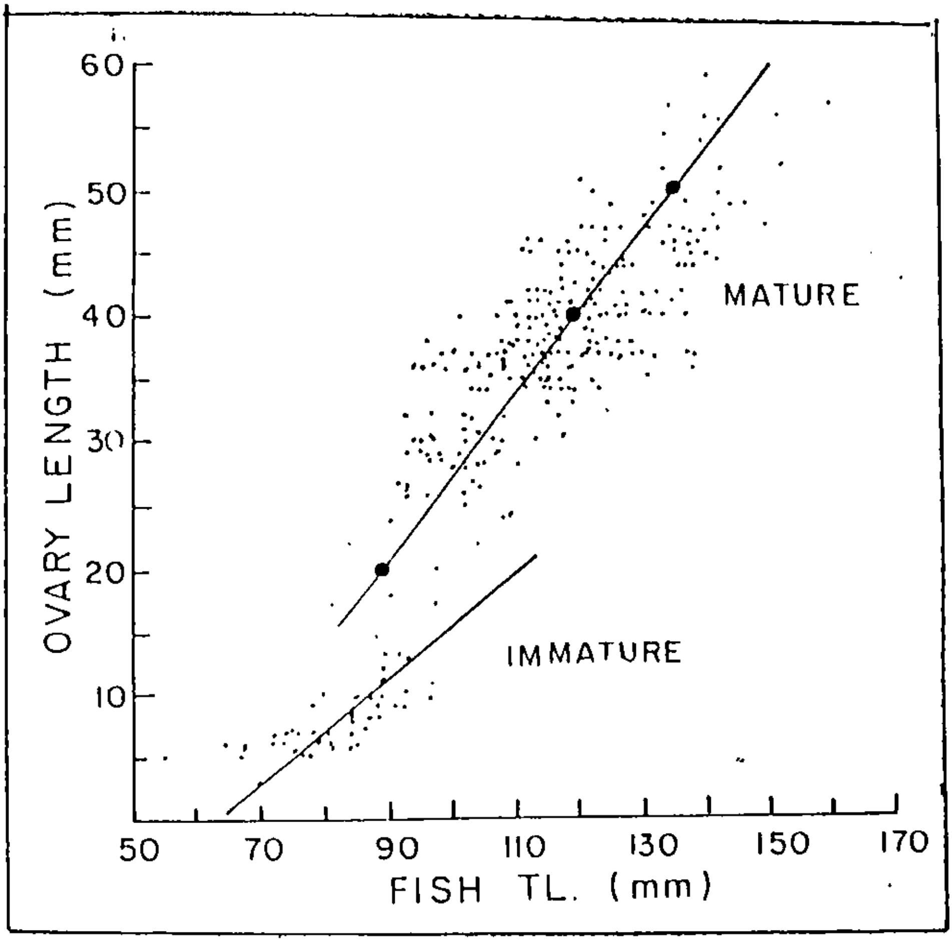


Fig. 4.7 Relation between ovary length and fish length in immature and mature *C.macrostomus*

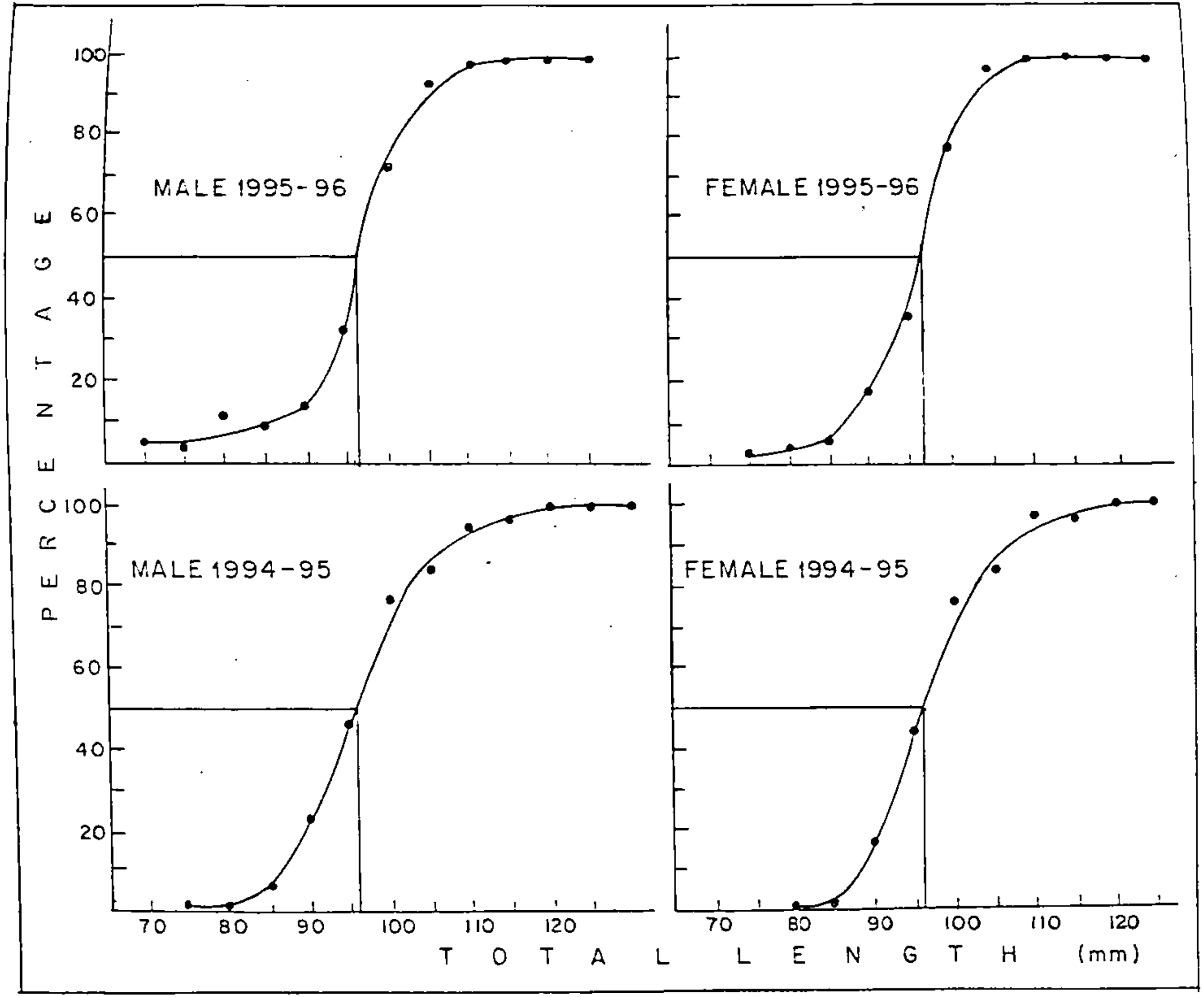


Fig.4.8 Size at maturity in males and females of <u>C.macrostomus</u> during during 1994-95 & 95-96

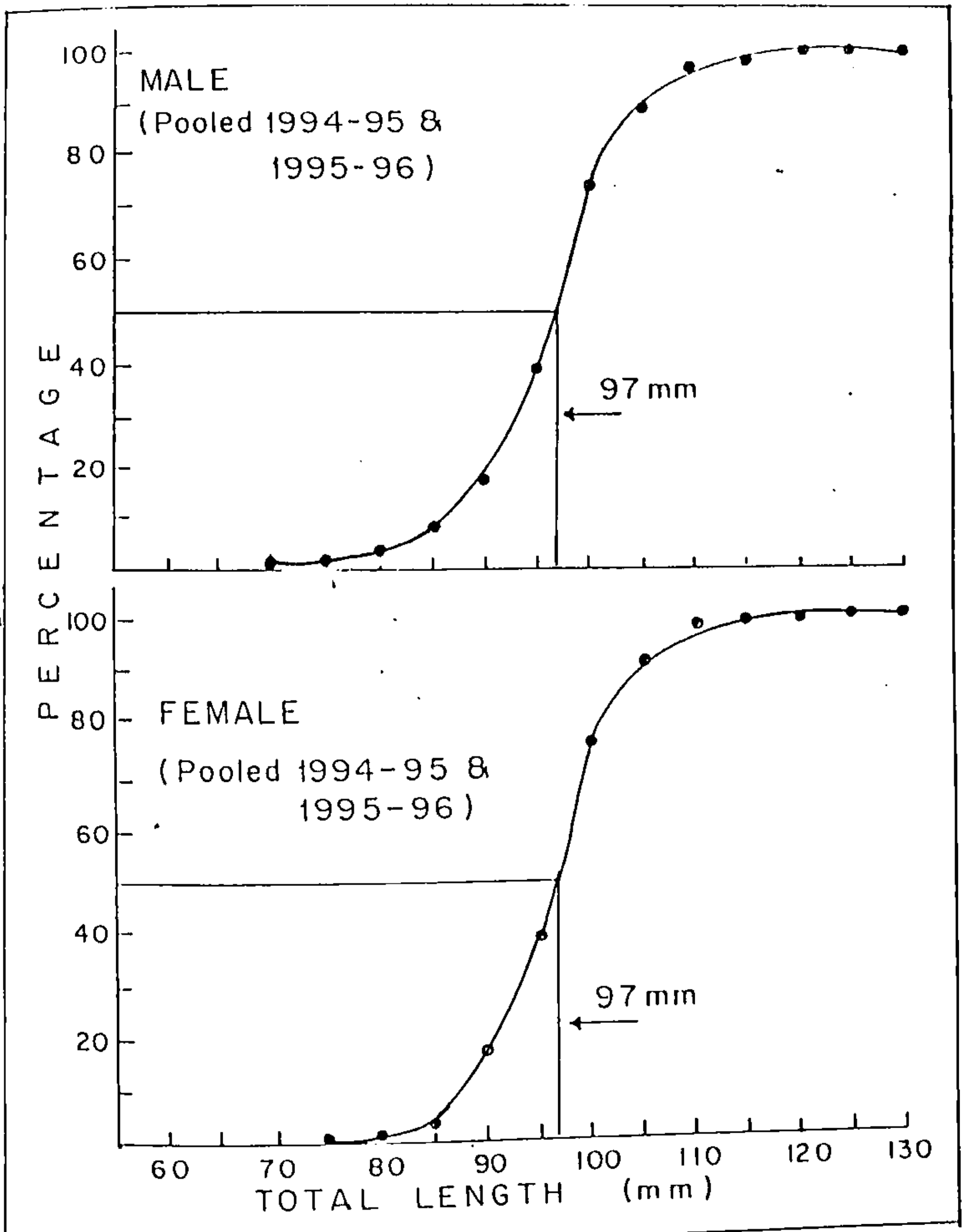


Fig. 4.9 Size at maturity in males and females of *C.macrostomus* based on pooled data for years 1994-95 and 1995-96

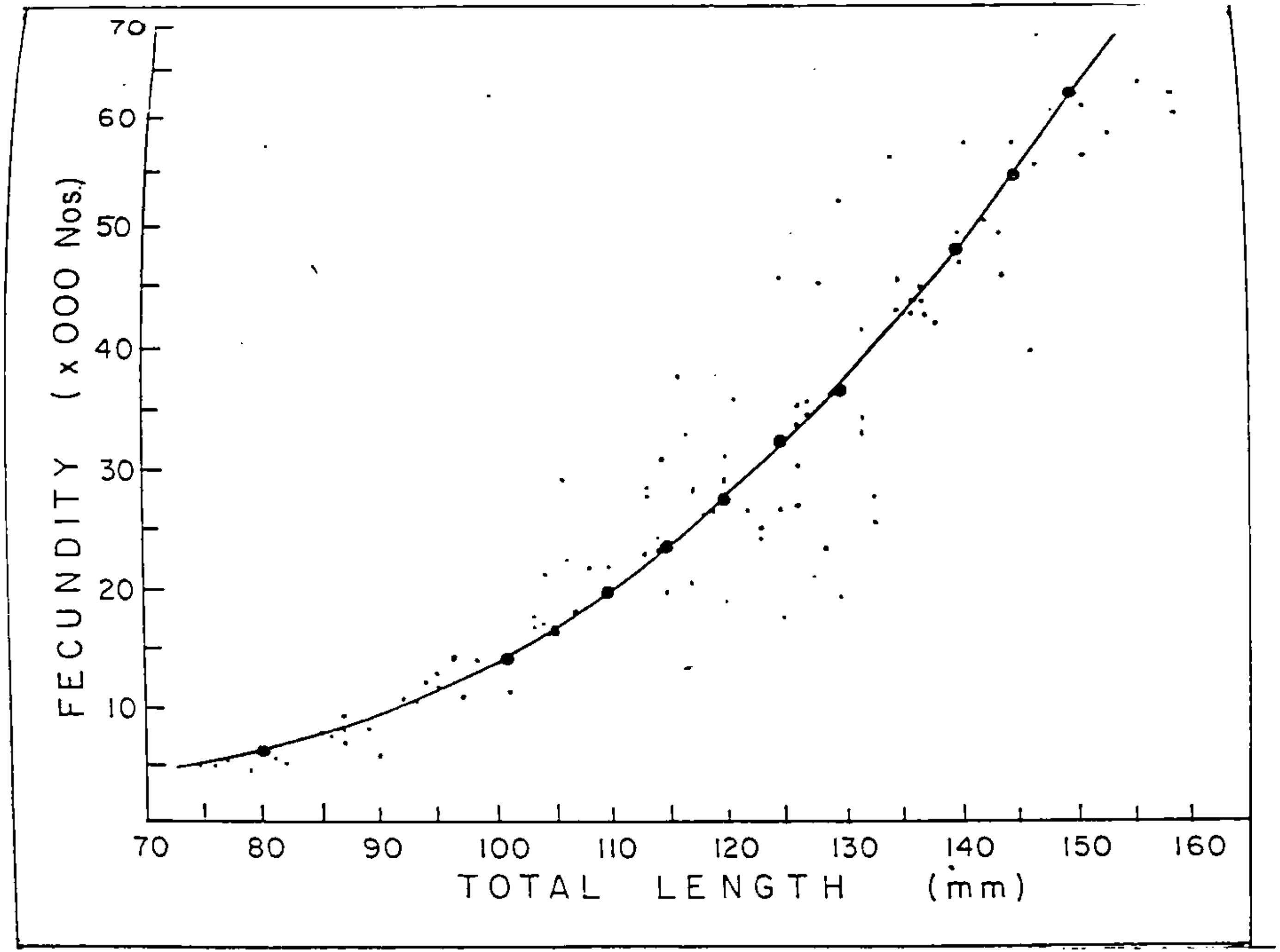


Fig. 4.10 Relation between fecundity and fish length in <u>C.macrostomus</u>

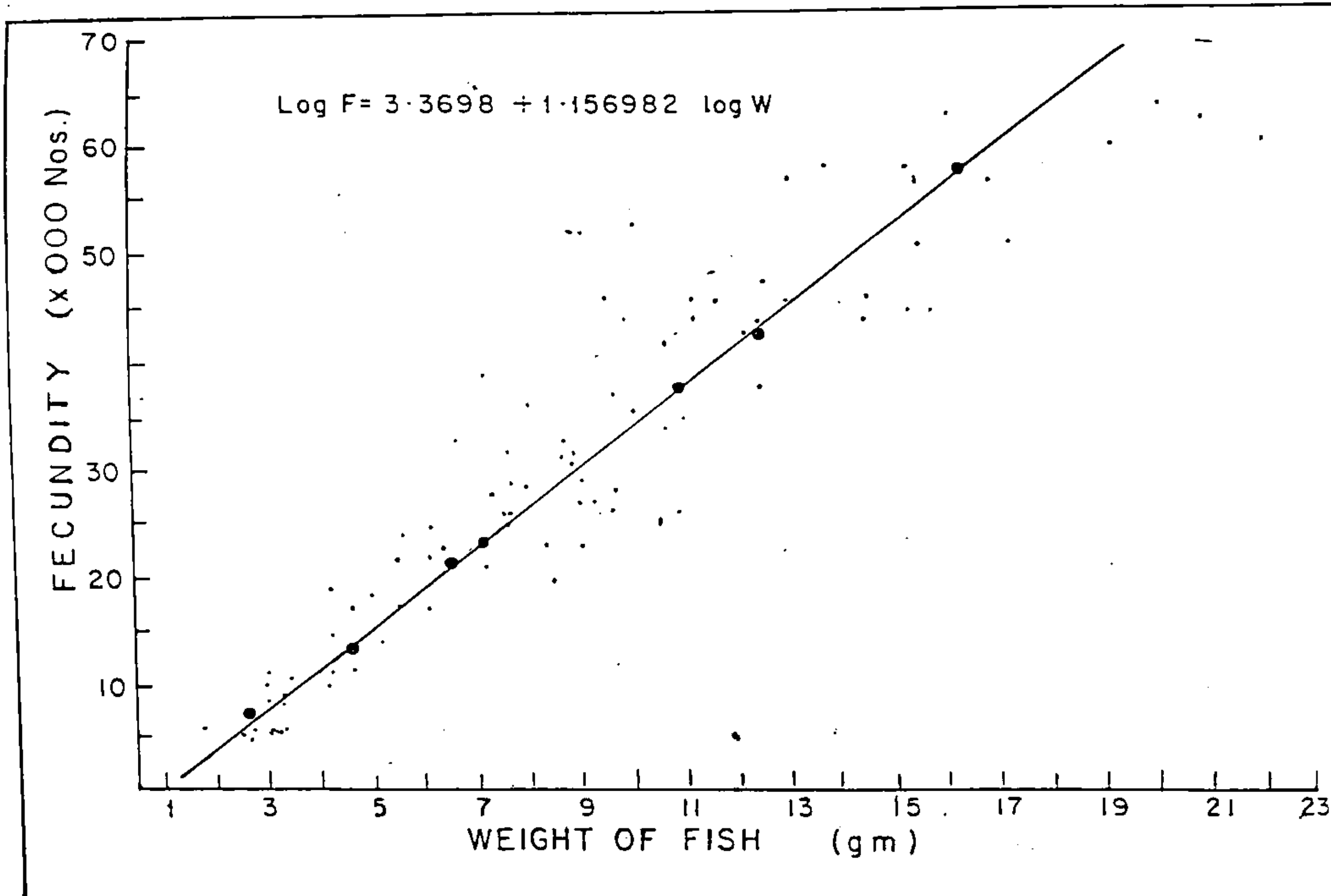


Fig. 4.11 Relation between fecundity and weight of C.macrostomus

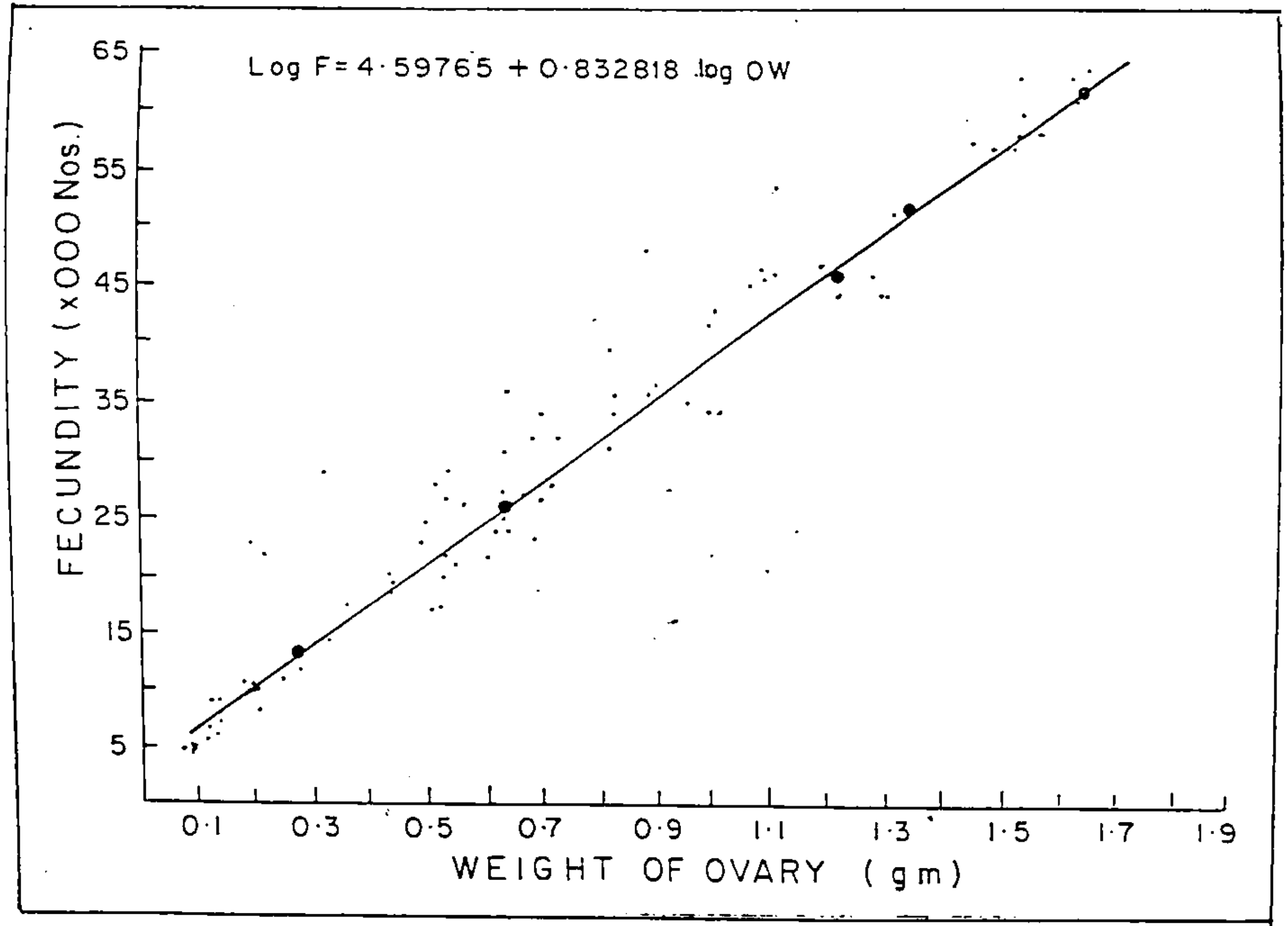


Fig. 4.12 Relation between weight of the ovary and fecundity in *C.macrostomus*

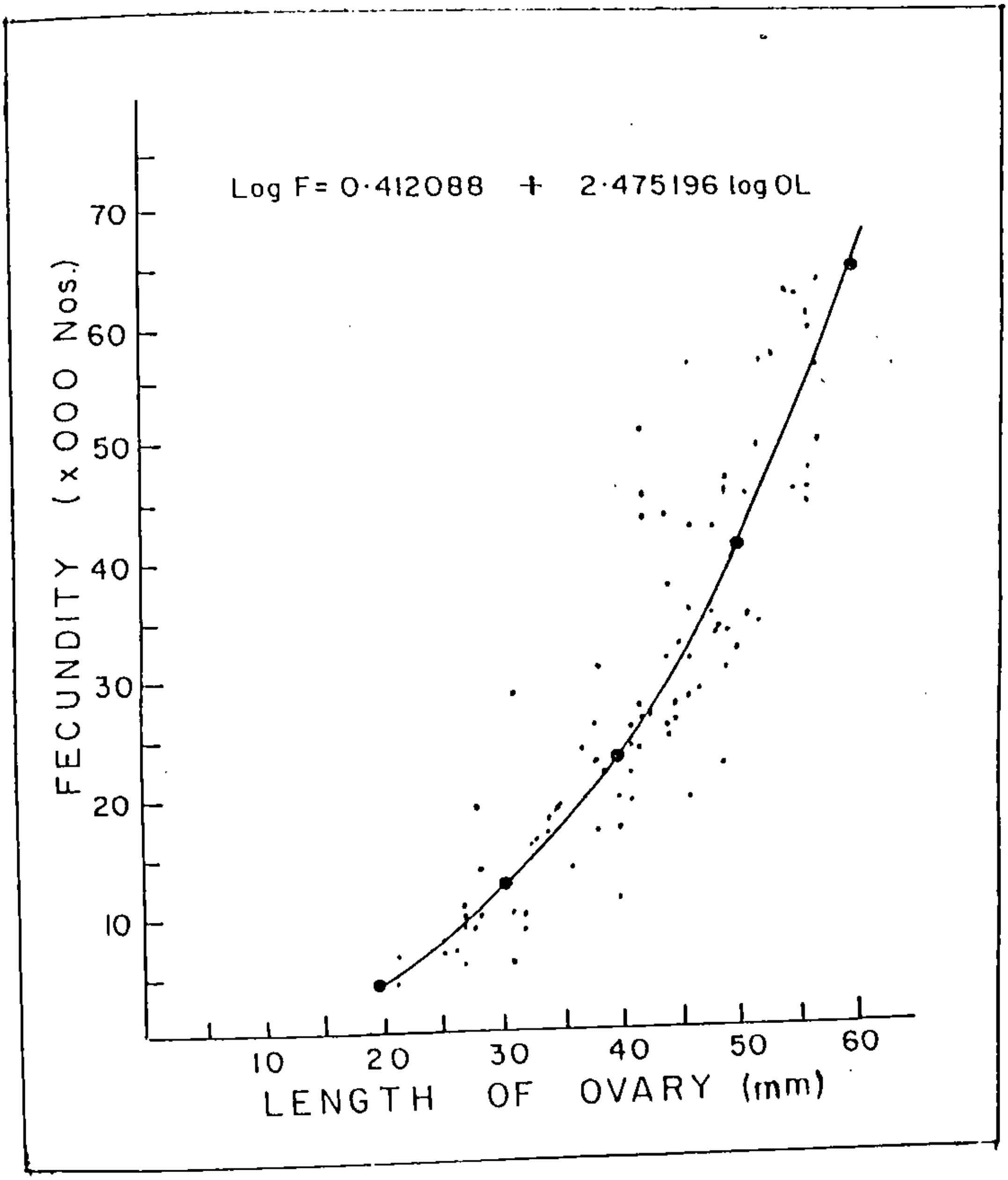


Fig. 4.13 Relation between fecundity and length of ovary in *C.macrostomus*

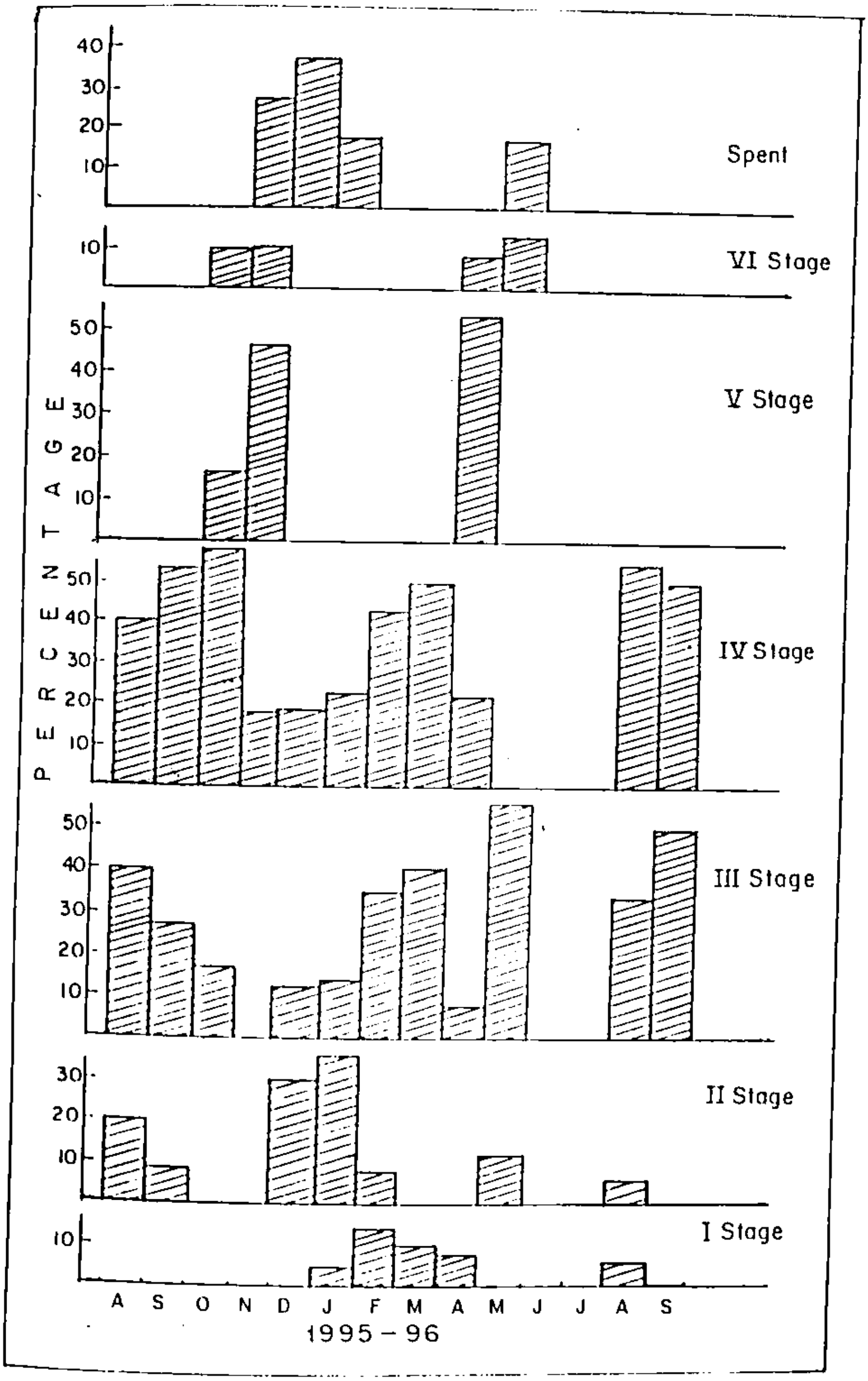


Fig. 4.14 Percentage occurrence of ovaries of Cynoglossus arel in different stages of maturity during 1995-96

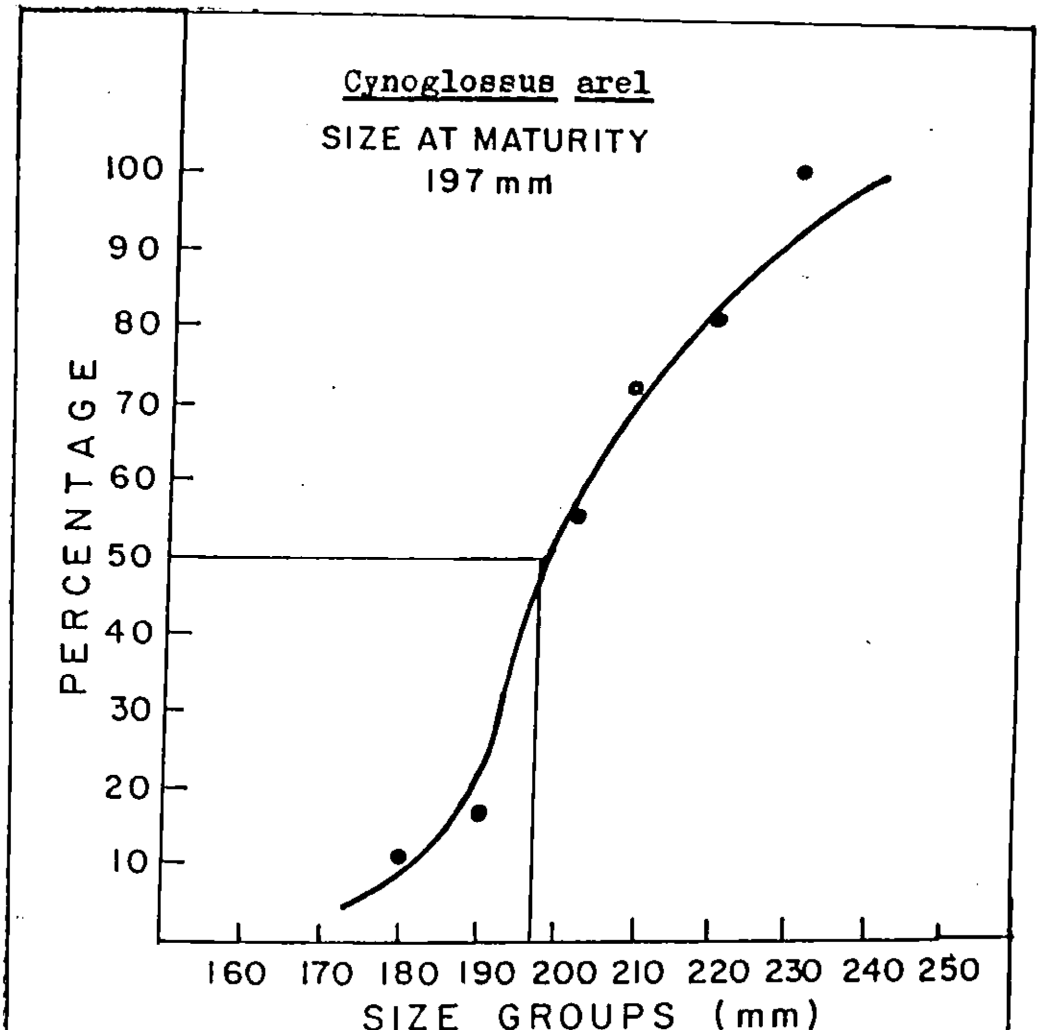


Fig. 4.15 Size at maturity in *Cynoglossus arel*

Table 4.1 Percentage occurrence of gonads of *C.macrostomus* in different stages of maturity

Cochin 1994-95

Month	No	Sex	I	II	III	IV	V	VI	VII
			Stages of maturity						
	90	F	-	3.3	24.4	72.2	-	-	-
Aug.	110	M	-	2.7	32.7	64.5	-	-	-
	69	F	1.4	47.8	21.7	28.9	-	-	-
Sep.	58	M	1.7	13.7	43.1	41.4	-	-	-
	136	F	2.2	2.9	0.7	24.3	16.2	5.9	47.8
Oct.	233	M	4.3	3.0	15.9	20.2	10.7	4.3	41.7
	176	F	-	13.6	0.6	0.6	0.6	1.7	82.9
Nov.	175	M	-	18.3	1.1	1.1	1.1	2.9	75.4
	83	F	-	34.9	1.2	1.2	-	-	62.7
Dec.	92	M	-	67.4	-	-	-	-	32.6
	226	F	92.9	2.2	2.7	2.2	-	-	-
Jan.	280	M	85.7	5.4	4.3	4.6	-	-	-
	288	F	88.9	4.2	1.4	3.5	1.4	-	0.7
Feb.	269	M	96.6	0.8	-	0.4	-	-	2.2
	170	F	47.6	28.8	4.1	8.2	5.3	3.5	2.4
Mar.	204	M	49.0	22.6	11.3	7.4	5.4	3.4	0.9
	106	F	34.9	31.1	9.4	13.2	4.7	-	6.6
Apr.	128	M	48.4	18.0	7.8	20.3	0.8	-	4.7
	112	F	-	27.7	18.8	13.4	-	-	40.1
May	126	M	9.5	39.7	33.3	11.9	-	-	5.6
	34	F	32.4	41.2	20.6	5.9	-	-	-
Jun.	67	M	41.8	29.9	20.8	7.5	-	-	-

Table 4.2 Percentage occurrence of gonads of *C.macrostomus* in different stages of maturity

Cochin 1995-96

Month	No	Sex	I	II	III	IV	V	VI	VII
			Stages of maturity						
Aug.	85	F	-	2.4	35.3	62.4	-	-	-
	121	M	0.8	2.5	40.5	56.2	-	-	-
Sep.	80	F	-	-	1.3	42.5	56.3	-	-
	68	M	2.9	1.5	1.5	42.6	51.5	-	-
Oct.	474	F	5.7	4.0	1.5	5.3	55.5	15.2	12.8
	510	M	0.2	5.3	11.2	6.3	30.4	34.5	12.2
Nov.	67	F	50.7	13.4	2.9	1.5	-	5.9	25.3
	82	M	37.8	21.9	1.2	-	-	7.3	31.7
Dec.	129	F	-	24.8	1.6	1.6	-	-	72.0
	199	M	-	74.4	1.0	0.5	-	-	24.1
Jan.	69	F	5.8	11.6	-	-	-	-	82.6
	90	M	-	20.0	-	-	-	-	80.0
Feb.	73	F	57.5	31.5	8.2	-	-	-	2.7
	89	M	52.8	24.6	8.9	2.2	-	-	11.2
Mar.	144	F	0.7	41.7	3.5	1.4	6.3	2.8	36.8
	185	M	-	53.5	1.1	2.2	9.7	2.2	31.3
Apr.	69	F	5.8	84.1	2.9	1.4	-	-	5.8
	57	M	7.0	87.7	-	-	1.8	-	-
May	286	F	0.3	26.6	66.4	6.6	-	-	-
	395	M	0.3	42.8	54.9	2.0	-	-	-
Jun	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug.	191	F	-	-	12.0	88.0	-	-	-
	150	M	-	1.3	26.0	72.7	-	-	-

Table 4.3 Percentage occurrence of gonads of *C.macrostomus* in different stages of maturity

FEMALES Neendakara 1994-95 to 1995-96

Month	No.of fish	Sex	Stages of maturity I	II	III	IV	V	VI	VII
Dec.94	101	F	12.9	84.2	-	-	-	-	2.9
Jan.95	133	F	0.8	28.5	5.3	5.3	1.5	-	58.6
Feb	48	F	35.4	29.2	18.7	2.1	-	-	-
Mar	87	F	5.4	61.1	4.2	5.6	7.2	6.1	10.4
Apr	109	F	11.9	28.4	27.5	15.6	2.8	4.6	5.5
May	76	F	7.8	27.3	64.9	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-
Sep	95	F	1.1	2.1	35.8	61.0	-	-	-
Oct	71	F	-	-	1.4	63.3	23.9	8.5	2.9
Nov	52	F	-	26.9	17.4	1.9	-	-	53.8
Dec	83	F	32.5	28.9	-	-	-	-	38.4
Jan.96	47	F	12.8	21.3	-	-	-	-	65.9
Feb	39	F	35.9	30.7	2.6	-	-	2.6	28.2
Mar	65	F	7.7	52.3	21.5	12.3	3.2	1.5	1.5
Apr	46	F	2.2	21.7	69.5	4.3	-	2.2	-
May	110	F	1.8	40.0	25.2	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-
Sep	43	F	-	2.3	4.7	39.5	34.9	7.0	11.6
Oct	131	F	-	-	6.9	42.7	19.8	0.8	29.8

Table 4.4 Ratios of smaller ova to larger ones during the spawning period in *C.macrostomus* from September to November 1995 at Cochin

Month	Tl. Fish (mm)	Stages of maturity	Ratio $\frac{B + C}{D}$	Ratio $\frac{C}{D}$
September	122	IV	1.63	0.97
	128	IV	7.30	5.2
	131	IV	1.4	0.73
	126	V	0.75	0.29
	124	IV	1.8	1.10
Average	126		2.5	1.6
October	134	IV	1.8	1.01
	129	IV	1.5	0.8
	115	V	0.6	0.21
	133	IV	1.4	0.77
Average	128		1.3	0.69
November	128	V	1.26	0.72
	131	V	1.94	1.18
	130	V	1.07	0.51
	129	IV	0.57	0.19
Average	130		1.21	0.65

Table 4.5 Percentage occurrence of different categories (based on GSI)in various months during 1994-95 and 1995-96 at Cochin

Month	Less than 1.0	1.0 - 1.5	1.5 and above
August 94	-	-	100.0
September	-	-	100.0
October	-	-	100.0
November	27.8	8.4	63.8
December	97.7	2.3	-
January 95	84.2	15.7	-
February	52.2	43.5	4.3
March	68.9	20.7	10.4
April	5.8	23.5	70.7
May	38.9	22.2	38.9
June	100.0	-	-
July	-	-	-
August	-	-	100.0
September	-	-	100.0
October	-	-	100.0
November	24.0	4.0	72.0
December	100.0	-	-
January '96	90.9	9.1	-
February	61.1	35.6	-
March	25.0	37.5	37.5
April	7.3	31.2	61.5
May	26.6	26.7	46.7
June	-	-	-
July	-	-	-
August	-	-	-
September	-	3.9	96.7

Table 4.6 Average monthly Gonado - Somatic Index of *C. macrostomus* during 1994-95 and 1995-96 at Cochin

Month	1994-95	1995-96
August	6.14	5.26
September	8.82	9.11
October	5.77	6.11
November	2.72	1.92
December	3.01	0.62
January	0.55	0.77
February	1.01	0.92
March	1.02	1.41
April	2.85	2.27
May	1.23	1.82
June	0.37	-
July	-	-
August	-	-
September	-	3.84

Table 4.7 Percentage occurrence of females of *C.macrostomus* in different stages of maturity in various size groups (1994-95) at Cochin

Size groups (mm)	No of fish	Maturity stages								
		I	II	III	IV	V	VI	VIIA	VII B	II B
50	-	-	-	-	-	-	-	-	-	-
55	3	100.0	-	-	-	-	-	-	-	-
60	7	100.0	-	-	-	-	-	-	-	-
65	21	95.2	4.8	-	-	-	-	-	-	-
70	62	98.4	1.6	-	-	-	-	-	-	-
75	148	97.9	2.1	-	-	-	-	-	-	-
80	185	90.8	8.6	0.6	-	-	-	-	-	-
85	135	81.5	17.8	0.7	-	-	-	-	-	-
90	105	58.1	25.7	10.5	5.7	-	-	-	-	-
95	72	29.2	26.4	15.3	29.2	-	-	-	-	-
100	58	6.9	17.2	44.8	20.7	-	-	-	6.9	3.4
105	64	-	17.2	23.4	34.4	4.7	1.6	1.6	15.6	1.6
110	91	-	3.3	19.8	25.3	5.5	1.1	5.5	30.8	8.8
115	168	-	4.2	10.7	23.8	4.8	-	16.7	32.1	7.7
120	141	-	0.7	2.1	24.1	5.7	0.7	12.8	41.8	12.1
125	111	-	-	3.6	21.6	5.4	0.9	10.8	47.7	9.9
130	54	-	-	3.7	25.9	-	5.6	7.4	50.0	7.4
135	44	-	-	-	29.5	11.4	6.8	6.8	38.6	6.8
140	30	-	-	3.3	20.0	3.3	10.0	3.3	26.7	10.0
145	10	-	-	-	-	-	30.0	-	30.0	20.0
150	2	-	-	-	100.0	-	50.0	-	-	50.0
155	2	-	-	-	66.7	-	-	-	-	-
160	3	-	-	-	-	-	-	-	-	33.3

Table 4.8 Percentage occurrence of females of *C.macrostomus* in different stages of maturity in various size groups (1995-96) at Cochin

Size groups (mm)	No of fish	Maturity stages I	II	III	IV	V	VI	VIIA	VII B	II B
50	1	100.0	-	-	-	-	-	-	-	-
55	2	100.0	-	-	-	-	-	-	-	-
60	2	100.0		-	-	-	-	-	-	-
65	7	100.0	-	-	-	-	-	-	-	-
70	16	81.3	19.7	-	-	-	-	-	-	-
75	42	57.1	40.5	2.4	-	-	-	-	-	-
80	51	41.2	54.9	3.9	-	-	-	-	-	-
85	90	27.8	66.7	3.3	2.2	-	-	-	-	-
90	115	11.3	70.4	6.1	6.9	5.3	-	-	-	-
95	135	3.7	60.7	17.0	9.6	8.9	-	-	-	-
100	75	-	22.7	42.7	17.3	14.7	-	1.3	1.3	-
105	80	-	2.5	37.5	23.8	23.8	7.5	2.5	2.5	-
110	89	-	1.1	18.0	38.2	29.2	3.4	3.4	3.4	3.4
115	139	-	-	5.0	13.7	41.7	9.4	12.9	8.6	8.6
120	219	-	-	4.1	21.0	27.9	8.2	18.3	13.2	7.3
125	196	-	-	2.0	17.3	33.2	10.7	17.3	12.8	6.6
130	129	-	-	-	10.0	29.5	8.5	14.0	19.4	18.6
135	80	-	-	-	11.3	40.0	7.5	6.3	16.3	18.9
140	42	-	-	-	24.4	28.6	4.8	14.3	16.7	14.3
145	18	-	-	-	11.1	27.8	-	11.1	11.1	39.9
150	12	-	-	-	50.0	33.3	-	8.3	8.3	-
155	2	-	-	-	50.0	50.0	-	-	-	-
160	1	-	-	-	100.0	-	-	-	-	-

Table 4.9 Percentage occurrence of males of *C.macrostomus* in different stages of maturity in various size groups (1994-95) at Cochin

Size groups (mm)	No of fish	Maturity stages I	II	III	IV	V	VI	VIIA	VII B	II B
55	1	100.0	-	-	-	-	-	-	-	-
60	2	100.0	-	-	-	-	-	-	-	-
65	22	100.0	-	-	-	-	-	-	-	-
70	74	100.0	-	-	-	-	-	-	-	-
75	195	91.3	7.7	1.0	-	-	-	-	-	-
80	259	89.9	9.3	0.4	0.4	-	-	-	-	-
85	163	76.6	17.2	4.3	0.6	-	-	1.2	-	-
90	88	60.2	17.0	20.5	2.3	-	-	-	-	-
95	82	24.4	29.3	37.8	6.1	-	-	1.2	-	1.2
100	68	1.5	22.1	30.9	32.4	-	-	7.4	1.5	4.4
105	89	1.1	1.5	19.1	35.9	3.4	-	8.9	6.7	10.1
110	132	-	5.3	21.2	25.8	4.5	-	14.4	13.6	15.2
115	163	-	3.1	23.3	25.8	2.5	0.6	10.4	17.2	17.2
120	161	-	-	13.7	21.1	6.2	4.3	11.8	24.8	18.0
125	107	-	-	11.2	26.2	6.5	5.6	26.2	12.6	4.7
130	73	-	-	-	32.9	4.1	5.5	19.0	31.5	6.8
135	38	-	-	5.3	31.6	7.9	7.9	7.9	34.2	5.3
140	22	-	-	-	9.1	13.6	4.5	9.1	54.5	9.1
145	12	-	-	-	41.7	-	-	-	50.0	8.3
150	2	-	-	-	50.0	-	-	-	-	50.0
155	1	-	-	-	-	-	-	-	-	100.0

Table 4.10 Percentage occurrence of males of *C.macrostomus* in different stages of maturity in various size groups(1995-96) at Cochin

Size groups (mm)	No of fish	Maturity stages								
		I	II	III	IV	V	VI	VIIA	VII B	II B
50	1	100.0	-	-	-	-	-	-	-	-
55	3	100.0	-	-	-	-	-	-	-	-
60	2	100.0	-	-	-	-	-	-	-	-
65	6	66.7	36.3	-	-	-	-	-	-	-
70	20	70.0	25.0	5.0	-	-	-	-	-	-
75	45	55.6	40.0	2.2	-	2.2	-	-	-	-
80	69	33.3	55.1	10.1	1.4	-	-	-	-	-
85	110	14.5	77.3	7.3	-	0.9	-	-	-	-
90	121	3.3	82.6	8.3	2.5	2.5	0.8	-	-	-
95	81	4.9	62.9	16.0	4.9	2.5	6.2	-	-	-
100	54	-	27.8	22.2	24.0	7.4	-	1.9	12.9	3.7
105	99	-	7.1	20.2	30.3	19.2	11.1	2.0	4.0	6.1
110	106	-	1.9	9.4	34.9	22.6	9.4	9.4	7.5	4.7
115	201	-	0.5	7.5	26.9	23.9	13.9	4.5	12.4	10.4
120	295	-	-	10.8	12.2	20.0	17.3	6.4	13.2	19.7
125	287	-	-	9.8	6.6	12.9	17.1	7.7	19.5	25.1
130	197	-	-	14.2	4.6	14.2	12.7	8.1	15.7	30.5
135	101	-	-	26.7	4.9	22.8	5.9	3.9	11.9	23.8
140	52	-	-	42.3	11.5	11.5	-	3.8	7.7	23.1
145	39	-	-	64.1	12.8	5.1	-	2.6	2.6	12.8
150	36	-	-	77.8	11.1	5.6	-	2.8	-	2.8
155	20	-	-	60.0	40.0	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-

Table 4.11 Percentage occurrence of immature and mature fishes in various size groups of *C.macrostomus*

Centre: Cochin Period: 1994-95 & 1995-96 (Pooled)

	MALE			FEMALE		
Stages	I & II	III & above	Total fishes	I & II	III & above	Total fishes
Tl mm						
50	100.0	-	1	100.0	-	1
55	100.0	-	4	100.0	-	5
60	100.0	-	4	100.0	-	9
65	100.0	-	28	100.0	-	28
70	98.9	1.1	94	100.0	-	78
75	98.3	1.7	240	99.5	0.5	190
80	97.0	3.0	328	98.7	1.3	236
85	93.0	7.0	273	97.3	2.7	225
90	82.3	17.7	209	82.7	17.3	220
95	60.7	39.3	163	61.4	38.6	207
100	25.5	74.5	122	23.3	76.7	133
105	11.2	88.8	188	9.1	90.9	143
110	3.8	96.2	238	2.2	97.8	180
115	1.6	98.4	364	2.4	97.6	296
120	-	100.0	411	0.3	99.7	353
125	-	100.0	351	-	100.0	300
130	-	100.0	229	-	100.0	173
135	-	100.0	90	-	100.0	114
140	-	100.0	38	-	100.0	62
145	-	100.0	20	-	100.0	19
150	-	100.0	10	-	100.0	13
155	-	100.0	1	-	100.0	4
160	-	-	-	-	100.0	4
Total			3406			2993

Table 4.12 Fecundity of the Malabar sole *C.macrostomus*

S.No.	Fish Tl mm (1)	Fish Wt.g (2)	Ovary Tl mm (3)	Ovary Wt.g (4)	Number of mature ova (5)	Stages maturity (6)
1	76	2.50	19	0.0775	5,021	IV
2	77	1.85	21	0.0823	5,332	IV
3	78	2.51	21	0.0877	4,978	IV
4	83	3.19	25	0.1279	5,408	IV
5	83	3.28	25	0.1315	5,561	IV
6	84	2.68	27	0.1355	5,227	IV
7	96	3.29	32	0.2149	7,551	IV
8	87	3.01	27	0.1435	8,144	IV
9	87	3.08	28	0.1950	9,527	IV
10	89	3.38	27	0.1358	8,732	IV
11	87	2.60	26	0.4410	7,022	IV
12	90	3.10	31	0.1137	5,972	IV
13	92	3.45	27	0.2045	10,419	IV
14	93	4.0	32	0.2011	10,244	IV
15	94	4.18	27	0.1882	12,226	V
16	95	4.59	30	0.2851	12,815	IV
17	96	5.22	28	0.3140	14,116	IV
18	97	4.18	32	0.2031	10,244	V
19	98	4.23	36	0.3301	14,601	V
20	101	3.12	40	0.2531	11,195	IV
21	103	4.25	58	0.4395	19,439	IV
22	104	4.60	34	0.5278	17,378	IV
23	104	5.55	39	0.6599	21,726	IV
24	104	5.58	40	0.3558	17,400	IV
25	105	5.58	40	0.3558	17,400	IV
26	106	7.70	31	0.3224	29,750	IV
27	107	5.00	34	0.4490	18,448	V
28	108	6.12	41	0.5322	21,866	IV
29	110	5.50	39	0.2241	22.097	IV
30	113	6.43	38	0.4884	23,098	IV
31	113	7.31	45	0.5131	28,098	V
32	113	7.95	46	0.1889	28,570	V
33	114	6.15	42	0.4966	24,673	IV
34	114	5.58	41	0.6188	24,203	IV
35	114	7.64	46	0.7283	31,954	IV
36	115	7.64	41	0.4489	19,763	IV
37	116	7.15	44	0.8254	38,885	V
38	117	6.58	48	0.8292	33,908	V
39	117	7.67	41	0.5640	26,442	IV
40	117	7.21	40	0.5554	20,946	V
41	118	7.52	45	0.6912	26,612	IV
42	119	9.68	42	0.7209	27,759	IV
43	120	8.69	38	0.8198	31,076	V

Table continued......

Table 4.12 continued. Fecundity of the Malabar sole

S.No.	(1)	(2)	(3)	(4)	(5)	(6)
44	120	9.10	47	0.5435	29,225	IV
45	121	8.12	48	0.9023	36,460	IV
46	122	9.26	42	0.6660	26,913	IV
47	122	9.60	51	0.6417	35,777	IV
48	123	9.00	37	0.6255	23,844	IV
49	123	8.97	44	0.6818	32,079	V
50	123	10.51	44	0.6390	24,962	IV
51	125	9.52	49	1.0976	46,419	IV
52	125	10.84	38	0.6316	26,712	IV
53	126	9.88	46	0.8162	35,453	V
54	126	9.00	43	0.5410	27,086	V
55	126	8.77	45	0.6998	33,883	IV
56	126	8.82	49	0.6302	31,254	IV
57	127	10.85	52	0.9624	34,846	IV
58	127	12.40	48	0.8896	35,488	IV
59	128	12.94	51	1.1486	45,824	IV
60	128	8.38	49	0.6858	23,245	IV
61	130	10.05	42	1.1217	53,392	IV
62	130	8.55	46	0.5304	19,889	IV
63	132	10.62	49	1.0135	41,678	IV
64	132	10.60	48	1.0642	33,759	IV
65	132	10.62	49	1.0838	34,128	IV
66	133	9.58	44	0.6205	25,715	IV
67	134	13.00	46	1.4516	57,494	IV
68	135	12.36	46	1.3310	43,915	IV
69	135	11.66	55	1.2701	45,757	V
70	136	12.16	46	1.0711	43,371	V
71	136	11.24	48	1.2245	43,770	IV
72	136	11.24	42	1.1147	43,427	IV
73	137	15.25	44	1.0732	44,701	IV
74	137	15.65	56	1.0199	45,362	IV
75	137	14.41	42	1.3035	43,537	IV
76	141	13.77	53	1.5336	58,297	IV
77	140	12.50	49	0.8966	47,580	IV
78	142	17.21	52	1.3111	50,761	V
79	144	14.45	56	1.1987	46,410	IV
80	145	15.21	56	1.5665	58,125	V
81	147	15.35	57	1.5169	56884	IV
82	148	15.41	57	1.3480	50549	V
83	151	16.08	54	1.5359	62,719	V
84	151	16.88	52	1.4775	57,202	IV
85	153	19.1	56	1.5487	59,959	IV
86	156	20.0	57	1.6643	64,434	IV
87	158	20.8	55	1.6328	63,216	IV
88	159	21.9	56	1.6470	61,112	IV

Table 4.13. Fecundity in relation to various size groups of *C. macrostomus*

Length of fish TL mm	Weight of fish g.	Length of ovary mm	Weight of ovary g.	Fecundity Nos.	No.of eggs per 1 g. Body wt.	Av.No.of eggs per 0.1 g.wt. of ovary
83.3	3.05	25.7	0.1316	5,399	1770	4102
87.2	3.07	28.0	0.1667	8,195	2669	4916
92.3	3.68	29.3	0.1298	9,715	2639	7484
96.5	4.56	31.5	0.2831	12,944	2838	4572
103.2	4.72	35.8	0.4803	16,778	3554	3493
106.5	6.10	36.5	0.4148	21,866	3584	5271
113.0	6.65	42.4	0.4655	26,099	3924	5606
117.0	7.65	43.0	0.6622	27,759	3628	4191
121.8	9.16	43.9	0.6899	30,042	3279	4354
126.4	10.14	47.0	0.8103	34,021	3355	4198
131.8	10.43	47.2	0.9837	38,008	3644	3864
136.1	12.99	47.4	1.1772	44,605	3433	3789
141.8	14.48	52.5	1.2350	50,762	3505	4110
146.7	15.32	54.0	1.4771	55,186	3602	3736
151.7	17.35	56.0	1.5207	59,960	3455	3942
157.7	20.9	56.7	1.6480	62,921	3010	3818
Average					3243	4465

Table 4.14. Absolute and relative fecundity at 5 mm length ranges of *C. macrostomus*

Fish TL mm	Fish Wt g	Length of fish & fecundity	Length OW. & fecundity	Wt.ovary & fecundity	Wt. of fish & fecundity	Absolute fecundity
80	3.05	6905	7979	7313	8513	5399
85	3.07	8581	9864	8905	8578	8195
90	3.68	10537	11037	7230	10579	9715
95	4.56	12799	13203	13842	13558	12944
100	4.72	15396	18123	21498	14110	16778
105	6.10	17247	19013	19027	18985	21866
110	6.65	21715	27551	20945	20979	26099
115	7.65	25499	28526	28090	24670	27759
120	9.16	29743	30026	29066	30387	30042
125	10.14	32524	35551	33232	34179	34021
130	10.43	39745	35927	39057	35313	38008
135	12.99	45574	36305	45358	45522	44605
140	14.48	52002	46754	47205	51616	50762
145	15.32	59067	50130	54794	55096	55186
150	17.35	66809	54852	56138	63627	59960
155	20.9	75265	56565	60025	78919	62921

Table 4.15 Sex ratio in the pre-adults of *C.macrostomus* during 1994-95 at Cochin

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Aug. 94	27	62.9	37.1	1.7 : 1	1.8148	NS
Sep	4	-	100.0	0 : 1	4.0000	S
Oct	1	-	100.0	0 : 1	1.0000	NS
Nov	3	66.7	33.3	2 : 1	0.3333	NS
Dec	32	71.8	38.2	2.6 : 1	6.1250	S
Jan	495	54.5	45.5	1.2 : 1	4.0909	S
Feb	577	55.6	44.4	1.3 : 1	7.3224	S
Mar	210	52.9	47.1	1.1 : 1	0.6857	S
Apr	231	55.4	44.6	1.2 : 1	2.7056	NS
May	16	56.3	43.7	1.3 : 1	0.2500	NS
Jun	101	71.3	28.7	2.5 : 1	18.3069	S
Total	1697	56.2	43.8	1.3 : 1	27.7400	S

Table 4.16 Sex ratio in the adults of *C.macrostomus* during 1994-95 at Cochin

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Aug. 94	174	52.3	47.7	1.1 : 1	0.3678	NS
Sep	123	46.3	53.7	0.9 : 1	0.6583	NS
Oct	138	55.1	44.9	1.2 : 1	1.4202	NS
Nov	191	53.4	46.4	1.1 : 1	0.8848	NS
Dec	296	65.5	34.5	1.9 : 1	28.5946	S
Jan	65	58.5	41.5	1.4 : 1	1.8615	NS
Feb	100	58.0	42.0	1.4 : 1	2.5600	NS
Mar	107	52.3	47.7	1.1 : 1	0.2336	NS
Apr	109	49.5	50.5	0.9 : 1	0.0092	NS
May	132	43.2	56.8	0.8 : 1	2.4545	NS
Jun	37	81.1	18.9	4.3 : 1	14.2972	S
Total	1472	55.2	44.8	1.2 : 1	16.1114	S

Table 4.17 Sex ratio in the pre-adults of *C.macrostomus* during 1995-96 at Cochin

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Aug.95	2	100.0	-	2 : 0	2.0000	
Sep	9	77.8	22.2	3.5 : 1	2.7777	
Oct	162	56.2	43.8	1.3 : 1	2.4691	
Nov	78	47.4	52.6	0.9 : 1	0.2051	
Dec	-	-	-	- -	-	
Jan	28	53.6	46.4	1.2 : 1	0.1429	
Feb	382	56.5	43.5	1.3 : 1	6.5445	S
Mar	35	57.1	42.9	1.3 : 1	0.7143	
Apr	323	46.4	63.6	0.8 : 1	1.6378	
May	288	59.4	40.6	1.5 : 1	10.1250	S
Jun	-	-	-	- -	-	
Jul	-	-	-	- -	-	
Aug	1	100.0	-	- -	1.000	
Total	1308	54.3	45.7	1.2 : 1	9.5902	S

Table 4.18 Sex ratio in the adults of *C.macrostomus* during 1995-96 at Cochin

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Aug.95	223	60.9	39.1	1.6 : 1	10.7668	S
Sep	145	42.8	57.2	0.7 : 1	3.0414	
Oct	863	53.1	46.9	1.1 : 1	3.2549	
Nov	68	60.2	39.8	1.5 : 1	2.8824	
Dec	328	60.7	39.3	1.5 : 1	14.9390	S
Jan	197	48.2	51.8	0.9 : 1	0.2487	
Feb	49	46.9	53.1	0.9 : 1	0.1837	
Mar	300	56.0	44.0	1.3 : 1	4.3200	S
Apr	394	57.1	42.9	1.3 : 1	7.9593	S
Jun	-	-	-	-	-	
Jul	-	-	-	-	-	
Aug	339	43.9	56.1	.8 : 1	4.9587	S
Total	2991	52.9	47.1	1.1 : 1	10.2391	S

Table 4.19 Sex ratio in the adults of *C.macrostomus*
Centre: Neendakara Period 1994-95

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Aug.94	208	57.2	42.8	1.3 : 1	4.3269	*
Sep	489	58.3	41.7	1.4 : 1	13.4172	*
Oct	248	64.1	35.9	1.8 : 1	19.7581	*
Nov	191	53.4	46.6	1.1 : 1	0.5548	
Dec	230	40.0	60.0	0.7 : 1	9.2000	*
Jan	286	53.1	46.9	1.1 : 1	1.1132	
Feb	50	46.0	54.0	0.9 : 1	0.3200	
Mar	91	51.6	48.4	1.1 : 1	0.0989	
Apr	147	59.9	40.1	1.5 : 1	5.7211	*
May	60	43.3	56.7	0.8 : 1	1.0667	
Total	2000	54.7	45.3	1.2 : 1	17.2980	*

*Significant

Table 4.20 Sex ratio in the adults of *C.macrostomus*
Centre: Neendakara Period 1995-96

Month	No. examined	Percentage M	Percentage F	Sex ratio M F	Chi-sq.	Remarks
Sep.95	778	60.2	39.8	1.5 : 1	32.0874	*
Oct.	257	61.5	38.5	1.6 : 1	13.5447	*
Nov.	332	45.2	54.8	0.8 : 1	3.0843	
Dec.	125	43.2	56.8	0.8 : 1	2.3120	
Jan.	190	64.7	35.3	1.8 : 1	16.5053	*
Feb.	180	65.0	35.0	1.8 : 1	16.2000	*
Mar.	123	50.4	49.6	1.0 : 1	0.0081	
Apr.	255	50.9	49.1	1.0 : 1	0.0980	
May.	349	43.8	56.2	0.8 : 1	5.2979	*
Jun.	-	-	-	-	-	
Jul.	-	-	-	-	-	
Aug.	-	-	-	-	-	
Sep.	148	70.3	29.7	2.4 : 1	24.3243	*
Oct.	340	64.7	35.3	1.8 : 1	29.4118	*
Total	3077	56.5	43.5	1.3 : 1	52.2590	*

* Significant.

Table 4.21 Sex ratio in the adults of *C.macrostomus*

Centre: Ambalapuzha Period 1994-95

Month	No. examined	Percentage M	Percentage F	Sex ratio M : F	Chi-sq.	Remarks
Oct.94	188	55.8	44.2	1.3 : 1	2.5745	
Nov	479	74.5	25.5	2.9 : 1	115.2922	*
Dec	8	50.0	50.0	1 : 1	0.0000	
Jan.	36	63.9	36.1	1.8 : 1	2.7778	
Feb	7	57.1	42.9	1.3 : 1	0.1429	
Mar	192	55.2	44.8	1.2 : 1	2.0833	
Apr.	59	25.4	74.6	0.3 : 1	14.2542	*
Mau	319	84.0	16.0	5.3 : 1	147.6144	*
Jun.	-	-	-	-	-	
Jul.	-	-	-	-	-	
Aug.	378	56.8	43.1	0.9 : 1	2.0741	
Sep.	281	41.6	58.4	0.7 : 1	7.8612	*
Total	1947	60.3	39.7	1.5 : 1	82.5891	*

Table 4.22 Sex ratio in adult *C. macrostomus*

Centre: Ambalapuzha Period: 1995-96

Month	No.examined	Percentage Male	Percentage Female	Sex ratio Male : Female	Chi-Sq. values	
October 1995	153	55.6	44.4	1.3 : 1	1.8888	
November	29	62.1	37.9	1.6 : 1	1.6897	
December	39	53.8	46.2	1.2 : 1	0.2308	
January 96	85	34.1	65.9	0.5 : 1	8.5765	*
February	10	40.0	60.0	0.7 : 1	0.4000	
March	43	34.9	65.1	0.5 : 1	3.9302	*
April	270	39.6	60.4	0.6 : 1	11.6148	*
May	183	23.5	76.5	0.3 : 1	51.4153	*
June	-	-	-	-	-	
July	-	-	-	-	-	
August	-	-	-	-	-	
September	-	-	-	-	-	
October	217	54.8	45.2	1.2 : 1	2.0322	
Total	1029	4209	5701	0.8 : 1	21.0000	*

* significant

Table 4.23 Sex ratio and Chi-square values of *C.macrostomus* in relation to size groups during 1994-95

Centre: Cochin

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.	
55	4	1	3	25.0	75.0	0.3:1	1.0000	
60	15	7	8	46.7	53.3	0.9:1	0.0667	
65	64	32	32	50.0	50.0	1:1	0.0000	
70	178	103	75	57.9	42.1	1.4:1	4.4045	*
75	378	222	156	58.7	41.3	1.4:1	11.5238	*
80	497	302	195	60.8	39.2	1.5:1	23.0362	*
85	351	192	159	54.7	45.3	1.2:1	3.1026	
90	226	107	119	47.3	52.7	0.9:1	0.6372	
95	159	96	63	60.4	39.6	1.5:1	6.8491	*
100	121	68	53	56.2	43.8	1.3:1	1.8595	
105	138	83	55	60.1	39.9	1.5:1	5.6812	*
110	224	141	83	62.9	37.1	1.7:1	15.0179	*
115	332	191	141	57.5	42.5	1.4:1	7.5301	*
120	306	184	122	60.1	39.9	1.5:1	12.5621	*
125	182	91	91	50.0	50.0	1:1	0.0054	
130	110	60	50	54.5	45.5	1.2:1	0.9091	
135	59	22	37	37.3	62.7	0.6:1	3.8136	*
140	32	8	24	25.0	75.0	0.3:1	8.0000	*
145	14	5	9	35.7	64.3	0.6:1	1.1428	
150	1	1	-	100.0	-	1:0	1.0000	
155	6	4	2	66.7	33.3	2:1	0.6667	
160	2	1	1	50.0	50.0	1:1	0.0000	

* Significant.

Table 4.24 Sex ratio and Chi-square values in relation to size of *C.macrostomus* groups during 1995-96

Centre: Cochin

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.
45	4	-	-	-	-	-	-
50	9	-	-	-	-	-	-
55	6	4	2	66.7	33.3	2:1	0.6667
60	4	2	2	50.0	50.0	1:1	0.0000
65	31	15	16	48.4	51.6	0.9:1	0.0323
70	83	48	35	57.8	42.2	1.4:1	2.0361 *
75	192	112	80	58.3	41.7	1.4:1	5.3333 *
80	270	145	125	53.7	46.3	1.2:1	1.4815
85	333	174	159	52.3	47.7	1.1:1	0.6757
90	384	205	179	53.4	46.6	1.1:1	1.7604
95	365	192	173	52.6	47.4	1.1:1	0.9890
100	218	127	91	58.3	41.7	1.4:1	5.9449 *
105	208	125	83	60.1	39.9	1.5:1	8.4808 *
110	211	116	95	54.9	45.1	1.2:1	2.0900
115	383	200	183	52.2	47.8	1.1;1	0.7546
120	479	261	218	54.5	45.5	1.2:1	3.8601 *
125	455	227	228	49.9	50.1	0.9:1	0.0022
130	345	184	161	53.3	46.7	1.1:1	1.5333
135	241	72	97	42.6	57.4	0.7:1	3.6982 *
140	70	31	39	44.3	55.7	0.8:1	0.9142
145	30	12	18	40.0	60.0	0.7:1	1.2000
150	23	8	15	34.8	65.2	0.5:1	2.1300
155	4	-	4	-	100.0	-	-

* significant

Table 4.25 Sex ratio and Chi-square values in relation to size groups of *C.macrostomus*

Centre: Quilon Period: August 1994 to May '95

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.
60	1	1	-	100.0	-	-	-
65	1	1	-	100.0	-	-	-
70	7	7	-	100.0	-	-	-
75	32	23	9	71.9	28.1	2.6:1	6.1250 *
80	159	89	70	55.9	44.1	1.3:1	2.2704
85	226	112	114	49.6	50.4	0.9:1	0.0177
90	217	94	123	43.3	56.7	0.8:1	3.8756 *
95	151	78	73	51.7	48.3	1.1:1	0.1656
100	134	79	55	58.9	41.1	1.4:1	4.2985 *
105	175	94	81	53.7	46.3	1.2:1	0.9657
110	253	137	116	54.2	45.8	1.2:1	1.7431
115	312	163	149	52.2	47.8	1.1:1	0.6282
120	277	137	140	49.5	50.5	0.9:1	0.0324
125	236	130	106	55.1	44.9	1.2:1	2.4407
130	156	85	71	75.2	24.8	1.2:1	1.2564
135	113	65	48	57.5	42.5	1.4:1	2.5575
140	71	37	34	52.1	47.9	1.1:1	0.1268
145	49	36	13	73.5	26.5	2.8:1	13.7959 *
150	22	17	5	77.3	22.7	3.4:1	6.5454 *
155	13	4	9	30.8	69.2	0.4:1	1.9231
160	9	1	8	11.1	88.9	0.1:1	5.4444 *

* Significant

Table 4.26 Sex ratio and Chi-square values in relation to size groups of *C.macrostomus*

Centre: Quilon Period: September 1995 to October 96

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.
40	1	1	-	100.0	-	-	-
45	1	1	-	100.0	-	-	-
50	-	-	-	-	-	-	-
55	1	1	-	100.0	-	-	-
60	7	6	1	85.7	14.3	6:1	3.5714 *
65	20	12	8	60.0	40.0	1.5:1	0.8000
70	75	48	27	64.0	36.0	1.8:1	2.2533
75	259	139	120	53.7	46.3	1.2:1	1.3938
80	538	295	243	54.8	45.2	1.2:1	5.0260 *
85	685	432	253	63.1	36.9	1.7:1	46.7752 *
90	673	368	305	54.7	45.3	1.2:1	5.8975 *
95	497	272	225	54.7	45.3	1.2:1	4.4444 *
100	247	116	131	46.9	53.1	0.8:1	0.9109
105	163	84	79	51.5	48.5	1.0:1	1.3803
110	206	118	88	57.3	42.7	1.3:1	4.3689 *
115	323	205	118	63.5	36.5	1.7:1	23.4334 *
120	394	232	162	58.9	41.1	1.4:1	12.4365 *
125	408	228	180	55.9	44.1	1.3:1	5.6471 *
130	312	195	117	62.5	37.5	1.7:1	19.5000 *
135	265	140	125	52.8	47.2	1.1:1	0.8491
140	116	65	51	56.0	44.0	1.3:1	1.6897
145	73	50	23	68.5	31.5	2.2:1	9.4800 *
150	42	25	17	59.5	40.5	1.5:1	1.5238
155	20	8	12	40.0	60.0	0.7:1	0.8000
160	9	1	8	11.1	88.9	0.1:1	5.4444 *
165	2	-	2	-	100.0	-	-

* Significant

Table 4.27 Sex ratio and Chi-square value in relation to size groups of *C.macrostomus*

Centre: Ambalapuzha Period: Oct. 1994 to Sep. 1995

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.
55	3	2	1	66.7	33.3	2:1	0.3333
60	13	8	5	61.5	38.5	1.6:1	0.6923
65	81	39	42	48.1	51.9	0.9:1	0.1111
70	259	139	120	53.7	46.3	1.2:1	1.3939
75	552	335	217	60.6	39.4	1.5:1	25.2246 *
80	668	390	278	58.4	41.6	1.4:1	18.7784 *
85	544	327	217	60.1	39.9	1.5:1	22.2426 *
90	382	216	166	56.5	43.5	1.3:1	6.5445 *
95	274	179	95	65.3	34.7	1.8:1	25.7518 *
100	223	136	87	60.9	36.1	1.6:1	10.7668 *
105	300	184	116	61.3	39.7	1.6:1	15.4133 *
110	296	157	139	53.0	47.0	1.1:1	1.0946
115	267	140	127	52.4	47.6	1.1:1	0.6329
120	190	95	95	50.0	50.0	1:1	0.0000
125	132	68	64	51.5	48.5	1.1:1	0.1212
130	46	20	26	43.5	56.5	0.7:1	0.7826
135	23	4	19	17.4	82.6	0.2:1	9.7826 *
140	8	5	3	62.5	37.5	1.7:1	0.5000
145	5	3	2	60.0	40.0	1.5:1	0.2000
150	1	-	1	-	100.0	0:1	-

* Significant

Table 4.28 Sex ratio and Chi-square values in relation to size groups of *C.macrostomus*

Centre: Ambalapuzha Period: Oct. 1995 to Oct.1996

Size Tl mm	No. Fish	Male	Female	% age Male	% age Female	Sex ratio M : F	Chi-sq.
55	1	1	-	100.0	-	-	-
60	5	4	1	80.0	20.0	4:1	1.8000
65	52	36	16	69.2	30.8	2.3:1	7.6923 *
70	229	135	94	58.9	41.1	1.4:1	7.3406 *
75	565	364	201	64.4	35.6	1.8:1	47.0248 *
80	966	538	428	55.7	44.3	1.5:1	12.5258 *
85	1004	612	392	60.9	39.1	1.6:1	48.2072 *
90	781	342	439	43.8	56.2	0.8:1	12.0474 *
95	441	165	276	37.4	62.6	0.6:1	27.9388 *
100	163	57	106	34.9	65.1	0.5:1	14.7301 *
105	84	44	40	52.4	47.6	1.1:1	0.1904
110	82	43	39	52.4	47.6	1.1:1	0.1951
115	91	44	47	48.4	51.6	0.9:1	0.0989
120	76	44	32	57.8	42.2	1.4:1	0.8421
125	47	23	24	48.9	51.1	0.9:1	0.0213
130	21	14	7	66.6	36.4	2.0:1	2.3333
135	12	4	8	33.3	66.7	0.5:1	1.3333
140	1	-	-	-	100.0	0.0:1	-
145	5	3	2	60.0	40.0	1.5:1	0.2000
150	1	-	1	-	100.0	0.0:1	-

* Significant

Table 4.29 Comparison of the sex ratio in the adults of *C.macrostomus* at three centres

Period: 1994-95 to 1995-96

Month	SEX RATIO Cochin M:F	Neendakara M:F	Ambalapuzha M:F
Aug. 94	1.1:1	1.3:1	-
Sep.	0.9:1	1.4:1	-
Oct.	1.2:1	1.8:1	1.3:1
Nov.	1.1:1	1.1:1	2.9:1
Dec.	1.9:1	0.7:1	1:1
Jan. 95	1.4:1	1.1:1	1.8:1
Feb.	1.4:1	0.9:1	1.3:1
Mar.	1.1:1	1.1:1	1.2:1
Apr	0.9:1	1.5:1	0.3:1
May	0.8:1	0.8:1	5.3:1
Jun.	4.3:1	-	-
Jul.	-	-	-
Aug.	1.6:1	-	-
Sep	0.7:1	1.5:1	0.7:1
Oct.	1.1:1	1.6:1	1.3:1
Nov	1.5:1	0.8:1	1.6:1
Dec.	1.5:1	0.8:1	1.2:1
Jan.96	0.9:1	1.8:1	0.5:1
Feb.	0.9:1	1.8:1	0.7:1
Mar.	1.3:1	1:1	0.5:1
Apr.	0.5:1	1.1:1	0.6:1
May	1.3:1	0.8:1	0.3:1
Jun.	-	-	-
Jul.	-	-	-
Aug.	0.8:1	-	-
Sep.	-	2.4:1	-
Oct.	-	1.8:1	1.2:1

Table 4.30 Comparison of the sex ratio in different size groups of *C.macrostomus* at various centres 1994-95 to 1995-96

	1994-95			1995-96		
	Cochin	Quilon**	Ambal*	Cochin	Quilon	Ambal*
Tl mm	M:F	M:F	M:F	M:F	M:F	M:F
55	0.3:1	2:1	-	2:1	-	-
60	0.9:1	1.6:1	-	1:1	4:1	6:1
65	1:1	0.9:1	-	0.9:1	2.2:1	1.5:1
70	1.4:1	1.2:1	-	1.4:1	1.4:1	1.8:1
75	1.4:1	1.5:1	2.6:1	1.4:1	1.8:1	1.2:1
80	1.5:1	1.4:1	1.3:1	1.2:1	1.5:1	1.2:1
85	1.2:1	1.5:1	0.9:1	1.1:1	1.5:1	1.7:1
90	0.9:1	1.3:1	0.8:1	1.1:1	0.8:1	1.2:1
95	1.5:1	1.9:1	1.1:1	1.1:1	0.6:1	1.2:1
100	1.3:1	1.6:1	1.4:1	1.4:1	0.5:1	0.8:1
105	1.5:1	1.6:1	1.2:1	1.5:1	1.1:1	1.1:1
110	1.7:1	1.1:1	1.2:1	1.2:1	1.1:1	1.3:1
115	1.4:1	1.1:1	1.1:1	1.1:1	0.9:1	1.7:1
120	1.5:1	1:1	0.9:1	1.2:1	1.4:1	1.4:1
125	1:1	1.1:1	1.2:1	0.9:1	0.9:1	1.3:1
130	1.2:1	0.8:1	1.2:1	1.1:1	2.0:1	1.7:1
135	0.6:1	0.2:1	1.4:1	0.7:1	0.5:1	1.1:1
140	0.3:1	1.7:1	1.1:1	0.8:1	0:1	1.3:1
145	0.6:1	1.5:1	2.8:1	0.7:1	1.5:1	2.2:1
150	1:0	0:1	3.4:1	0.5:1	0:1	1.5:1
155	2:1	-	0.4:1	-	-	0.7:1
160	1:1	-	0.1:1	-	-	0.1:1

* Ambalapuzha

** Neendakara

Table 4.31 Percentage distribution of maturity stages of *C.arel*

Centre: Quilon August 1995 - September 1996

Month	No. fish	Sex	Maturity stages I	II	III	IV	V	VI	VII
Aug.95	12	M	8.3	8.3	41.7	41.7	-	-	-
	10	F	-	20.0	40.0	40.0	-	-	-
Sep.	14	M	-	-	42.9	50.0	7.1	-	-
	10	F	-	9.0	27.3	54.5	-	-	-
Oct.	18	M	-	-	5.6	66.6	16.7	11.1	-
	12	F	-	-	16.7	58.3	16.7	8.3	-
Nov.	7	M	-	-	-	42.8	28.6	-	28.6
	11	F	-	-	-	18.2	45.4	9.1	27.3
Dec.	9	M	-	22.2	33.3	11.2	-	-	33.3
	16	F	-	31.2	12.5	18.8	-	-	37.5
Jan.	40	M	7.5	7.5	10.0	20.0	-	-	55.0
1996	22	F	4.5	36.0	13.6	22.7	-	-	18.2
Feb.	15	M	-	13.3	26.7	60.0	-	-	-
	14	F	14.3	7.1	35.7	42.9	-	-	-
Mar.	11	M	-	-	27.3	72.7	-	-	-
	10	F	10.0	-	40.0	50.0	-	-	-
Apr.	9	M	-	-	11.1	77.8	11.1	-	-
	13	F	7.7	-	7.7	23.1	53.8	7.7	-
May	12	M	16.7	25.0	41.6	-	-	-	16.7
	16	F	-	12.5	56.3	-	-	12.5	18.7
Jun. July		Monsoon							
Aug.	21	M	-	9.5	23.8	66.7	-	-	-
	18	F	5.6	5.6	33.3	55.5	-	-	-
Sep.	15	M	-	-	33.3	66.7	-	-	-
	12	F	-	-	50.0	50.0	-	-	-

Table 4.32 Size at maturity of females of *Cynoglossus arel*

Centre: Quilon Period: 1995-96

Tl mm	No. Fish	Maturity stages I	II	III	IV	V	VI	VII
140	2	100.0	-	-	-	-	-	-
150	2	100.0	-	-	-	-	-	-
160	1	100.0	-	-	-	-	-	-
170	1	100.0	-	-	-	-	-	-
180	9	-	88.8	11.1	-	-	-	-
190	6	-	83.3	16.6	-	-	-	-
200	11	-	45.5	36.4	18.1	-	-	-
210	7	-	28.5	42.9	14.3	14.3	-	-
220	5	-	20.0	40.0	20.0	20.0	-	-
230	27	-	-	74.1	11.1	7.4	3.7	3.7
240	26	-	-	53.8	30.8	3.8	-	11.6
250	20	-	-	-	75.0	10.0	5.0	10.0
260	11	-	-	-	63.6	27.3	-	9.1
270	9	-	-	-	55.6	11.1	11.1	22.2
280	11	-	-	-	54.6	9.0	18.2	18.2
290	6	-	-	-	50.0	-	-	50.0
300	6	-	-	-	50.0	16.7	-	33.3
310	2	-	-	-	50.0	50.0	-	-
320	2	-	-	-	100.0	-	-	-

Table 4.33 Fecundity estimates of the large-scaled tongue sole *C.arel*
Centre: Quilon Period 1995-96

Fish Tl mm	Fish wt. g	Ovary wt. g	Fecundity in Nos.
201	33.7	1.221	24,325
204	35.4	1.261	29,718
208	38.72	1.533	38,826
212	39.14	1.805	49,209
215	41.2	2.397	31,417
218	43.3	2.724	45,789
220	45.16	2.313	65,271
223	46.23	2.812	59,245
227	48.0	2.886	49,868
228	49.05	2.484	67,386
231	50.28	3.116	86,612
234	50.96	3.078	95,305
238	52.0	4.132	98,159
242	53.23	3.846	97,523
243	55.17	4.817	101,123
245	57.45	5.311	118,710
240	52.80	4.964	135,624
248	58.7	4.805	133,018
253	62.5	3.611	103,414
254	63.4	4.578	131,664
259	66.3	5.714	154,326
265	71.31	3.982	121,019
262	66.94	5.987	162,556
266	72.35	5.011	127,141
269	74.96	6.414	169,823
272	79.2	6.703	178,264
272	78.5	5.561	154,102
278	89.5	5.118	141,325
280	92.04	6.458	201,615
288	94.51	6.581	214,985
290	96.0	6.398	235,168
297	103.0	7.214	244,716
302	105.1	6.108	215,721
318	117.23	6.982	277,501
322	125.2	7.511	289,823

CHAPTER 5

AGE AND GROWTH

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INTRODUCTION

In modern fisheries research, ageing of fishes is considered very important because it has been realised that a knowledge of the age and growth rate of fishes is a prerequisite for many practical and scientific questions related to management and conservation. Through age determinations we have the means to identify the age composition of a fish population, and it can be determined to which degree the various age classes are utilised by the fishery against time. Once the addition (weight) in a fish stock in relation to time is determined, the optimum size at age can be fixed for rational exploitation of a fishery. Further, the loss in given fish stock due to natural and fishing mortality is to be estimated for arriving at maximum sustainable yield and biomass estimation. Thus a knowledge of the size (age) structure and growth rate and other related growth parameters is an essential pre-requisite for successful fishery management.

In fishes, age and growth rate can be determined by:

i) tagging and recapture;

ii) culturing the fishes in cages/ponds providing congenial environment and suitable food;

iii) markings (annual/seasonal) found on the hard parts such as scales, otoliths, fin rays and other skeletal parts; and

iv) length distribution method.

The first two methods are direct and preferable as they offer evidence (results) but are difficult to implement, as appropriate infrastructure facilities are required to carry out the programme. The other methods are indirect. Growth determination from markings on hard parts have been successfully used in temporate waters. Fishes being poikilothermal, a characteristic feature of their growth is periodicity, *i.e.* growth during certain months or periods is rapid than other times (Nikolskii,1963). This unevenness in growth rate is reflected on hard parts in the form of growth checks which are formed during periods of slow growth. During summer and autumn, fish in their ecosystem tend to register maximum growth due to optimum food supply and as well due to favourable environmental conditions particularly temperature. The growth becomes slow during winter and spring when both the food availability and environmental factors are relatively at low levels. Corresponding to the seasonal changes the annual markings in the hard parts are seen as widely spaced or opaque zones due to fast growth followed by narrower and more transparent spaced zones owing to slow growth.

Literature on the utility of hard parts as aids in age determination are numerous. Age determination in fishes using hard parts is two centuries old. A Swedish clergyman determined the age of pike (*Esox lucius*) and other species by counting the rings on the vertebrae, and his findings were comparable to the modern readings (Hederstorm, 1959, original version, 1759). Maier (1906) reviewed the history of age determination from the 17th to end of 19th centuries. Hoffbauer's (1898) grouping of circuli in carp and his interpretation as yearly marks prompted Thompson (1902) to extend this procedure to marine fishes. The earlier reviews on this aspect are given by Thompson (1902), Lee (1920), Hutton (1921), Creaser (1926), Graham (1929), Van Oosten (1929) and the recent ones may be referred to in the works of Chugunova (1959), Bagenal (1974) and Pauly (1978). The problems involved in the age determination in tropical fishes have been discussed by Hardenberg (1938), Menon (1953) and De bont (1967). According to Tesch (1971) there is need to develop better methods for tropical fishes.

In tropical waters, the markings on hard parts, though less pronounced, are found in marine and freshwater fishes, but no authentic evidences are available as to their annual nature. As there is no marked variation in the environmental factors like temperature, various workers attribute the causative factors for such markings to spawning, fluctuations in food supply, monsoon etc. Nevertheless, there have been a number of studies on age determination of fishes from Indian waters using hard parts (Menon, 1953; Seshappa and Bhimachar, 1951, 1954; Radhakrishnan, 1957; Pantulu, 1961, 1962; Qasim and Bhatt, 1966; Rao, 1970, to mention a few). Qasim (1973 a) reviewed the various methods used by different workers for the study of age and growth in fishes in India from 1952 to 1971. Murty (1976) reviewed the work done on the age determination in Indian teleosts from 1954 to 1972 and pointed out the diverse views regarding the causative factors and the time of formation of the growth rings.

Consequent upon the doubtful authority of marking as to its depicting the annual nature of growth pattern as noted above, in the tropics, the method of length frequency distribution has found wider application for age determination. Moreover, it is generally found easier to analyse the length frequency data as it requires less equipment and facilities. Hence this method has been most popular technique for age determination of fishes all over the world. It was first introduced by Petersen (1892) and commonly known as 'Petersen Method' in which peaks in the length frequency of given sample is assumed to represent different year classes (age groups). In another method, known as 'Modal Progression Analysis', the peaks in the length frequency samples arranged sequentially in time are connected to follow the progression of modes (peaks) and the growth estimated (George and Banerji, 1964 and Brothers, 1980).

The application of the first method is however, beset with certain short comings as the modes representing the older fishes may overlap, as, normally the growth rate slows down considerably with increasing age and hence the accurate fixation of age difficult. Nevertheless, it is possible to separate the year classes by graphical methods, as described by Harding (1949), Cassie (1954), Tanaka (1956) and Bhattacharya (1967) or by computer based methods as demonstrated by Hasselblad (1966), Abrahamson(1971) and Young and Skillman (1971). In the second method, the problem posing is, the difficulty in interconnecting the several modes available in the length frequency. The peaks in the length distribution may be the outcome of several broods arising from prolonged or fractional spawning of fishes as it happens in tropical waters and hence the various modes occurring in any single length frequency sample cannot be fixed to a definite age group. Due to the same reason the peaks in the time series length frequency cannot be interconnected with certainty. Thus, both the methods are highly subjective and often leads to doubtful results (Pauly, 1981, 1982; Josse *et al* 1979; and Ricker, 1975).

Recently, Pauly (1980 and 1983) has proposed an integrated method by combining, the above two methods. In this, a growth curve joining majority of the peaks is drawn directly upon length frequency distribution arranged sequentially in time or on to the same sample repeated over and over along the time axis with a concept that growth in length in fishes is fast in early part of life and then slows smoothly. Such a smooth curve is likely to represent the average growth of fish in a population. Devaraj (1982) introduced 'the scatter diagram technique' of modal progression analysis in which the modal lengths in the length frequency distribution are plotted in the form of scatter diagram against sequence of time and the trend of progression of modes through time is marked by eye fitted line. By these two methods, some of the doubts encountered in the Peterson's method can be overcome and certain extent of reliability can also be achieved.

Pauly and David (1981) have attempted a new approach for a rapid reliable and objective method of computer based length frequency analysis called ELEFAN (Electronic LEngth Frequency Analysis). The principle involved in this programme is to split the composite length frequency into peaks and troughs and the best growth curve passing through maximum number of peaks avoiding troughs is selected using a goodness of fit by a ratio ESP/ASP. "ESP" stands for "Explained sum of Peaks" and "ASP" stands for "Available sum of Peaks". Here the peaks are assumed to represent individual cohorts.

A number of mathematical models of growth described by Bompertz (1825), von Bertalanffy (1938), Bagenal (1955), Rafail (1973) and Udupa (1976) and some known as logistic (Pearl and Read, 1923) and exponential (Ricker, 1958) are now available for deriving growth information of fish stocks and for further use in the yield models. Beverton and Holt (1957), Ursin (1968) and Ricker (1975) have described the theory of various models. Of the available models, the most widely used one is that of von Bertalanffy for which methods of fitting the formula have been given by Beverton and Holt (1957) and Ricker (1958).

The model expresses the length 'L' at time 't' as

$$L_{(t)} = L_{oo} (1 - e^{-k (t-t_o)})$$

Where L_{oo} = the maximum length that the fish can theoratically attain, K = growth coefficient or curvature parameter or the rate at which the fish approaches asymptotic length, t_o = theoretical age of fish at (birth) length zero, provided the fish grows conforming to von Bertalanffy growth equation and 'e' = the base of natural logarithm.

The studies on the age and growth in flatfishes in India are limited to the work of Seshappa and Bhimachar (1951) who showed the utility of scales of Malabar sole *C.semifasciatus* Day (= *C. macrostomus* Norman) as age indicators. Seshappa and Bhimachar (1954, 1955) studied the age and growth of *C.semifasciatus* by length frequency and scale methods. Krishnankutty (1967) and Seshappa (1974 b) studied the growth rings on scales of *C. macrolepidotus* and *C. dubius* respectively. Feroz Khan and Nandakumaran (1993) studied the age and growth of *C. macrostomus* along Calicut coast, by length frequency studies.

Since not much information is available on the age and growth of the Malabar sole *Cynoglossus macrostomus* Norman a study was undertaken to elucidate various aspects of the age and growth of this species. More over information on these aspects are essential for successful management of the fishery.

MATERIAL AND METHODS

Age determination of the Malabar sole, *Cynoglossus macrostomus* was done by the length frequency analysis, from the growth checks on scales and by the ELEFAN Method (Pauly and David (1981). The results of these studies were then compared.

1) LENGTH FREQUENCY ANALYSIS

The material for the study was collected from the trawl landings at Fisheries Harbours at Cochin and Neendakara (Quilon) and from the minitrawl catch at Ambalapuzha. Weekly trips were made to the Cochin Fisheries Harbour and during each trip 100-150 fishes were measured randomly Fortnightly trips were made to Neendakara (Quilon) and Ambalapuzha and nearly 200 fishes were measured on an average at each time. The length of the fish referred to in the following pages is the total length in mm taken on the mid-longitudinal axis from the tip of the snout to the longest caudal fin ray. A fish measuring board was used for this purpose.

Data base

Centre	Gear	No.of specimen	Period	Monthly av. Nos.
Cochin	Trawls	9032	Aug 94 to Oct 96	335
Neendakara	Trawls	8067	Aug 94 to Oct 96	298
Ambalapuzha	Minitrawl	9633	Nov 94 to Oct 96	401

The monthly length data were grouped into 5 mm class intervals separately for the three centres. Based on the scatter diagram of modes observed during successive months, the trend lines tracing the growth of successive broods by means of modal progression through time were fitted free hand. The samples were repeated to get a comprehensive picture. These lines were extrapolated (with reference to the growth lines for younger broods) to intersect the time axis in order to resolve the periodicity and frequency of brood production during each spawning season and also the growth of various broods through successive months. The mean length at time were then worked out. The data, from Ambalapuzha, though collected were not used for age determination as the entire range of the fish was not represented in the catch. This was because the minitrawling is carried out in the inshore areas, mostly in 10 m depth and large size groups are not represented in the catch.

2) SCALES

Scales of the Malabar sole have been found to be useful in age determination (Seshappa and Bhimachar, 1951). Regular monthly scale samples were collected. The study was based on the examination of scales from 648 males and 585 females of the size range 44 to 162 mm in total length. After noting the total length, sex, maturity and other biological details 5-10 scales were taken out from the pectoral region just below the lower lateral line. This procedure was followed throughout. The scales collected from each fish were separately placed in water in small plastic tubes. The scales were then placed in 2% potassium hydroxide (KOH) solution for 20 minutes, washed further and then dried between blotting papers. Scales of individual fishes were then placed neatly between two glass slides and framed tightly using cellophane tapes. A thin strip of paper with details of date, place, length, sex and maturity also was kept in between the two slides at the edge before framing, to identify the scales. The scales of males and females were arranged month wise for further studies. Since the scales are very small a monocular microscope with an eye piece 10 x and objective 5 x gave good results for the study. A micrometer was utilised to measure the radius (length) of the scale and also the radius between successive growth checks. Each micrometer micrometer division is equivalent to 0.0286 mm.

Based on the results obtained from the length frequency and scale studies, the growth curve by a plot of the length at ages was made which could adequately be expressed by the von Bertalanffy equation for growth in length (Beverton, 1954, Beverton and Holt, 1957). Further, the parameters of L_{oo} and K were estimated by the Ford-Walford Plot (Beverton and Holt, 1957; Ford, 1933; Walford, 1946). The parameters of K and L_{oo} were also calculated by the Gulland and Holt (1959) plot.

The value of t_o was estimated by two methods (1) by plotting $\text{Log}_e (L_{oo} - L\ t)$ against t (Beverton, 1954) and (2) by estimation of t_o from the equation.

$$t_0 = 1/K\ (\log_e L_{oo} - \log_e (L_{oo} - Lt))-t$$

The length data were also analysed by computer based ELEFAN method (COMPLEAT ELEFAN Package) as described by Gayanilo *et al* (1988) to obtain growth parameters.

AGE DETERMINATION BY LENGTH FREQUENCY STUDIES

The monthly length measurements of Malabar sole collected from Cochin, Neendakara and Ambalapuzha were separately grouped into 5 mm class intervals and the dominant modes during each month was noted. The scatter diagram of the modes and growth of successive broods by means of modal progression through time with respect to these centres were made free hand. Figure 5.1 gives the scatter diagram of modes at Cochin, Figure 5.2 from Neendakara and Figure 5.3 from Ambalapuzha. The mean length at age was calculated taking into account the modal values. The modal values of broods 1 to 10 observed during different months at Cochin are given in Table 5.1. From this, those broods which could be traced to four successive years were selected. The broods 1 and 2 as indicated in Figure 5.1 gave satisfactory results and were selected. The various broods 1 to 10 are indicated in Table 5.1. Based on this the length at age in each successive quarters were worked out for Cochin. From the data at Neendakara length attained at the completion of each year was worked out. Thus, at Cochin, the fish was found to attain a total length of 72.5, 87.5, 101.5, 114.0, 122.0,126.5, 131.5, 136.5,141.5, 145.5, 149.0, 152.5, 154.5, 158.0, 159.5 and 161.0

mm at the end of 1st to the 16 quarters respectively. The yearly growth in length attained has been found to be 114.0 mm, 136.5 mm, 152.5 mm and 159.5 mm at the end of I to IV years at Cochin. The length attained by the fish at the completion of I to IV years at Neendakara was found to be 115, 135, 150 and 160 mm respectively. A comparison of the growth of this species observed at Cochin and Neendakara showed remarkable agreement.

The growth was fast in the early part of the life. The fish attained 72.5 mm by the end of three months itself showing an average growth of 24.2 mm per month. Further, the growth slows down. The fish attained 87.5 mm at the end of 6 months. During this three months the average monthly growth was 5 mm compared to 24.2 mm per month in the initial three months. At the end of 9 months the fish attained 101.5 mm. The average monthly growth from 6th to 9th month was 4.7 mm and in the next 3 months the growth was 4.2 mm per month. The fish attained 114 mm at the end of 12 months indicating an average monthly growth of 9.5 mm during the first year. The fish attained 136.5 mm at the end of 2nd year. The growth during the second year was 1.9 mm per month. During the third year the average monthly growth is 1.3 mm. It is to be noted here that the size at maturity of the fish is 97 mm. The maximum growth took place before the attainment of maturity. After an initial fast rate the growth slowed down after 6 months of life, mostly due to energy investment in maturation and gonadal development. A uniform growth of 5 mm per quarter was observed from 21st to 27th month. Again the quarterly growth was uniform during the 33 to 36th months. Analysis showed that these periods of uniform growth mostly coincided with the time immediately after the spawning. This indicated the recovery of the fishes from the spawning stress. But again the growth in length slackened due to energy diversion for maturation and subsequent spawning.

AGE DETERMINATION OF MALABAR SOLE BY SCALES

The Malabar sole has prominent ctenoid scales which are longer than wide. A juvenile scale shows a centre or nucleus and a number of circuli, except in regenerated scales. The posterior side bears a number of closely packed cteni. The anterior side is slightly broader. In the fully grown scale the circuli are interrupted by a number of radii, The radii extends from the focus or from the breaks in circuli, towards the lateral as well as anterior margin. In a scale with no annuli the structure of the circuli is more or less uniform all over the scale.

Relation between fish length and scale length (radius)

Since the scale of a fish is a birth and age certificate an accurate knowledge of the relationship between fish length and some dimension of the scale from a given area is essential for back calculation of growth history. The mean scale length for 363 fishes ranging in total length from 44 to 162 mm were plotted against length (radius) of scales as in Figure 5.4. The scatter of the points clearly showed that the relationship between them is linear and of the form $L = a + b S$ where L = fish length in mm, S = scale length (radius) in m.d., and 'a' and 'b' are constants. The regression equation calculated by the method of least squares is

$$L = 23.881 + 2.0134\ S$$

GROWTH CHECKS ON SCALES (Plate III)

The annuli or growth checks when they occur can be recognised by the following characters.

i) the narrowing of the sclerites and the closing up of the intervals between successive sclerites;

ii) the sclerites are wavy and broken up elsewhere, becoming continuous and nearly straight from radius to radius;

iii) an increase in the number of radii of the annulus; and

iv) the portions of the radii outward of the annulus being frequently not in a straight line with portions inward of it, but inclined at an angle or even disconnected at the annulus.

Scales from a total of 648 males and 585 females of the size range 44 to 162 mm in total length were utilised for studying growth rings. The fishes were grouped into 5 mm class intervals. The frequency and the number of annuli observed on scales were then plotted against the class intervals and mean fish size was calculated. Out of 585 females, 163 specimens had no rings on scales, 115 showed 2 rings and 25 fishes had 3 rings. In males, out of 648 specimens examined, no ring was observed in the scales of 228 fishes, 290 fishes had one ring, 106 had 2 rings and 24 fishes showed 3 rings. The mean fish length (TL mm) worked out for one to three rings in the scales of males were 118.4, 134.4 and 149.4 mm respectively. For females it was 118.7 mm, 134.8 mm and 150.3 mm respectively. The growth pattern in males and females were similar showing no difference in the growth. The frequency distribution of growth checks in the scales of *C.macrostomus* for males and females is given in Table 5.2.

Scale radius to different growth rings

While taking the scale length (radius) measurements, radius of the scale upto the Ist and subsequent growth checks were also measured to find out the mean scale radius to successive growth rings. This was done by using a micrometer under a low power monocular microscope. The scale radius in microdivisions (m.d) upto 1 to 3 ring were then grouped microdivision wise to calculate the mean radius. This was done by combining the data sets of males and females. The mean scale radius for 1 to 3 rings was found to be 41.4 m.d, 54.2 m.d and 63.4 m.d respectively. Table 5.3 gives the frequency distribution of scale radius at 1,2 and 3 growth checks formation in the Malabar sole.

Back calculation of fish length from scales

For each scale studied, back calculation was done. Lea (1910) introduced the scale method of back calculation for determining the growth of fish and since then this method has been used by many workers (Lea, 1913, 1929, 1938; Mottram, 1916;

Hile, 1950; Blackburn, 1949,1950). In India very few workers have attempted the back calculation method. Jhingran (1959) has investigated the growth of *Cirrhina mrigala*, and Sarojini (1957) studied the growth of gray mullet *Mugil parsia* by the back calculation method. Among the marine teleosts this method has been used for studying the growth of the Malabar sole *Cynoglossus semifasciatus* (Seshappa and Bhimachar, 1954), *C. macrolepidotus* (Krishnankutty, 1967) and in *Pseudosciaena diacanthus* (Rao,1970).

For each scale studied, back calculation was done by using the corrected Lee (1920) formula based on the fish length scale length relationship.

$$L_t = L\, S_t/S + a\,(1-S_t/S)$$

here referred to as method A, where L and S are lengths of the fish and scale respectively, L_t is the calculated length at age t and S_t is the length of the scale upto t^{th} annual ring, 'a' is the constant in the equation for regression denoting the length of the fish when the scales are formed.

The second method referred here as B is after Bagenal (1974) using the formula

$$\text{Log } L_n = \text{Log } L_t + b \times \text{Log } rn - \text{Log } R_t$$

where L_t = length at capture, b = regression coefficient, R_t = scale radius at capture and Rn = scale radius at age n. The mean length of fish calculated from the scales for 1 to 3 rings by Lee's method was 114.9, 134.0 and 150.2 mm respectively. The mean back-calculated length (mm) from scales at the end of each year of life of *C.macrostomus* is given in Table 5.4. The corresponding values obtained from Bagenal method was 115.3, 134.3, and 150.5 respectively. The values obtained by the two methods showed remarkable agreement. Further, these values agree well with the results of length frequency studies. This indicates that the growth checks on scales are annual in nature.

TIME OF FORMATION OF GROWTH CHECKS

This study was undertaken to determine if the periodic markings on hard tissues considered to be annuli are actually formed at the rate of one per year. In order to validate the scale method for aging Malabar sole, it is necessary that some direct evidence be obtained to show that the rings on scales are true year marks. It appears reasonable to assume that if these rings are laid down regularly once each year, rather than randomly, a study of margins of scales collected periodically throughout the period of study should indicate the approximate period of ring formation. The width of the margin from the last ring to the edge of the scale (the increment of the last ring) should be at a maximum immediately before, at a minimum just at or after the formation of the last ring. Scale samples from 771 fishes were studied for this purpose. Scales with the minimum width in the terminal zone, after or during the growth ring formation were noted and their percentage from the total scale (fish) samples were analysed from January to December. The Figure 5.5 indicates that fishes with minimum width or growth in the terminal zone are more during the months of October-November and March-May. Further, the time of formation of the 1st, 2nd and 3rd annuli were worked out based on the width of the terminal zone of the respective annulus as indicated in Figure 5.6. This study also showed that the growth checks are formed during October-November and March-May.

Seshappa and Bhimachar (1951, 1954, 1955) showed that the rings seen in the scales of the Malabar sole *Cynoglossus semifasciatus (= C. macrostomus)* were not erratic structures, but were closely related to the size and age of the fish. They termed the growth rings in the scales of these fishes as monsoon rings and suggested that they are perhaps formed due to the lack of food leading to starvation. But Seshappa and Bhimachar (1954) based on length frequency studies have shown that the growth is not suspended throughout the monsoon period, because, between May and September some growth is usually recorded. They further stated that if starvation alone is the cause, it must obviously occur during the later part of the monsoon to account for the growth recorded between May and September. According to Seshappa and Bhimachar (1955), whatever be the cause of variation in the rate of growth leading to the ring formation, the fact remains that the ring is annual in nature and can be used in determining the age of the fish.

Studies on scales of *Cynoglossus lida* by Seshappa (1974 b) revealed the presence of growth checks comparable to those seen in *C.macrostomus*, though they were sometimes fainter as in the case of *C.macrolepidotus* observed by Krishnankutty (1967), who found 6+ and 7+ growth rings in individuals of 26 to 33 cm length in that species. In *C.dubius* some rings are, however, better marked than others, though all the rings can easily be read once the eye gets used to them. Krishnankutty (1967) opined that the growth rings in *C.macrolepidotus* are perhaps formed during the southwest monsoon, in the same way as in Malabar sole. It is probable that the growth rings in the scales of *C.dubius* are also formed in the same way and in the same season, due to the physiological factors prevailing in the fish under the influence of environmental conditions of the southwest monsoon. Growth rings as observed in the Malabar sole have been reported by Seshappa (1974) in other species of *Cynoglossus* like *C.bilineatus,* and *C.puncticeps.*

If monsoon is the causative factor for the formation of growth rings in the scales of Malabar sole, as opined by Seshappa and Bhimachar (1955), the following points require clarification.

1) The findings of Seshappa and Bhimachar (1955) that the new recruits of September-October develop the first monsoon ring by next year during September-October when they are one year old. This appeared reasonable.

2) But, if monsoon is the causative factor for the formation of growth checks, the question is whether rings are formed in the scales of the new recruits of February-March during the later part of monsoon, *i.e.* by September? These new

recruits would be only 6-7 months old by September, the time indicated for monsoon ring formation. They would complete one year only by next February-March, which is surely not the time of the monsoon ring formation.

3) Even if the monsoon ring is formed in the new recruits of February-March by the ensuing September they would be only 6-7 months old and that the fish would be one and half year old when the second monsoon ring was formed again in the next September, which cannot be.

4) The present study indicated that the average scale radius when one ring is formed is 41.7 m.d. The scales of the new recruits of February-March will not attain that radius by September, but do attain by next February-March period when they complete one year.

5) Hence the factors responsible for the formation of these growth checks appear to be something else.

FACTORS INDUCING FORMATION OF GROWTH CHECKS ON SCALES

The present study indicated that the time of ring formation is during October-November and then in March-April-May. This showed that two rings are formed in an year. Studies have shown that the spawning of this species takes place during October-November and again in February-March-April. Malabar sole is not a multiple spawner. The spawners during the above two spawning periods are different (Chapter Reproduction). Consequently there are two broods in an year, one that of the October-November spawning and the other pertaining to the February-March spawning. Fishes with the Ist ring formed during October-November represent the broods of the previous year October-November period. Likewise fishes with one ring formed in their scales during February-March represent broods of the previous February-March period. These two broods spawn after the end or at the completion of one year growth during the respective periods.

Since there is remarkable coincidence in the timings of the ring formation with that of the spawning time, the causative factor in all probability could be the spawning stress.

According to Graham (1929) there are five tests for deciding the validity of any method of age determination in fishes.

1) Agreement with peterson's method
2) Seasonal record of the ring or zone formation
3) Observation of the stock over a long period of years
4) Marking experiments
5) Tank or pond experiment with fish of known age.

The following three points from the studies on the age and growth of *C. macrostomus* presented here answer the first three tests mentioned by Graham (1929) satisfactorily which is fair vindication of the validity of the method.

1) There is close agreement between the age determined by the length frequency and scale studies.

2) The studies on the seasonal nature of the edges (margins) of the scales show clearly that only one ring is formed in an year and at the same period during each year.

3) It was possible to trace and follow the different year classes in the fishery from length frequency studies during the period of 1994-96.

FITTING OF VON BERTALANFFY'S GROWTH EQUATION

Putter (1920) developed a growth model which can be considered the basis for most other models on growth including the one which was developed as a mathematical model for individual growth of most fish species. The theory behind various growth models has been reviewed by Beverton and Holt (1957), Ursin (1968), Ricker (1975), Gulland (1983) and Pauly (1984 a).

The mathematical expression in fitting growth curves is helpful in interpolation and extrapolation, besides their utility in production computations. Based on the concept that growth is the net result of anabolism and catabolism, von Bertalanffy (1938) formulated a growth equation which, according to Beverton (1954) and Beverton and Holt (1957), produces a growth curve in length that fits well the growth rate of many species. This equation gives a linear relationship between length at time 't' and at time 't + x' and is expressed as

$$L_t = L_{oo} (1-e^{-k(t-t_o)}) \quad \text{.......................(1)}$$

where L_t = length at age 't'; L_{oo} = maximum or asymptotic length a fish can theoretically reach; e = base of the neperian or natural logarithm; K = Coefficient catabolism; 't' = age of fish and 't_o'= arbitrary origin of the growth curve.

ESTIMATION OF GROWTH PARAMETERS

Two different methods are in use to estimate the growth parameters mentioned in equation 1 *viz*; Arithmetic and Graphic.

ARITHMETIC METHOD: von Bertalanffy's growth equation can be rewritten in the following form:

$$L_t+1 = L (1-e^{-k})+L_t e^{-k} \quad \text{.........................(2)}$$

This is a linear equation in terms of L_t+1 and which Bagenal (1955) used to study the growth of *Hippoglossoides platessoides*. This is the same as

$$L_t + 1 = a+b * L_t \quad \text{.........................(3)}$$

in which $a = L(1-e^{-k})$ ....(4)

and $b = e^{-k}$ ....(5)

The constants L_{oo} and e^{-k} can be solved by applying the least square method (Snedecor, 1946) as shown below; for the following values of L_t and L_t+1 in the age length-data of Malabar sole *C. macrostomus*. Since the fish is a small growing species living for a short period and the age traceable was only upto 4 years, the quarterwise growth in length derived from the modal progression of length frequency studies were utilised for estimating various growth parameters. The 't' indicated is in quarters. The length attained at the end of successive quarters are given in Table 5.5.

The estimated values of 'a' and 'b' are 'a' = 27.20878 and 'b' = e^{-k} = 0.836372295

Substituting the values of e^{-k} and 'a' in equation 4 we have

$$27.20878 = L(1-0.836372295)$$

Therefore $L_{oo} = \frac{27.20878}{1-0.836372295} = \frac{27.20878}{0.1636278} = 166.284$ mm.

The values of K was determined from the values of e^{-k} using the formula

$$K = \log_e \frac{1}{e^{-k}} = \log_e \frac{1}{b} = \log_e \frac{1}{0.836372295}$$

$$= \log_e 1.195639796 = 0.178681436 \text{ (per quarter)}$$

$$0.734724 \text{ (per year)}$$

The value of t_o was estimated by two methods;

(1) by plotting $\text{Log}_e(L_{oo} - L_t)$ against t (Beverton, 1954) as shown in Figure 5.7.

(2) by estimating t_o using the formula

$$t_o = t1 + \frac{1}{K} * \ln\left(1 - \frac{L(t1)}{L_{oo}}\right)$$

Based on the formula the average value of t_o calculated for different ages was found to be

Cochin t_o = −5.63626 (/month) (Table 4.5)
−1.87875 (/quarter)
−0.46968 (/year)

Thus in the equation 1, when the values for L_{oo}, K and t_o are substituted, becomes.

$$L_t = 166\,(1-e^{-0.061227\,(t-(-5.63626))}) \qquad \ldots\ldots\ldots(7)$$

The fit of von Bertalanffy's equation to length increments (mm) at successive quarters from 1 to 16 was done (Table 5.5). The theoretical lengths at various ages was then worked out and compared with the results obtained from the length frequency and scale studies which indicated close agreement. The results of this analysis and the comparisons made are given in Table 5.5.

GRAPHIC METHODS

Ford-Walford plot: This method introduced by Ford (1933) and Walford (1946) has gained wide application. From the original equation (1) it follows a series of algebraic manipulations that

$$L\,(t + \Delta t) = a + b * L_{(t)}$$

where $a = L_{\infty}\,(1-b)$ and $b = \exp\,(-K\,\Delta t)$

Table 5.5 contains column A and B representing pairs of consecutive lengths, $L_{(t)}$ and $L\,(t + \Delta t)$ from Cochin. Using the values as x and y, the equation $a + b * L_t$ was used for linear regression. The different values obtained were

$a = 27.20978$, $b = 0..836372$, $L_{\infty} = \dfrac{a}{1-b} = 166.29$ mm and

$$K = -\frac{1}{\Delta t}\ln b = 0.178681 \text{ (/quarter)}$$

$$= 0.714725 \text{ (/year)}.$$

Ford-Walford plot of L_t against $L_t + 1$ is shown in Figure 5.8.

The Gulland and Holt plot:

The Gulland and Holt (1959) plot indicates that the intersection point between the regression line and the L - axis gives L_{oo} . It is, however, possible to turn the Gulland Holt plot into an "Exact Gulland and Hold plot" *i.e.* a regression analysis which is correct for any value of t, if the time interval remains constant, *i.e.* if we have pairs of observations as indicated in Table 5.6.

The eouation

$L\ t = L_{oo}\ [1-e^{-k(t-t_o)}]$ implies that

$Lt - L\ (t + \Delta t) = b * L_{oo} - b * L_{(t)}$

where $b = 1-\exp(-\Delta t * K)$

Thus if Δt remains constant b will remain constant and the above equation becomes a linear regression analysis:

$$Y = a-b * L(t)$$

with $Y = L(t) - L(t+\Delta t)$, intercept, $a = b * L_{oo}$ and with slope, $b = 1-\exp(-\Delta t * k)$.

The growth parameters are then derived from:

$K = -(1/\Delta t)\ \ln(1-b)$

Table 5.6 gives the L(t) and (t) and X and Y values, (obtained at Cochin) used in the regression. The Gulland and Holt plot is give in Figure Figure 5.9.

The values obtained were a = 9.804197, b = -0.05884 and L_{oo} = -a/b = 166.6029 mm, K(/month) =0.058847, K(/yr)=0.706172.

von Bertalanffy plot:

The first method for estimating the von Bertalanffy growth parameters was suggested by von Bertalanffy (1934). It can be used to estimate K and t_o from age length data, while it requires an estimate of L_{oo} as input. The von Bertalanffy growth eouation (equation 1) can be rewritten:

$$-\ln (1 - L(t)/L_{oo}) = -K * t_o + K * t$$

With age, t, as the independent variable (x) and the left-handed side as the dependent variable (y) the equation defines a linear regression, where the slope b = K and the intercept a = $-K * t_o$. The von Bertalanffy plot is a more robust method than the Gulland and Holt plot and Ford-Walford plot in the sense that it nearly always gives a reasonable estimate of K, given that a reasonable estimate of L_{oo} is used in the computations. The values obtained were K (/month) = 0.061227, K (/year) = 0.734724, t_o = -5.63626 and t_o (year) = -0.463626. The von Bertalanffy plot based on quarterwise length increments in Malabar sole is indicated in Figure 5.10. The regression for the von Bertalanffy plot is given in Figure 5.11 in which the slope indicates K and t_o = -a/b.

FITTING GROWTH CURVES BY MEANS OF COMPUTER PROGRAMME

The computer-based methods require so many computations that it is almost impossible to do them by paper-and -pencil. The two alternative approaches are:

1. The 'ELEFAN' 1 (Electronic LEngth Frequency ANalysis)
2. The 'Maximum-likelihood' method. The first method introduced by Pauly and David (1981). The second may be considered a computerised version of the Bhattacharya (1967) method.

In the present analysis the first method is considered. The 'ELEFAN' 1 programme deals with estimation of growth parameters using length frequency analysis (Pauly and David, 1981; and Pauly, 1987). Basically, 'ELEFAN' 1 is a modal progression analysis involving a time series data or by repeating the sample for a suitable range of years. Here time series data on Malabar sole at Cochin from August 1994 to October 1996 and data from Neendakara (1994 to 1996) have been analysed. The restructured data with peaks and troughs exaggerated make it possible to define an objective measure for goodness fit for which Pauly and David (1981) suggested the ratio "ESP/ASP", where the former stands for *Explained Sum of Peaks* and the latter *Available Sum of Peaks* respectively. By following the progression of modes and testing a large number of alternate combinations of growth parameters the best fit was found to be with an L_{∞} 170mm and K = 0.9. at Cochin as indicated in Figure 5.12.

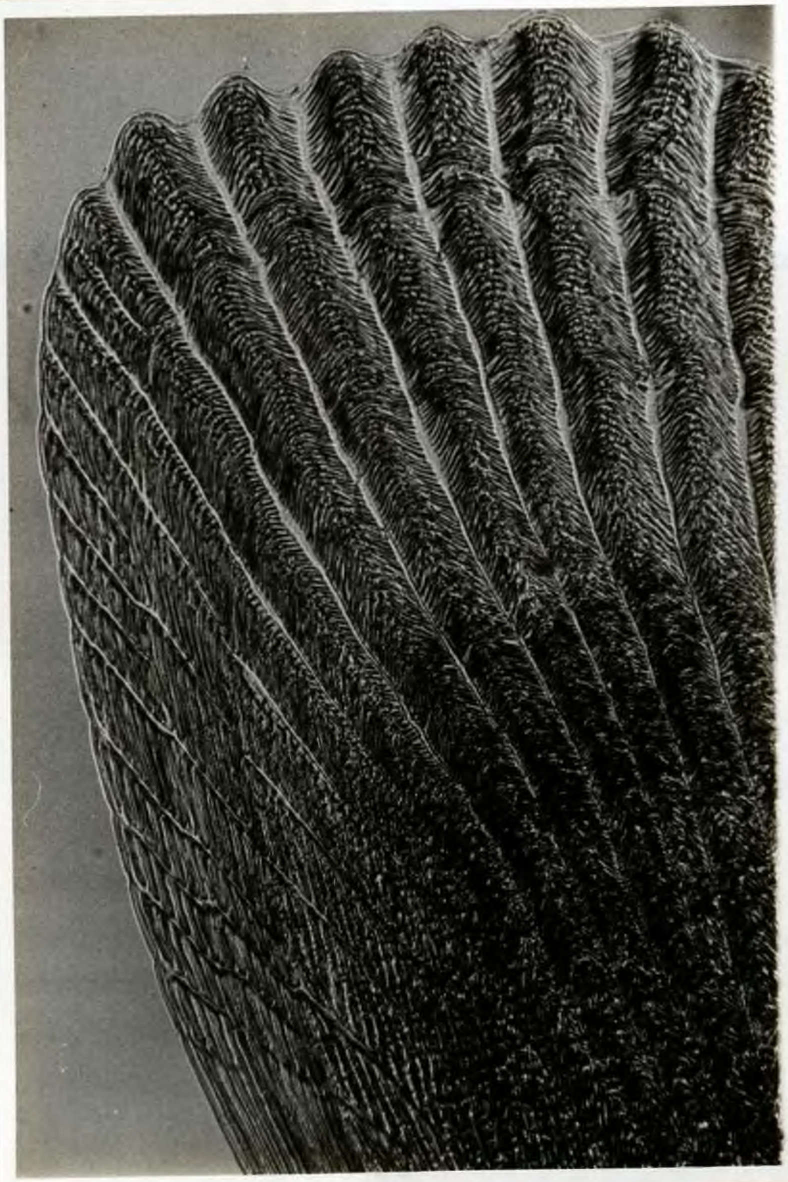
DISCUSSION

The age and growth studies by Seshappa and Bhimachar (1951) using the growth checks on scales and by length frequency methods indicated that the Malabar sole attained a length of 100-129 mm in the first year, 140-149 mm and 170-180 mm in the second and third years respectively. Ferozkhan and Nandakumaran (1993) indicated that the species attained 106 mm in the first and 131 mm in the second year. They stated that the largest specimen measured by them during the period of study was 159 mm in total length. But they obtained an asymptotic length (L_{oo}) of 139.9 mm

The age and growth rate of Malabar sole in the present study was based on length frequency method, growth checks on scales, numerical and graphic methods such as von Bertalanffy, Gulland-Holt plot, Ford-Walford; and by the ELEFAN method which yielded comparable results. The length attained at the end of each quarter starting from first to the 16th quarters have been traced with ease. The growth rate has been found to be very fast during the first three months and then gradually slowing down by the time the fish completes six months and further it slows down with the onset of maturity and subsequent spawning at a time when the fish is nearly one year old. The growth again gradually slows down during the subsequent periods. The fish has been found to attain 115.0 mm, 136.5 mm, 152.5 mm and 161.1 mm at the end of I to IV years respectively. The results of the studies on the growth checks on scales of this fish are in close agreement with the results obtained from length frequency data analysis. The fish has been found to attain 118.5 mm, 134.6 mm and 149.8 mm at the time of formation of 1 to 3 rings on the scales. Studies on the growth checks on scales and the length at age in males and females showed similarity. These growth checks are formed as a result of the spawning stress. Ferozkhan and Nandakumaran (1993) based on their studies at Calicut obtained values of L_{oo} as 139.9mm, K = 1.6117 and t_o as -1.878. In the present study the length infinite (L_{oo}) of 166 mm and a 'K' value of 0.714 (year) appeared reasonable. The K value will be lower in fishes having a long life span compared to fishes like Malabar sole with a short life span.

The estimated length at age in Malabar sole by various methods agreed well. The growth parameters estimated would be a useful tool in the stock assessment of the species and as well to propose management measures for optimum utilisation of the resource.

PLATE III



SCALE OF MALABAR SOLE (*C.MACROSTOMUS*) 164 MM (TL)
SHOWING THREE ANNUAL GROWTH RINGS

(Note the III rd ring and the terminal growth zone)

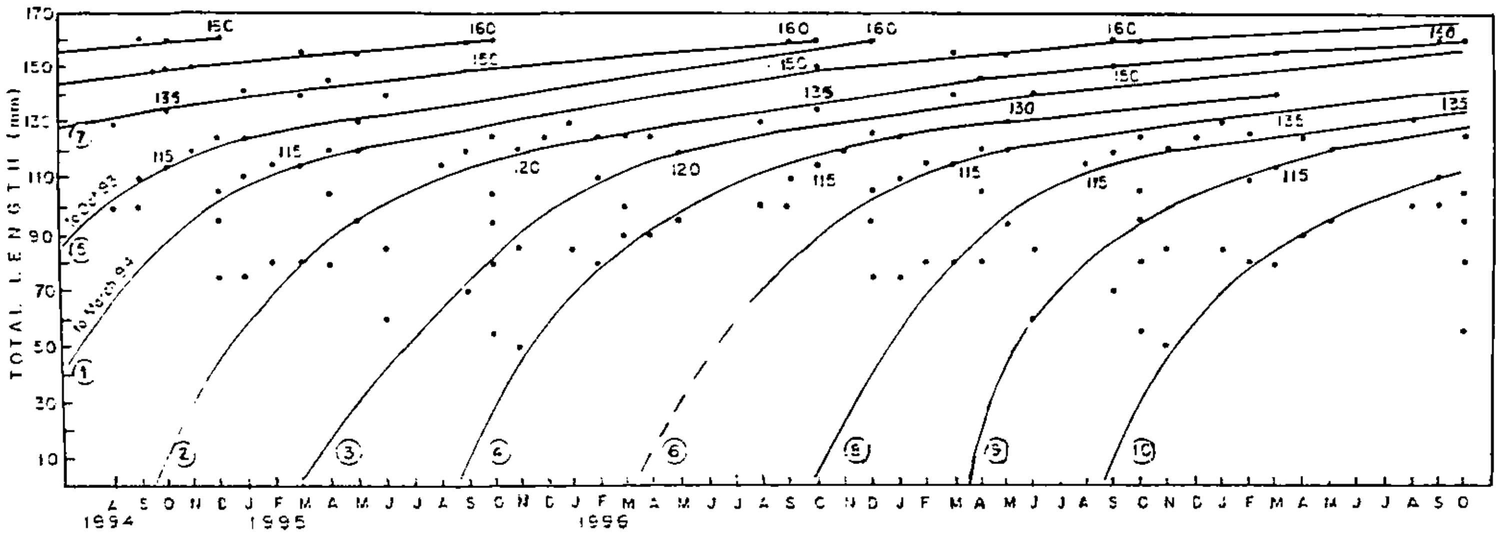


Fig. 5.1 Monthly modal progression by scatter diagram of modal lengths for *C.macrostomus* at Cochin

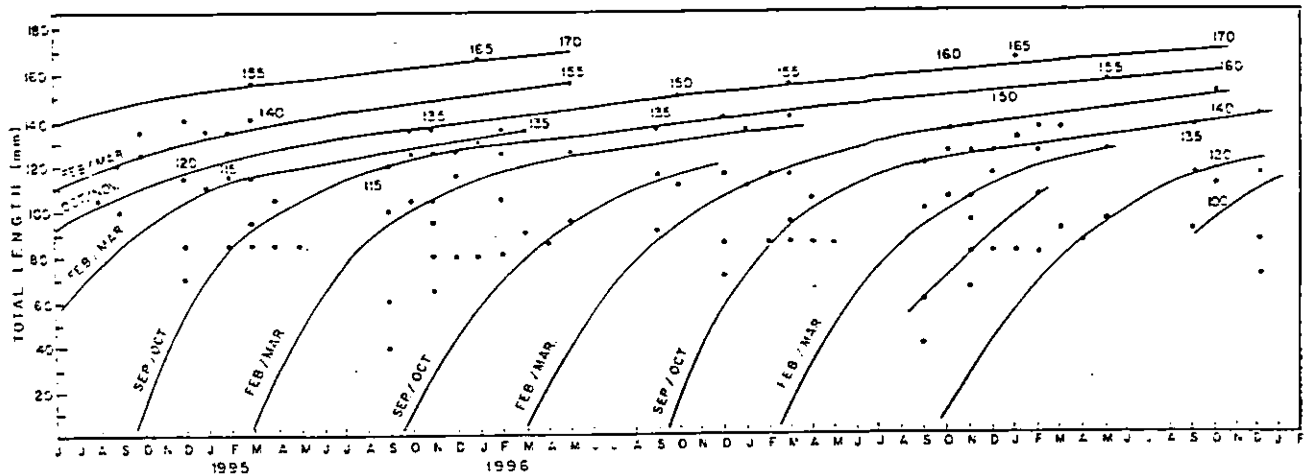


Fig. 5.2 Monthly modal progression by scatter diagram of modal lengths for C.*macrostomus* at Neendakara

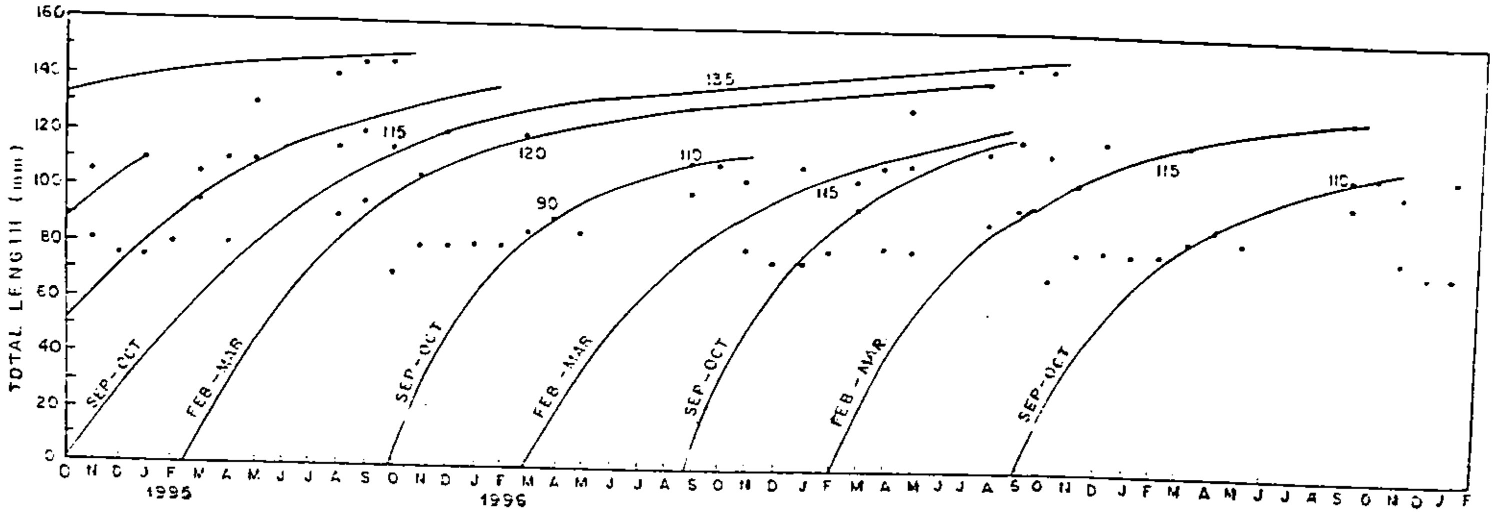


Fig. 5.3 Monthly modal progression by scatter diagram of modal lengths for *C.macrostomus* at Ambalapuzha (Minitrawl)

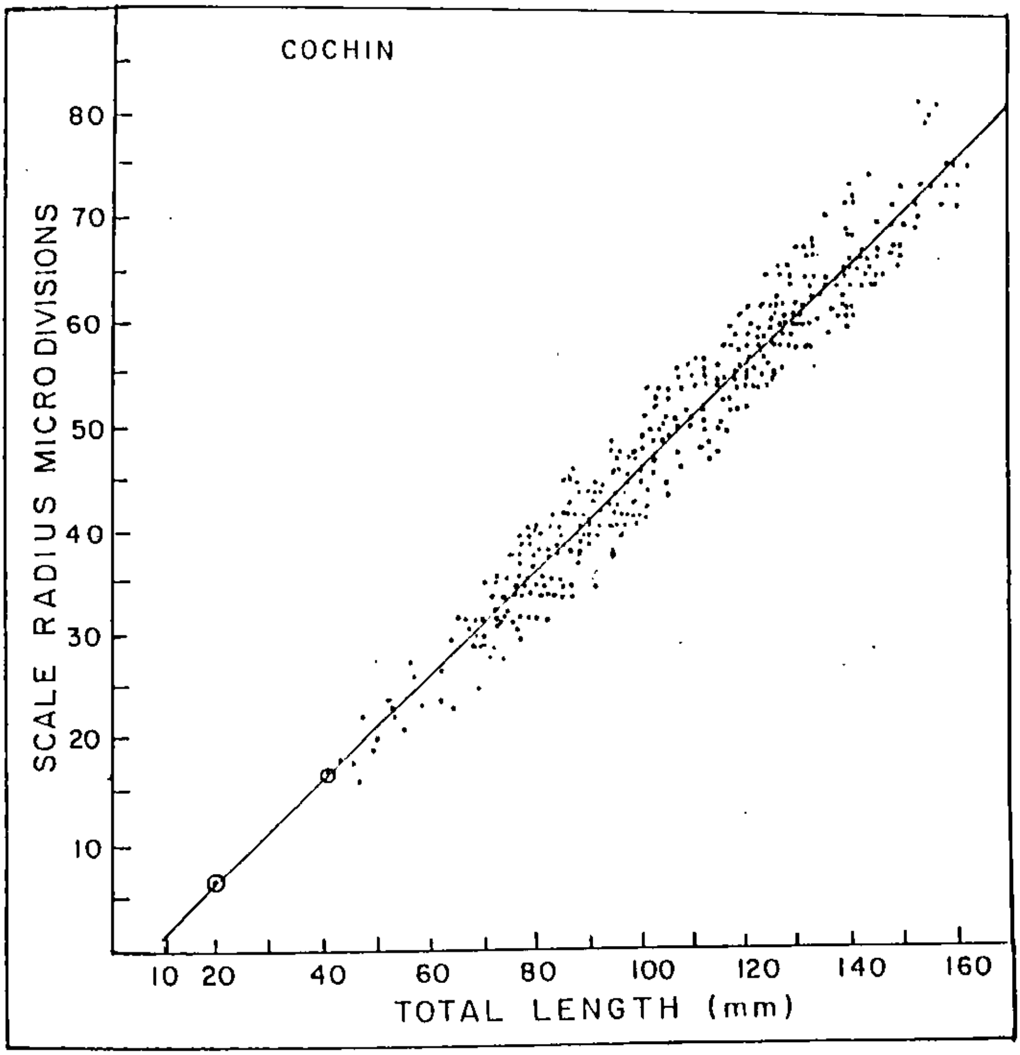


Fig. 5.4 Relation between scale radius and fish length in Malabar sole (*C.macrostomus*)

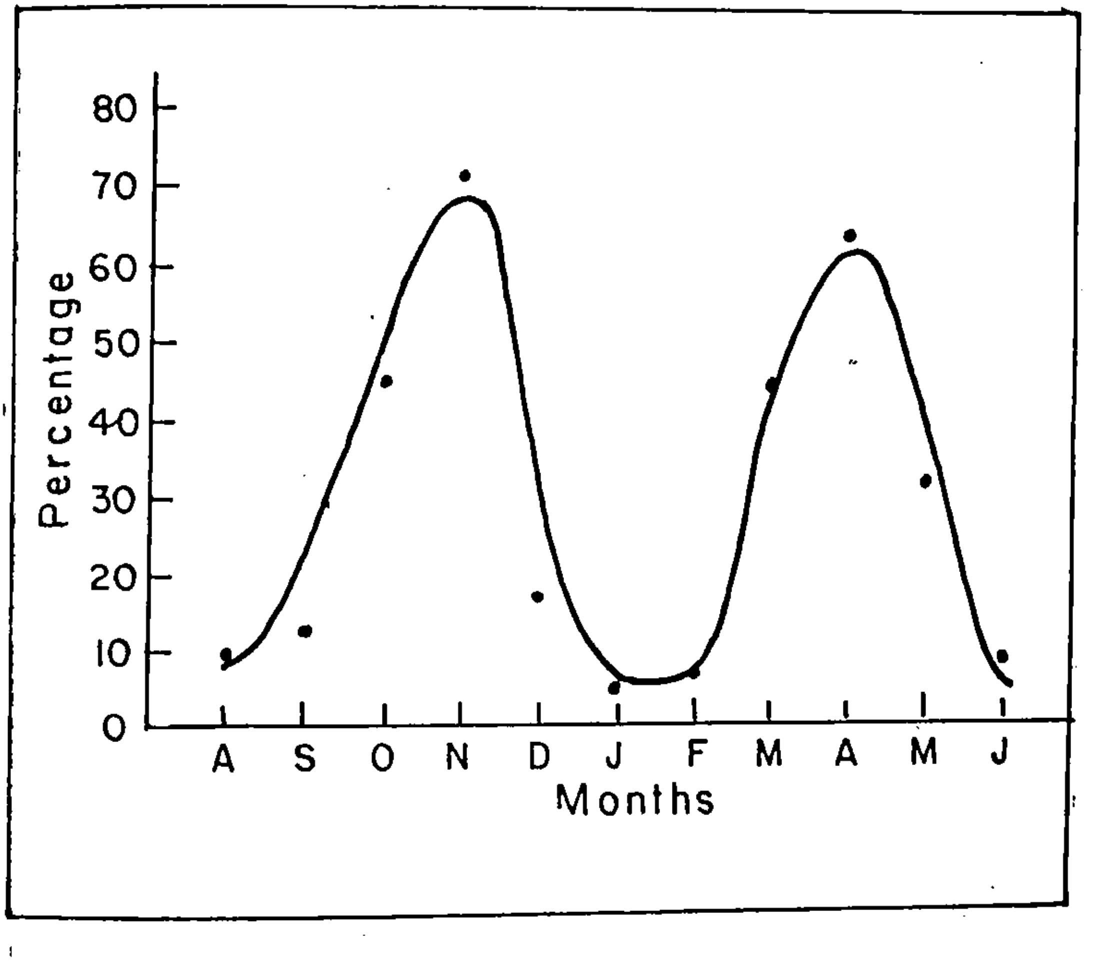


Fig.5.5 Monthly percentage occurrence of minimum width in the terminal zone of scales of *C.macrostomus* showing time of formation of growth checks

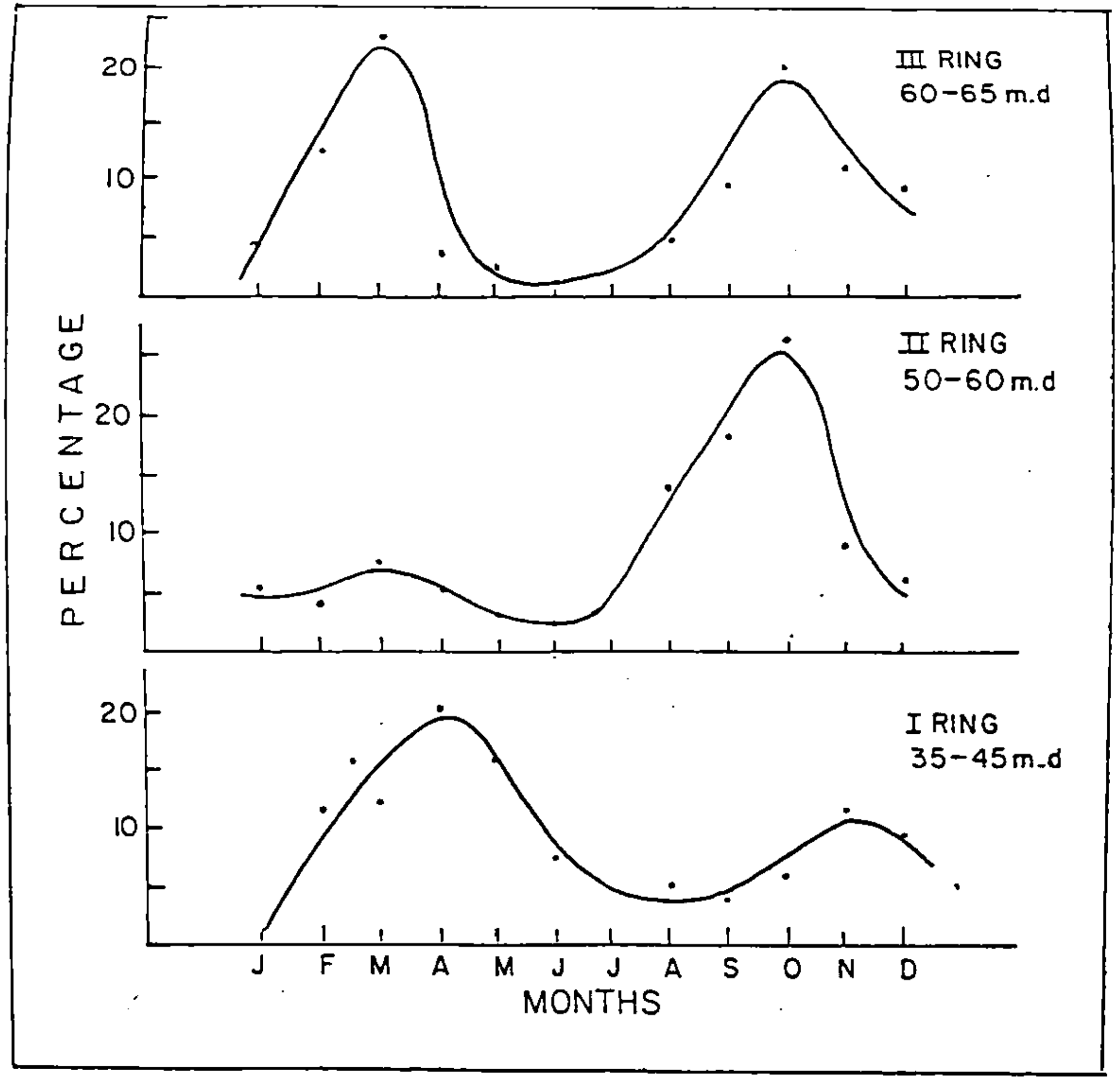


Fig. 5.6 Time of formation of the I, II and III annual growth checks on scales of *C.macrostomus*. (Based on minimum width in the terminal zone of successive growth checks)

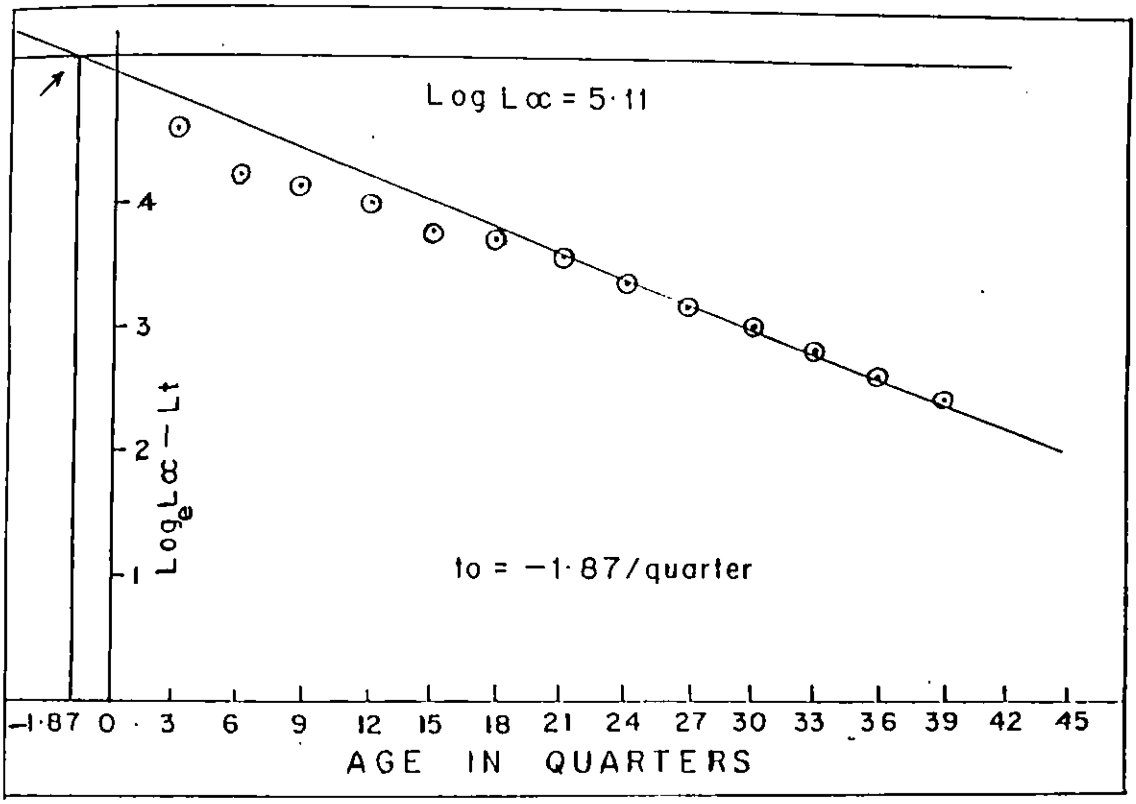


Fig. 5.7 Log $_e$ (L_{oo} - L_t) plotted against age 't' for estimation of 't_o' in *C.macrostomus*

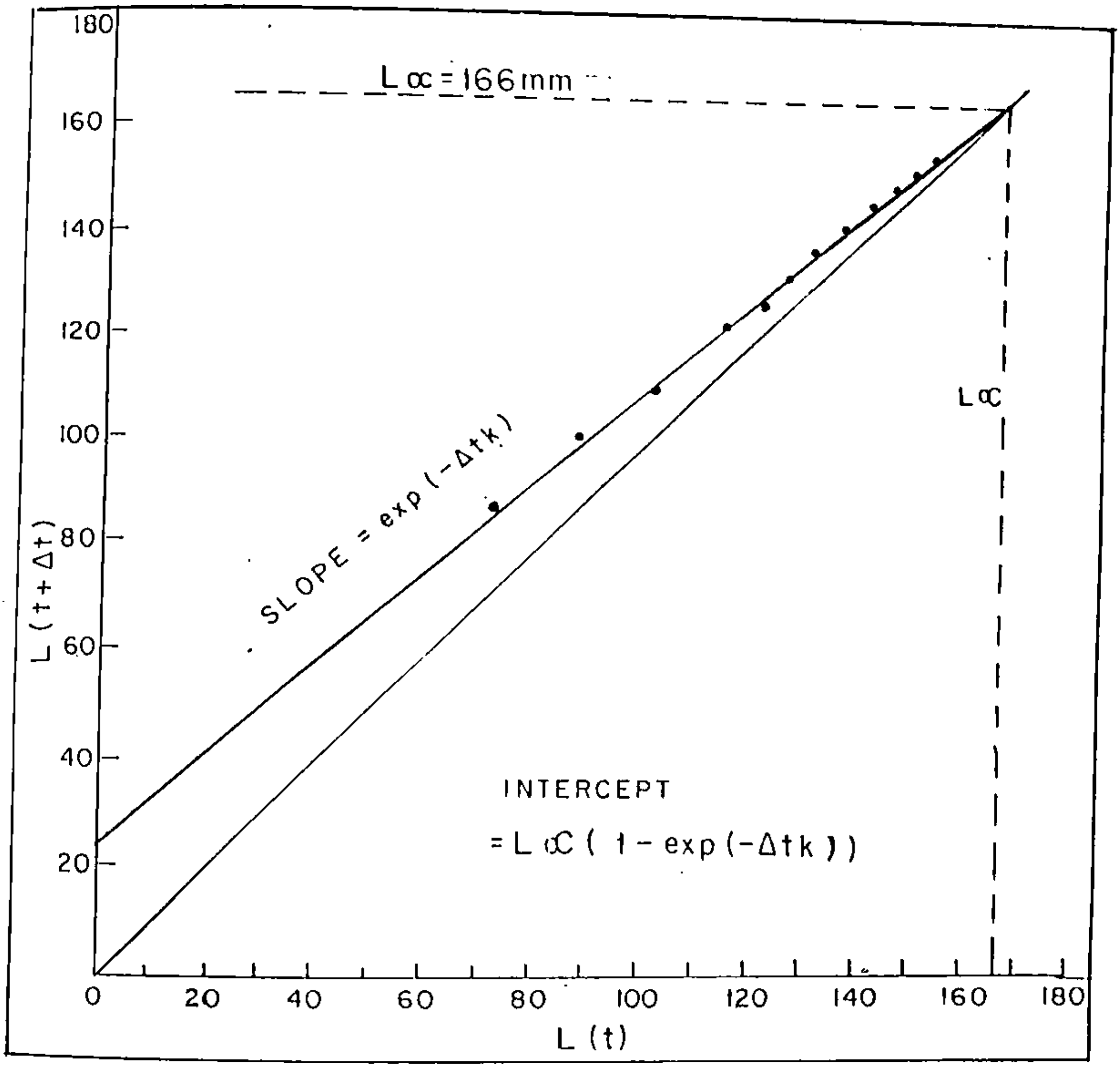


Fig. 5.8 Ford-Walford plot of L_t against $L_t + 1$ for *C.macrostomus*

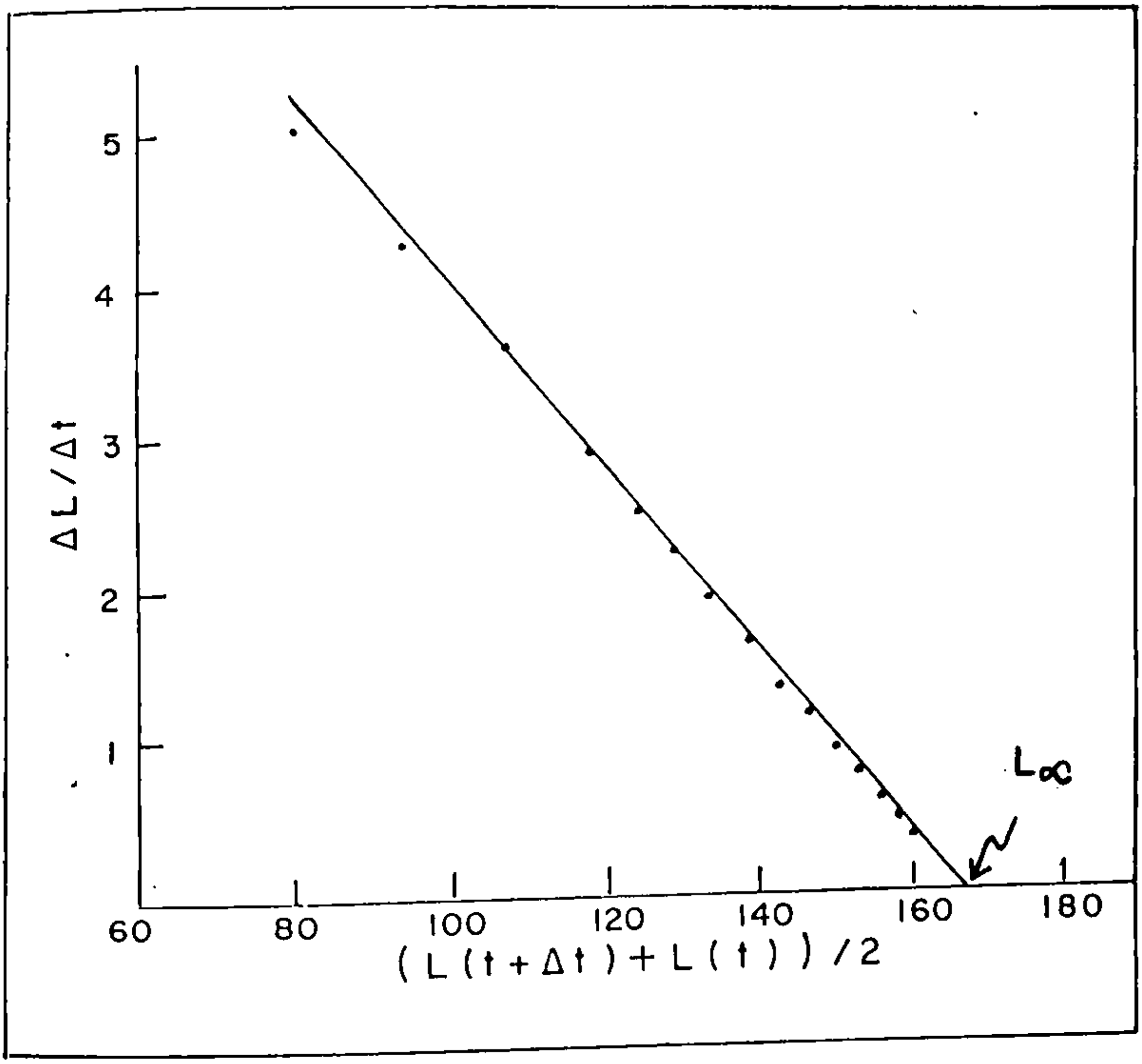


Fig. 5.9 Gulland and Holt plot for finding L_{∞} of *C. macrostomus*

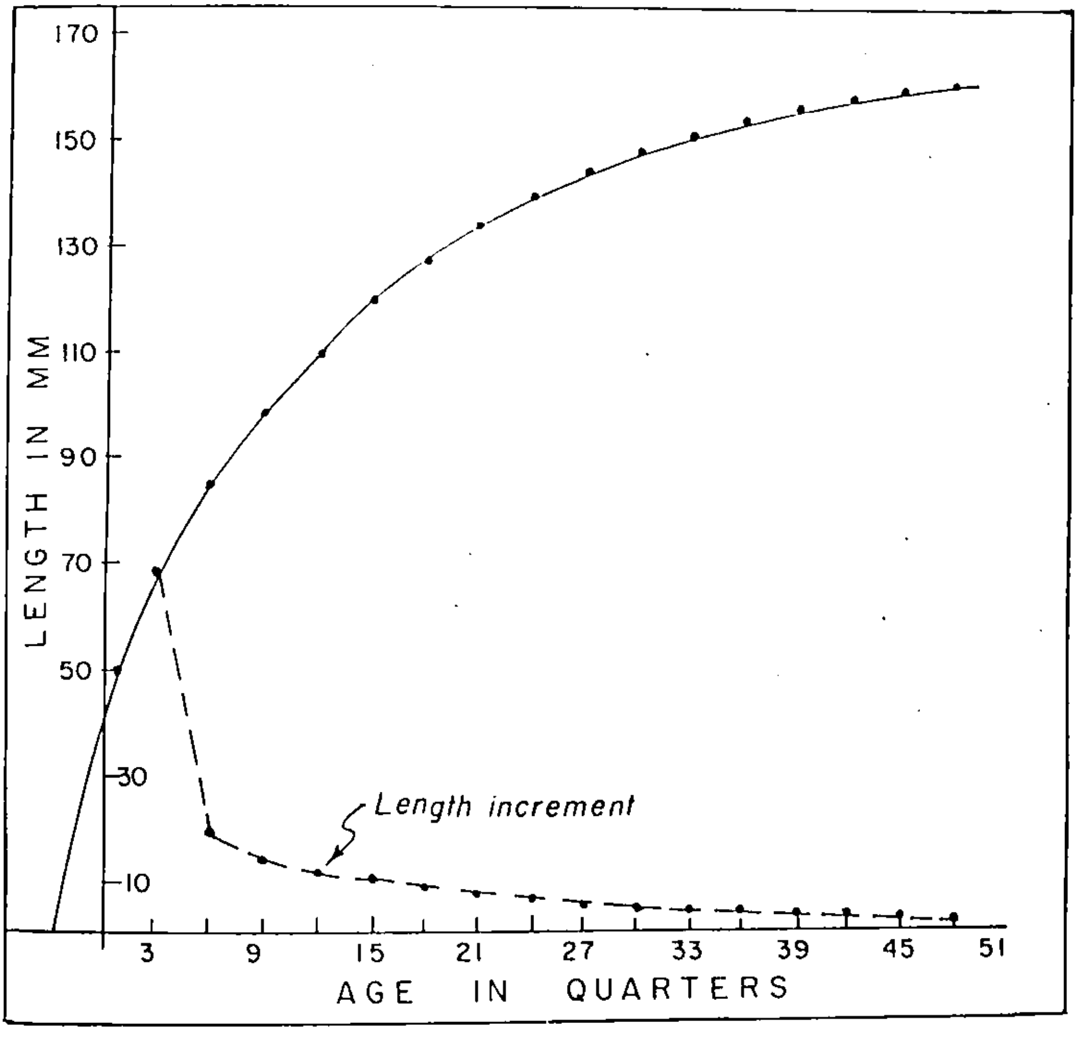


Fig. 5.10 von Bertalanffy growth curve for Malabar sole *C.macrostomus* based on quarterwise growth increments

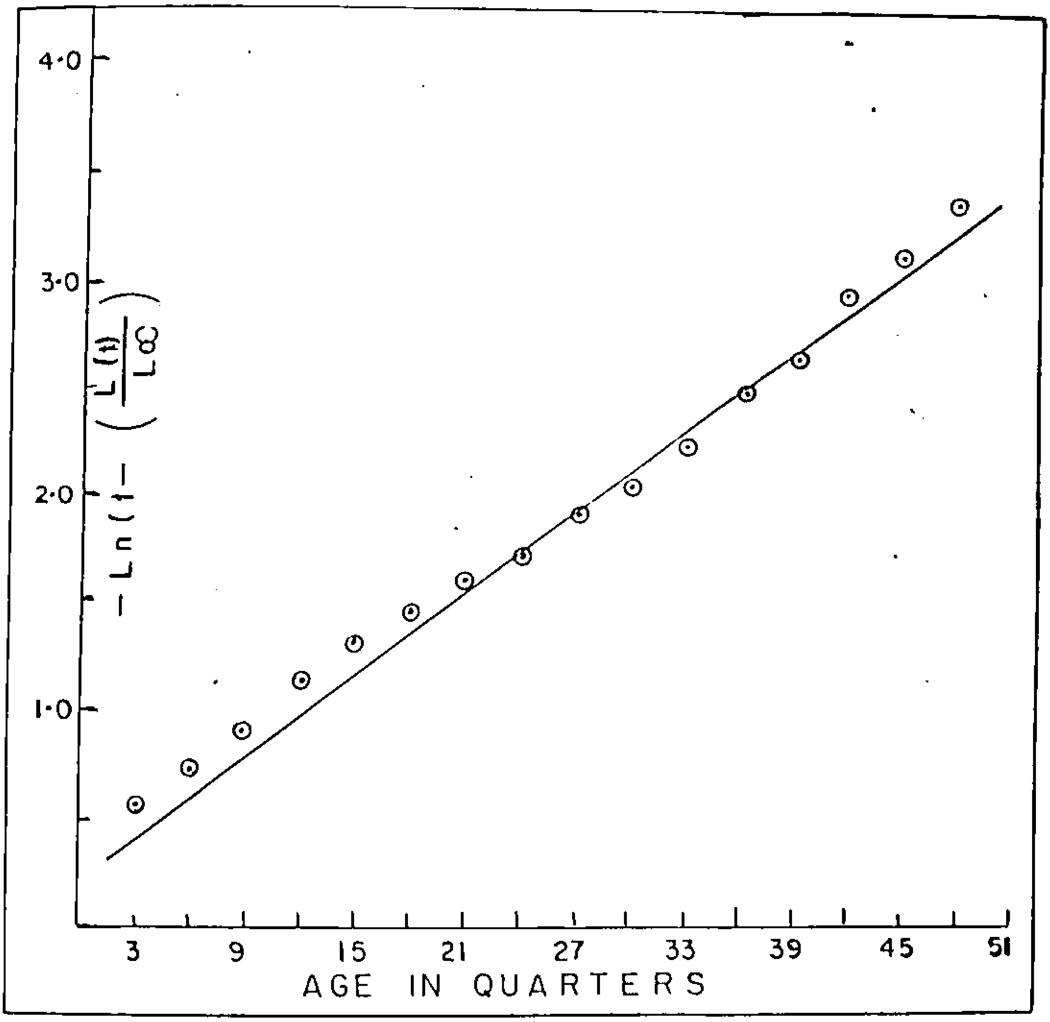
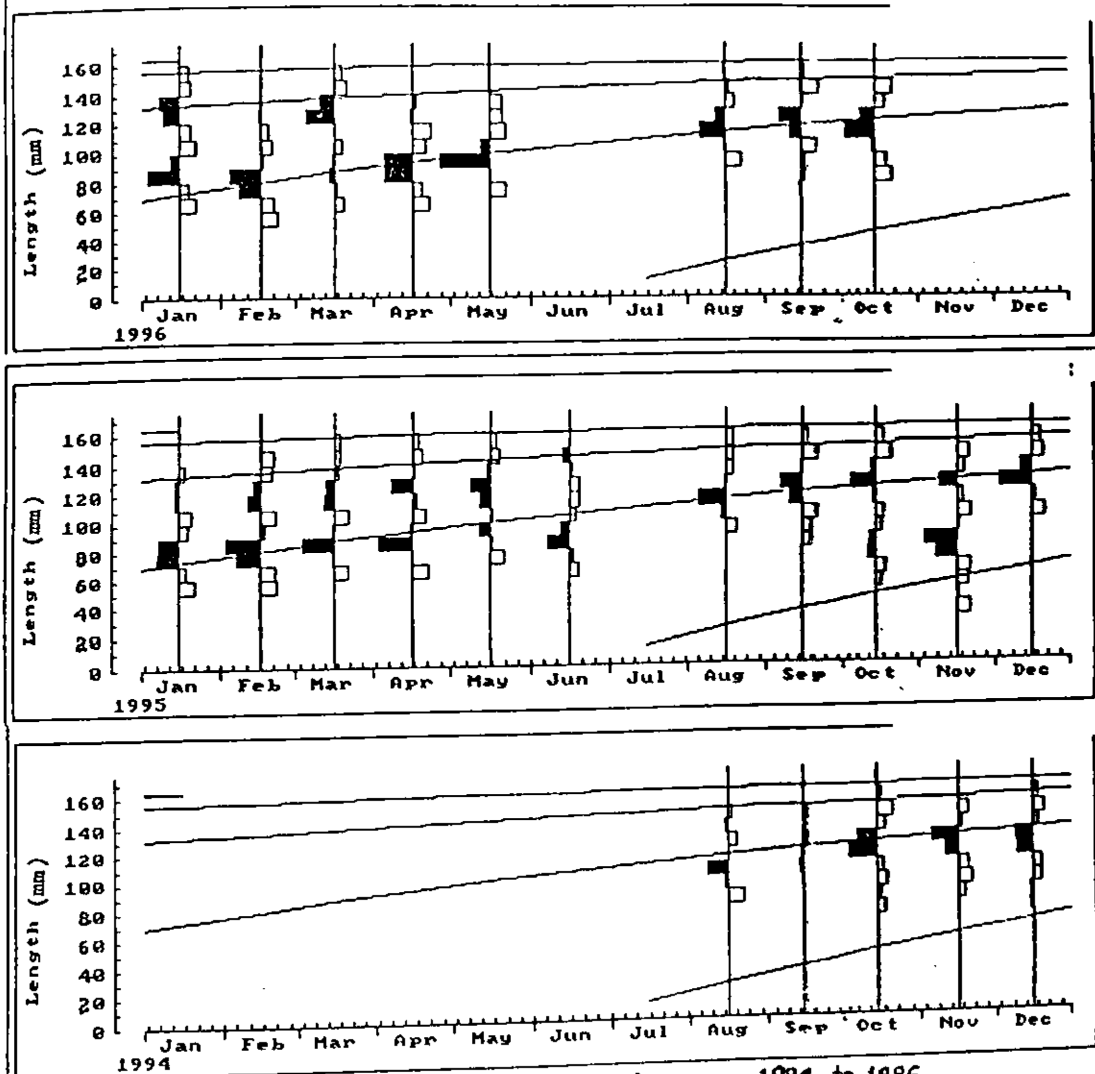


Fig. 5.11 Regression for the von Bertalaffy plot for *C.macrostomus*. The slope indicates K and $t_o = -a/b$



1994 to 1996

Species name ▸ Cynoglossus macrostomus Trawl
(Imported from LFSA: unit is not defined))

Loo ▸ 170.00
K ▸ 0.970
C ▸ 0.000
WP ▸ 0.000
SS ▸ 7
SL ▸ 80.00
Rn ▸ 0.273

Fig. 5.12 Growth curve of *C.macrostomus* identified by ELEFAN (based on combined length frequency data from Cochin, Neendakara and Ambalapuzha)

Table 5.1 Modal progression and quarterwise increment in growth obtained from length frequency studies of *C.macrostomus* at Cochin (1994-95 to 1995-96)

Modes	1	2	3	4	5	6	7	8	9	10	Average of columns 1 & 2	Growth increments mm
Age in months	MODAL VALUES (MM)											
3	70	75	43	45		46		40	40	47	72.5	72.5
6	90	85	90	78		80		80	80	80	87.5	15.0
9	103	100	95	95		105		104	100	95	101.5	14.0
12	115	113	112	112	110	115		115	112	107	114.0	12.5
15	123	121	124	120	125	122		121	120		122.0	8.0
18	128	125	127	126	128	126		125	126		126.5	4.5
21	133	130	132	120	133	130		130			131.5	5.0
24	138	135	136	133	137	134	132	133			136.5	5.0
27	143	140	140	136	141	137	137				141.5	5.0
30	147	144	143	139	146		140				145.5	4.0
33	151	147	146		150		145				149.0	3.5
36	155	150	149		156		150				152.5	3.5
39	156	153	152		160		152				154.5	2.0
42	160	156	155				154				158.0	3.5
45	161	158					157				159.5	1.5
48	162	160					160				161.0	1.5
51	164											
54	166											

Table 5.2 Frequency distribution of growth checks in the scales of Malabar sole *C. macrostomus*

Size groups mm	MALE Growth rings 0	1	2	3	FEMALE Growth rings 0	1	2	3
45	3				1			
50	4				-			
55	2				-			
60	2				-			
65	7				4			
70	13				2			
75	23				11			
80	12				14			
85	27				12			
90	20				20			
95	23	9			29	15		
100	17	9			16	17		
105	9	11			10	20		
110	8	43			3	24		
115	10	66			5	37	1	
120	10	57	9		7	49	11	1
125	12	45	11		8	59	21	
130	12	28	20		8	31	18	1
135	4	16	32		7	24	24	
140	4	6	17	3	4	6	14	5
145	5		12	5	11		10	2
150	1		4	9	1		8	4
155			1	6			6	7
160				1			2	5
165								
170								
Total	228	290	106	24	163	282	115	25
Mean size mm.		118.4	134.4	149.4	-	118.7	134.8	150.3

Table 5.3 Distribution of scale radius at the formation of different growth rings in *C. macrostomus*.

Micro divisions	I No.	I %	II No	II %	III No	III %
20	1	0.13				
22	-	-				
24	1	0.13				
26	1	0.13				
28	4	0.50				
30	20	2.65				
32	16	2.12				
34	40	5.29				
36	37	4.90				
38	88	11.66				
40	200	26.49	4	1.5		
42	115	15.23	1	0.4		
44	92	12.19	6	2.4		
46	21	2.78	1	0.4		
48	32	4.24	16	6.4		
50	47	6.23	44	17.5	1	3.1
52	17	2.25	53	21.1	1	3.1
54	12	1.59	15	5.9	2	6.2
56	1	0.13	8	3.2	-	-
58	5	0.66	30	11.9	4	12.5
60	3	0.39	37	14.7	3	9.4
62	-	-	22	8.8	7	21.9
64	3	0.39	8	3.2	1	3.1
66			1	0.4	3	9.4
68			2	0.8	4	12.5
70			2	0.8	5	15.6
72			1	0.4	-	-
74					1	3.1
76						
78						
Total fishes	756		251		33	
Mean scale radius	41.4. m.d		54.2 m.d		63.4 m.d	

1 m.d = 0.0286 mm

Table 5.4 Mean back-calculated lengths (mm) from scales at the end of each year of life of *Cynoglossus macrostomus*

		GROWTH RINGS					
	No.of fish	A*	B*	A	B	A	B
115	12	113.8	114.7	..	..	..	..
120	14	114.9	115.7	..	..	..	..
125	24	117.2	117.0	..	..	..	..
130	36	114.9	114.4	132.9	133.5	..	..
135	40	114.1	113.2	132.3	132.5	..	..
140	28	113.8	114.4	133.9	134.5	..	..
145	32	116.9	118.3	135.1	134.8	148.2	149.2
150	24	114.4	114.9	134.9	134.6	150.1	150.9
155	17	114.1	113.9	134.7	135.1	151.5	151.1
160	8	115.7	116.6	134.5	134.9	151.1	150.9
Total	239						
Mean Total	235	114.9	115.3	134.0	134.3	150.2	150.5

* Method A: $Lt = L\, S_t / S + a\,(1-S_t / S)$

** Method B: $\text{Log } Ln = \text{Log } L_t + b * \text{Log } rn - \text{Log } R_t$

Table 5.5 Growth of Malabar sole *C.macrostomus*

Input data for Ford-Walford and von Bertalanffy plot

Length frequency studies		Ford-Walford		von Bertalanffy plot		Scale studies
Age in months	Length (mm)	Lt (mm)	Lt+1 (mm)	-ln(1-lt/l inf	Expected length (mm)	
3	72.5	72.5	87.5	0.572671	68.17157	
6	87.5	87.5	101.5	0.746941	84.58706	
9	101.5	101.5	115.0	0.942574	98.24805	
12	115.0	115.0	122.0	1.176226	109.61670	118.5
15	122.0	122.0	126.5	1.322961	119.07770	
18	126.5	126.5	131.5	1.430102	126.95120	
21	131.5	131.5	136.5	1.564385	133.50360	
24	136.5	136.5	141.5	1.719538	138.95640	134.6
27	141.5	141.5	145.5	1.903265	143.49430	
30	145.5	145.5	149.0	2.079227	147.27070	
33	149.0	149.0	152.5	2.263563	150.41340	
36	152.5	152.5	154.5	2.489736	153.02880	149.8
39	154.5	154.5	158.0	2.646418	155.20540	
42	158.0	158.0	159.5	2.998591	157.00670	
45	159.5	159.5	161.0	3.198169	158.52410	
48	161.1	161.0		3.447769	159.77850	

Results of Ford-Walford analysis
Regression output:

a=	27.20878 ,	L_{oo}	=166.2907	(L_{oo} =a/(1-b))
Std error of Y Est =	1.391739	K (Qr.) =	0.178681	(K Qr=@ LN (b))
R Squared =	0.996326	K(/Yr) =	0.714725	(k(Yr)= 4*K)
No. of observations	15			
Degrees of freedom	13			
b=	0.836372			
Std error of Coef.	0.014084			

Results of vBGF plot analysis

Regression out put:

a=	0.345092	K(/mon)=0.061227	K(Qr)+0.183681
Std error of Y Est =	0.091008	K(/Yr) =0.734724	t_o = -1.87875
R squared =	0.989992	t_o =-5.63626	
No. of observations =	16	t_o =-0.46968	
Degrees of freedom =	14		
b =	0.061227		
Std error of Coef. =	0.001645		

Table 5.6 Gulland-Holt analysis for finding the L_{oo} of the Malabar sole *C.macrostomus*

L_t	L_t + 3	Δ l/Δ t	L bar	Expect
72.5	87.5	5.00	80.00	5.10
87.5	101.5	4.67	94.50	4.24
101.5	115.0	4.50	108.25	3.43
115.0	122.0	2.33	118.50	2.83
122.0	126.5	1.50	124.25	2.49
126.5	131.5	1.67	129.00	2.21
131.5	136.5	1.67	134.00	1.92
136.5	141.5	1.67	139.00	1.62
141.5	145.5	1.33	143.50	1.36
145.5	149.0	1.17	147.25	1.14
149.0	152.5	1.17	150.75	0.93
152.5	154.5	0.67	153.50	0.77
154.5	158.0	1.17	156.25	0.61
158.0	159.5	0.50	158.75	0.46
159.5	161.0	0.50	160.25	0.37

Results of Gulland-Holt analysis

Table containing the details please take it from lotus file
Here the results only indicated.

Regression output:

a=	9.804197	L_{oo} = 166.6029
Std Err of Est	0.505056	K(/mon)= 0.058847
R Squared	0.895866	K(/yr) = 0.706172
No. Observations	15	
Degrees of Freedom	13	
b=	-0.05884	
Std Err of Coef.	0.005564	

CHAPTER 6

LENGTH-WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

CHAPTER 6

LENGTH-WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

INTRODUCTION

Every animal grows in length and weight. The relationship between these has both theoretical and practical importance. The study of the relationship between length and weight in fishes, according to Le Cren (1951) has been mainly directed towards two objectives; namely to provide a mathematical relationship between two variables, length and weight, as a means of interconversions; and secondly, to measure the variations from the expected weight for length of individual fish or groups of fish as indications of fatness, general well being or gonad development, inshort to calculate the 'condition factor'. In a species of commercial importance, the former object has been found essential to convert the catch statistics of that species from weight to numbers in order to obtain the abundance of stock in space and time (Antony Raja, 1967). Further the relationship between length and weight in the growth of the fish is important in that the knowledge of the size at which the fish increases most rapidly in weight is of value in determining the size at which it may be usefully harvested. In the interconversions of length and weight and in the determination of a 'condition factor' an important aspect to be considered is whether a single equation will suffice or separate equations are required to describe the relationship between length and weight of sexes at various times of the year and phases of life history. In view of these practical utilities, an attempt was made to determine the length-weight relationships of commercially important species of flatfishes of the Genus *Cynoglossus* like the Malabar sole *C.macrostomus* and *C.arel* and the results are presented.

It is well established that the weight of a fish increases with increase in length but in a much more rapid manner, thereby showing that the weight is a function of length. Since length is a linear measure and weight a measure of volume, the weight of fishes was generally found to increase approximately as the cube of its length. This can be expressed by a hypothetical cube law $W = cL^3$, where 'W' represents the weight of the fish, 'L' its length and 'c' a constant. If the form and specific gravity of the fish remains constant throughout life such a formula can be applied to serve as the basis for the calculation of the weight of fish of known length or *vice versa*. But Le Cren (1951) has pointed out that a more general parabolic equation of the form $W=aL^n$ would serve better than the cube formula to express the relationship between the two factors where 'W' and 'L' represent weight and length of the fish respectively, 'a' a constant equivalent to 'c' and 'n' a constant to be determined from the data.

The applicability of the cube relationship of weight and length of fishes has been much discussed. If the fish does not change form or density as it grows, the weight will be proportional to the cube of any linear dimension. Allen (1938) has shown that for an ideal fish which maintain constant shape n=3. However, the change in morphology due to increase in age often cause the coefficient of regression of logarithm of weight on logarithm of length to depart substantially from 3. According to Hile (1936) and Martin (1949) the value of the exponent 'n' in the parabolic equation usually lies between 2.5 and 4.0. Beverton and Holt (1957) has stated that the value of 'a' and 'b' may vary within wide limits for very similar data and are sensitive to quite unimportant variations in the latter. They further opined that instances of important variations from isometric growth (p=3) in adult fishes are rare. Based on his studies on the Australian barracouta (*Thyrsites atun*) Blackburn (1960) has shown that the value of 'n' was considerably below 3.0. Antony Raja (1967) in a detailed study on the length-weight relationship of oil sardine (*Sardinella longiceps*) from Calicut region has shown that in the groups indeterminate, immature and mature the values of 'n' in majority were between 2.5 and 3.0, although in some instances most extreme values on the lower and higher sides were significantly different from isometric growth. The constant 'a' which is calculated after 'n' is established, can be used to compare an individual with others of the same species. Since the specific gravity of the fish flesh does not vary much within species, the value of 'a' will depend on the fatness, being high in fat fishes and low in thin fishes (Brown, 1957).

The equation $W=aL^n$ can be transformed into linear function by taking logarithmic values of the length and weight data, and the values of 'a' and 'b' can be estimated by regression analysis. Then the equation takes the form of

$$\text{Log } W = \log a + b \log L \quad \text{or} \quad y = a + bx.$$

where $Y = \log W$; $X = \log L$; $\log a$, the intercept of the line on the 'y' axis and b = an exponent.

Exhaustive data on length and weight representing wide ranging sizes can be grouped into short length classes and the average length and weight of each classes can form the input data for linear regression analysis. The length-weight relationship borne out of such exercise would form a representative relationship for the population. However, if the sampling consists of only older age group of fishes of individuals, belonging to a particular size group, the relationship so established would then become a biased one.

The real beginning in this line of work in India with the application of an approved modern statistical technique may be said to have been made by Jhingran (1952) on three species of major carps namely, *Labeo rohita*, *Cirrhina mrigala* and *Catla catla*. He determined the length-weight relationships in these fishes using the modification (i.e. $W= cL^n$) of Herbert Spencer's cube law equation which is $W= aL^3$. Using the same method Prabhu (1955a) studied the length-weight relationship in five perches near Mandapam and also in the ribbonfish (Prabhu 1955b)

Trichiurus haumela. Subseguently, studies on length-weight relationship have been included by most of the Indian workers in their studies on biology of many a species. Literature on the length-weight relationship on a large number of marine teleosts are available. Some of them include *Coilia dussumieri* (Bal and Joshi, 1956), mackerel (Pradhan, 1956; Udupa and Bhatt, 1983), *Thrissocles mystax* (Venkataraman, 1956), *Silago sihama* (Radhakrishnan, 1957), *Pseudosciaena diacanthus* (Rao, 1962), *Sardinella longiceps* (Antony Raja, 1967), *Trichiurus lepturus* (James,1967),*Sardinella albella* and *S.gibbosa* (Sekharan, 1968), *Nemipterus japonicus* (Krishnamoorthi,1971), *Polynemus heptadactylus* (Kagwade, 1971), *Tachysurus thalassinus* (Mojunder, 1971), *Decapterus dayi* (Srinivasan, 1981), *Leiognathus bindus* (Murthy, 1983), *Leiognathus dussumieri* (James and Badrudeen, 1981), *Johnieops vogleri* (Muthiah, 1982), *Stolepborus devisi* (Rao, 1988) and *Megalaspis cordyla* (Sivakami, 1995).

Though most of the work on Indian waters pertain to teleosts of different shape and dimensions, not much literature is available on the length-weight relationship in many of the flatfishes. The flatfishes are well known for the bilaterally asymmetrical nature of their body, an exceptional feature for the vertebrates. Their bodies are highly compressed laterally and the ocular side is more convex than that of the blind side. Kyle (1921), Ochiai (1966), Datta and Das (1985) and Das and Datta (1987a 1987 b) have observed various aspects of the body asymmetry emcompassing morphology and anatomy of different groups of fishes. Edwards *et al* (1970) determined the length-weight relationship of four species of *Cynoglossus* namely *C.brevis*, *C.cynoglossus*, *C.puncticeps* and *C.lida* from the southwest coast of India. Victor (1978) made observations on the length-weight relationship of the Malabar sole, *Cynoglossus macrostomus* at Mangalore. Seshappa (1981 a) reported the length-weight relationship in three species of *Cynoglossus* namely *C.semifasciatus*, *C.dubius* and *C.bilineatus*. Seshappa and Chakrapani (1983) worked out the length weight relationships in the males and females of *C.lida* from Calicut area. The length weight relationship in the Indian Halibut *(Psettodes erumei)*, Flounder *(Pseudorhombus arsius)* and sole *(Synaptura commersoniana)* have been made by Das and Mishra (1989). Recently King (1996) reported the length-weight relationship in *Cynoglossus canariensis* from coastal waters of Nigeria.

The present work attempts to study the length-weight relationships of Malabar sole *(Cynoglossus macrostomus)* and large-scaled tongue sole *C arel* collected from Cochin.

MATERIAL AND METHODS

Random samples of Malabar sole *C. macrostomus* and *C. arel* were collected from the commercial landings at Cochin, Ambalapuzha and Neendakara. The total length was measured in mm from tip of snout to the tip of mid caudal ray. Weight of individual fishes were taken using a triple beam balance with 0.01g accuracy. The length data were grouped into 5 mm intervals.

For adopting the general exponential equation $W = a\ L^b$, least square computations were made using log L (x) and log W (y) for obtaining values of EX, EX^2, X, EY, EY^2, Y and EXY where E denotes summation and X and Y represent mean values of x and y respectively. The regression coefficient or slope of the regression line (b) was computed using the equation

$$b = \frac{EXY - (EX)\ (EY)\ /N}{EX^2 - (EX)^2\ /\ N}$$

where N= number of samples. The intercept (a) was determined by the formula

$a = Y - b\ X$. Using the values, the linear equation of length-weight relationship

$$\text{Log } W = \log a + b \log L \quad \text{or } y = a + b\ x$$

was obtained. Further, converting these logarithmic values into antilogarithms the exponential form $W = aL^{\ b}$ was obtained. The estimates of regression coeficient of males and females were tested for finding the significance of variation from tested value of 3 by employing the 't' test using the formula

$$t = \frac{b - B}{S_b} \quad \text{where B is equal to 3.}$$

RESULTS

A total of 340 male of Malabar sole of the size range 61 mm to 161 mm in total length and 1 g to 21.6 g in weight; and 329 females of 50 mm to 162 mm and weight 0.25 g to 23.2 g were utilised for computing the length-weight relationship. Samples of large scaled tongue sole (*C.arel*) consisted of 124 males of the size range 160-293 mm (16.2 g to 122 g in weight) and 91 females of the size range 180 mm to 338 mm (29.5 g to 140 g) were analysed for computing the length-weight relationship.

MALABAR SOLE *C.MACROSTOMUS*

The general equation $W = aL^n$ can be written as

$\text{Log } W = \log \text{`a'} + \text{`n'} \log L$, or $Y = A + BX$ where $Y = \log W$,

$A = \log \text{`a'}$, $B = \text{`n'}$ and $X = \log L$, which is a linear relationship between Y and X. This linear equation was fitted separately to the data of male and female fishes. The estimates of the parameters 'A' and 'B' for each of these categories obtained by the method of least squares were

Male	$W = 0.000002194\ L^{3.16378}$
Female	$W = 0.000002953\ L^{3.10734}$
Pooled	$W = 0.000002576\ L^{3.13309}$

The corresponding logarithmic equation may be written as

Male	$\log W = -13.02977 + 3.16378 \text{ Log } L$	$(r = 0.986311)$
Female	$\log W = -12.73267 + 3.10734 \text{ Log } L$	$(r = 0.969272)$
Pooled	$\log W = -12.86942 + 3.13309 \text{ Log } L$	$(r = 0.978135)$

The scatter diagram of observed values of weight (g) against total length (mm) and the fitted curve separately for males and females are given in Figures 6.1 and 6.2. which showed a curvilinear relationship for both sexes.

While the above formula holds good for the length-weight relationship of *C.macrostomus*, the significance of variation in the estimate of 'B' for this species from the expected value for ideal fish (3.0) was tested by the 't' test as given by the formula t = b-B/Sb . The results were as follows:

Male	3.164-3/0.3511	=	1.476	Not significant
Female	3.107-3/0.1575	=	0.01685	Not significant
Pooled	3.137-3/0.1359	=	1.00806	Not significant

The values were not significant and the cubic formula $W=al^3$ is a proper representation of the length-weight relationship of *C.macrostomus*. Since the values are not significant the growth in weight is isometric in both males and females.

LARGE-SCALE TONGUE SOLE *CYNOGLOSSUS AREL*

The length-weight relationship in the large-scaled tongue sole *Cynoglossus arel* also was worked out. The length-weight relationship equation fitted for each of these categories were found to be

$$\text{Male} = 0.000003211\ L^{3.05395}$$

$$\text{Female} = 0.000006494\ L^{2.92315}$$

$$\text{Pooled} = 0.000002576\ L^{2.97478}$$

The relationship was found to be curvilinear in both males and females.

The corresponding logarithmic equation is expressed as

Male	Log W	=	-12.64902+3.05395 Log L	(r = 0.954200)
Females	Log W	=	-11.94467+2.92315 Log L	(r = 0.955859)
Pooled	Log W	=	-12.22171=2.97478 Log L	(r = 0.955717)

Further, the significance of of the variation in the estimate of 'β' for this species from the expected value for ideal fish (3.0) was tested by the 't' test and the results were as follows:

Male:	3.054-3/0.00783	= 0.61025	not significant
Female:	2.923-3/0.19193	= -0.7554	not significant
Pooled:	2.975-3/0.0943	= -0.26499	not significant.

In this species also the formula $W = aL^3$ is a proper representation of the length-weight relationship. The growth is isometric in both the sexes.

To test the equality of the length-weight relationships between males and females, the analysis of covariance was carried out and the results obtained for *C.macrostomus* are given in Tables 6.1 and for *C.arel* in Table 6.2. The analyses revealed no significant difference between the relationship in respect of *C.arel*. However, in the case of *C.macrostomus* there was statistically significant difference between the elevations among sexes. But for all practical purposes since there was no apparent difference in the mean values, a common length-weight relationship could be considered. It may be noted here that when the sample sizes are large even a small difference between the estimates may get magnified.

The the length-weight relationship in flatfishes obtained by various authors are given in Table 6.3. From the values of b it appeared that the growth in these fishes are isometric.

RELATIVE CONDITION FACTOR

The constantly dynamic nutritional, physiological, environmental and the biological cycle drive the condition of the fish towards great many variations. Hence possession of additional information regarding seasonal variations of the condition of a fish in relation to both the internal and external environment becomes an utmost necessity in fishery biological studies. Calculation and utilisation of the relative condition factor has obviously gained significance towards understanding the nutritional and biological cycle of the fish species.

The analysis of the length-weight relationship with the object of finding the variation from the expected weight for length of individual fish or groups of individuals as indicative of fatness, general well being or gonad development may be termed as condition (Le Cren, 1951). Tester (1940) has shown that the variations in the specific gravity in the flesh of the fish occur, and Kestevan (1947) discussed their importance in studies on condition. Usually the density of the fish is maintained as the same as that of the surrounding water, and hence changes in weight for length are due to changes in form or volume and not specific gravity. Such changes are analysed by the condition factor or coefficient of condition or ponderal index (Hile, 1936; Thompson, 1943) which is given by the formula

$K = \frac{100\ W}{L^3}$ where 'K' represents the condition factor, 'W' the weight and 'L' the length of the fish respectively. This formula is based on comparison with ideal fish, where the cube relationship holds good. The value of K will be affected if the fish does not obey the cube law in its length-weight relationship. Factors like age, sex, maturity, racial differences, food supply, degree of parasitation, environment and selection in sampling may affect K indirectly through the values of the exponent. Instead, by using an empirical calculated length-weight relationship, $W = aL^n$, the factors affecting 'K' could be eliminated (Le Cren, 1951). The condition factor so calculated is called the relative condition factor (K_n) and is expressed by the formula $K_n = W'/W$, where 'W' represents the observed weight and W the calculated weight of fish obtained by using the logarithmic formula. The difference, therefore, between K (condition factor) and K_n (relative condition factor) is that, the former measures the deviation of an individual from the average weight for length, while the latter measures the deviation from the hypothetical ideal fish.

Practically there exists no study on the relative condition factor in flatfishes of India. Hence a detailed study of the relative condition factor in a commercially important flatfish, the Malabar sole *C.macrostomus* was undertaken. The relative condition factor K_n for this fish was calculated by employing the formula $K_n = W'/W$. To find out the K_n values in different size groups nearly 297 males and 229 females in the length range 60-160 mm were considered. The seasonal variation in the k_n values were based on 412 males and 626 females. Since the predominance of preadults may result in higher K_n value and also to, prevent the influence of other factors, only the most commonly occurring size groups in the fishery and fishes above the size at maturity were considered for the purpose. For males, a length range of 100-147 mm and for females 100-149 mm were analysed to study the seasonal pattern in the K_n values.

Using the length-weight relationship formula the calculated weight of all specimens separately for males and females were worked out both size group-wise and month-wise following the formula of Le Cren (1951).

RELATIVE CONDITION FACTOR IN RELATION TO SIZE

The K_n values of different size groups give an idea about the variations in the condition of the fish during its growth. In Malabar sole the fluctuations in the relative condition with increase in length of the fish are quite apparent (Figure 6.3). The K_n values in females showed an increase from 0.95 in 60 mm length group to 1.12 in the 80 mm group. The same trend was noticed in males also but here the K_n value of 1.2 was noticed in 70 mm length group. The point of inflexion for both sexes was found to occur at 95 mm length group. Subsequently the K_n value reached a peak at 115 mm length group. The decrease in the value from this size indicated spawning. The next peak in K_n value was seen at 130 mm which was followed by a decline that indicated the second maturity and spawning there after. The fish is nearly two years old by this time. Again the K_n value indicated a peak in 150mm length group. A further decrease there after in both sexes indicated gonadal maturity and subsequent spawning.

Pillay (1958), Sarojini (1957), Narasimham (1970), Bhatt (1970), Parulekar and Bal (1971) and Devaraj (1973) stated that the point of inflexion on the curve showing decrease in K^n with increasing length is a good indication of the length at which sexual maturity starts. In the light of Hart's (1946) argument that the diminution of 'K' or the point of inflexion at 95-99 mm can be considered as minimum size at first maturity which also confirm the findings from gonadal maturity observations. The point of inflexion for both sexes is at 95-99 mm . If this is any indication of the length corresponding to the attainment of sexual maturity, then in either sex of the Malabar sole, the size at maturity is to be assumed at 95-99 mm size group. Further it is confirmed following the gonadal development also.

It was suggested by Pantalu (1961) and Devaraj (1973) that the increase in the K_n values between different length groups of both sexes be related to the number of spawnings during the longevity of a fish. Three peaks and three valleys are observed in the K_n of Malabar sole indicating three spawning during the life of this fish. This again supported the findings that the Malabar sole is not a multiple spawner.

SEASONAL VARIATION IN RELATIVE CONDITION FACTOR

The monthly fluctuations in K_n values are known to be influenced by many factors. Majority of authors have reported that the fluctuations in condition are closely related to the sexual cycle of the fish and an increase or decrease in K_n is due to a similar fate in the weight of gonads before and after spawning (Le Cren, 1951; Pillay, 1958; Sarojini, 1957; Pantalu, 1961; Devaraj (1973). However, Hile (1936), Qasim (1957), Bal and Jones (1960), Blackburn (1960) and Bhatt (1970) have pointed out that the monthly fluctuation in the K_n values are independent of the reproductive cycle and can be better related to the feeding rhythm.

The monthly K_n values of Malabar sole was worked out for the period August 1994 to September 1996 for both males and females. Here, fishes of the size range 100-150mm size range only were considered through out the period (Figure 6.4) so that the mean length (120-125mm) was almost maintained during each month. The results indicated that the seasonal pattern of fluctuations of K_n values in both sexes of Malabar sole have been found to be the same during the two years of study from 1994 to 1996. The average K_n values for the entire period was 1.01 and 0.95 for females and 1.03 and 1.01 for males during 1994-95 and 1995-96 respectively. The condition factor in females started increasing from August and reached a peak of 1.24 in October during 1994 and then steeply declined to a value of 0.97 in February, again the value showed an increase in March. Later the value decreased to

0.89 in May and then slowly increased by September 1995. In the males, higher K_n value was seen during November 1994 which dropped to a low value of 0.82 in December. But again it peaked in February and then steeply plummeted hence forth. In males also the seasonal fluctations in the K_n values followed a pattern similar to that in the females.

The increase in the K_n value from August corresponded with the period of maturation of gonads as it was clearly associated with a rise in the gonado-somatic indices during these months. So also the increase from February indicated the maturation of gonads. The abrupt fall in the condition after October 1994, May 1995, November 1995 and February 1996 may be attributed to the increased metabolic strain of spawning. In the malabar sole spawning takes place during October-November and March-April/May. This aspect has been corroborated by following the process of maturation during different months. The changes in K_n values are more or less similar in both sexes during different seasons, indicating that the metabolic strain undergone by males as well as females is almost the same.

Variations in the condition factor of different fishes have been attributed to different factors by earlier workers. Thompson (1943) pointed out that the high and low condition in the Plaice *Pleuronectes platessa* are found before and after spawning. Hickling (1945) found the condition low before spawning and high after it in the case of the cornish pilchard, *Sardina pilchardus* which was explained by him as due to sexual cycle and the availability of food respectively. Qasim (1957) offered the explanation that the increase and decrease of condition in *Blennius pholis* are probably due to general building up and loss of reserves respectively. Blackburn (1960) in his studies on the australian barracouta *Thyrsites atun* remarked that it was not possible to interpret the changes in condition of this fish basing on sexual cycle or the intake of food, and that it may depend on several other factors. Neelakantan and Pai (1985) found that the fluctuations in the condition in the whitefish *Lactarius lactarius* are closely related to sexual cycle. Devaraj (1973) observed a steep decline in the K_n value of the snakehead *Ophicephalus marulius* when there is a change in the food habits of younger ones from a macro-invertebrate diet to piscivorous diet. He further observed higher values of K_n during periods whenever there was predominance of young ones in the sample. James (1967) while studying the K_n values in *Eupleurogrammus intermedius* suggested that the variation in K_n value may be due to factors other than sexual cycle. So also the variations in the K_n values have not shown any relation to differences in the intensity of feeding. According to Brown (1957) the balance between maintenance and growth may vary with physico-chemical factors of the environment and with age and physiological state of the fishes.

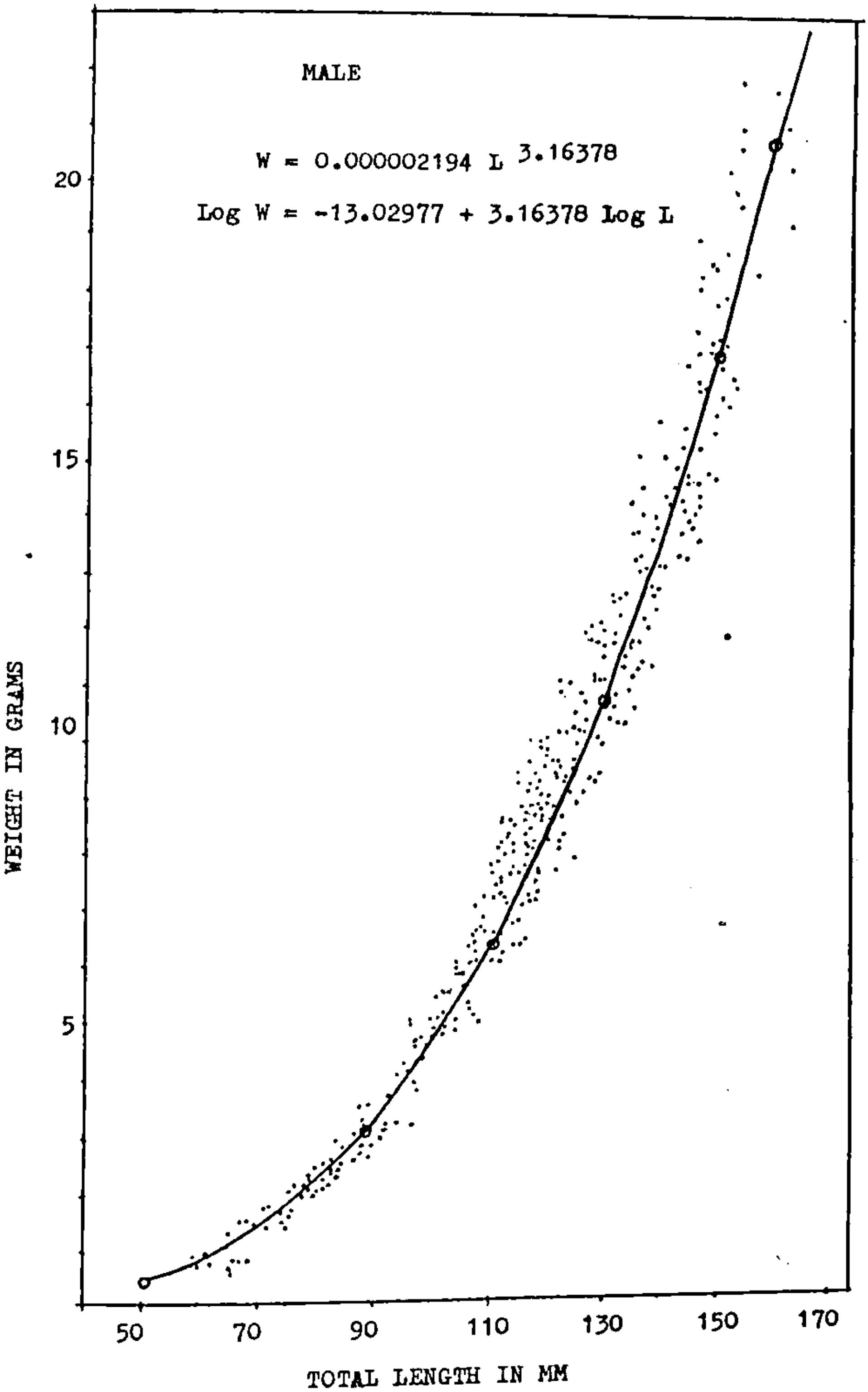


Fig. 6.1 Parabolic relationship between length and weight in males of C.macrostomus

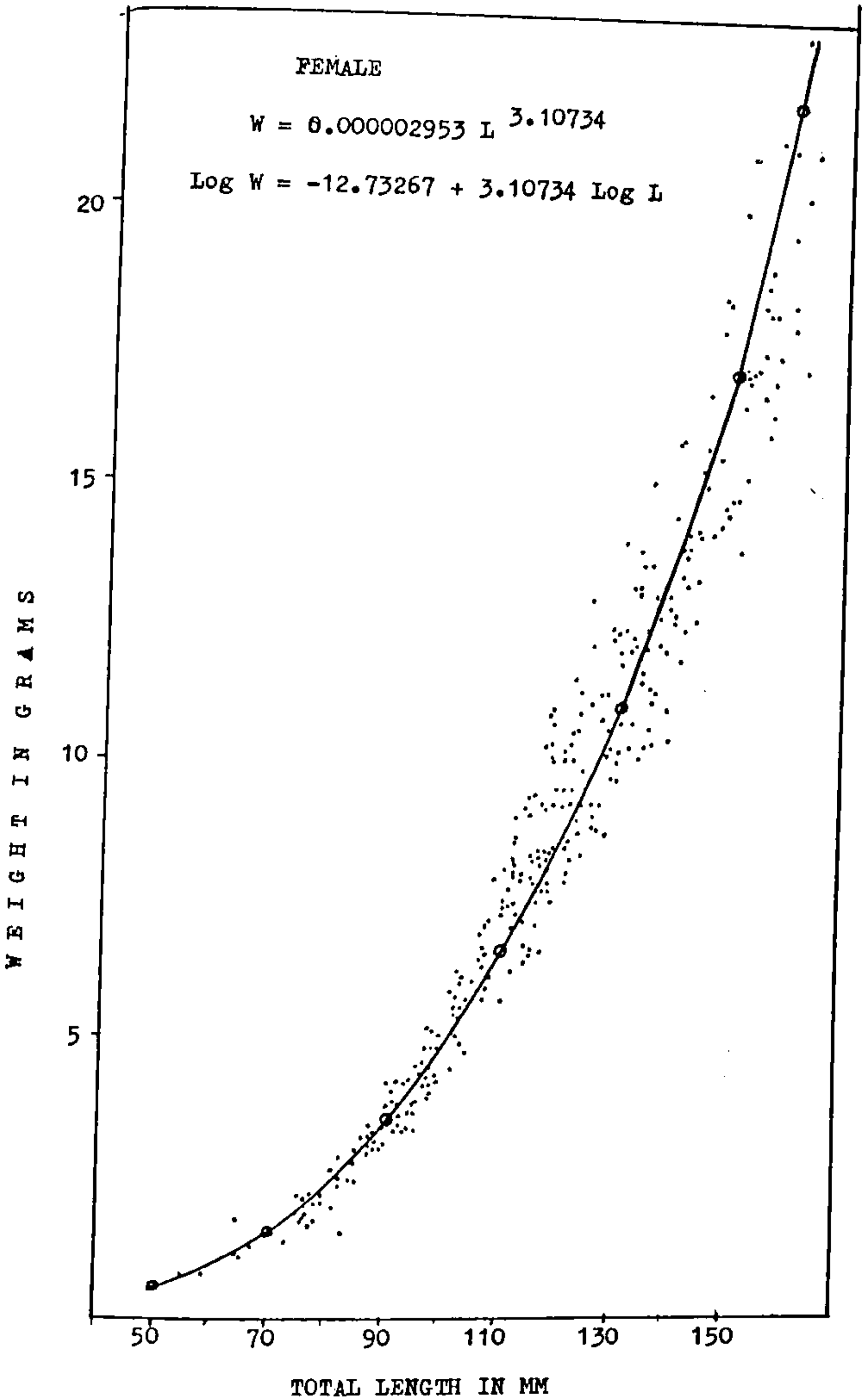


Fig. 6.2 Parabolic relationship between length and weight in females of <u>C.macrostomus</u>

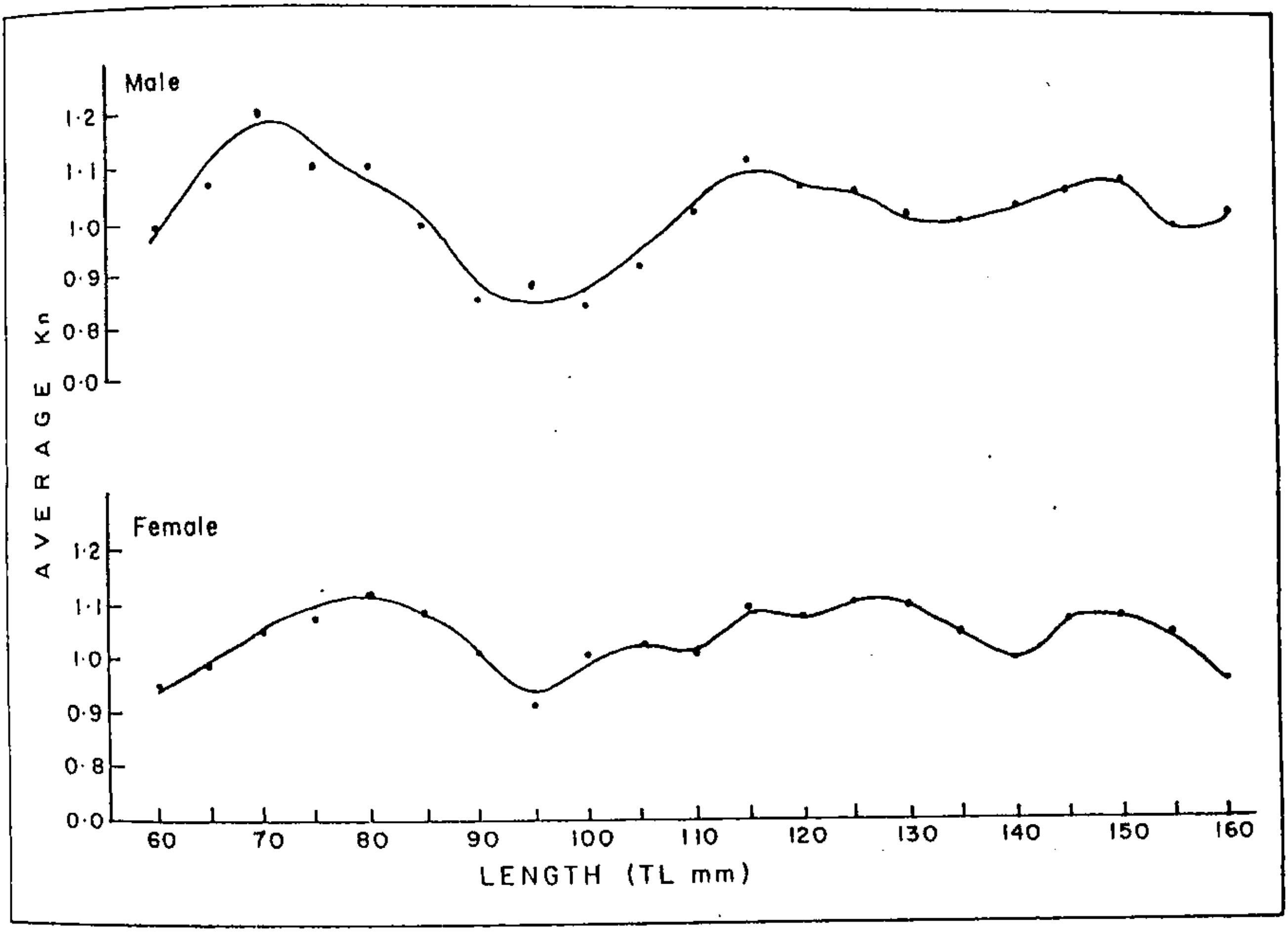


Fig. 6.3 Relative condition factor in different size groups of C.macrostomus

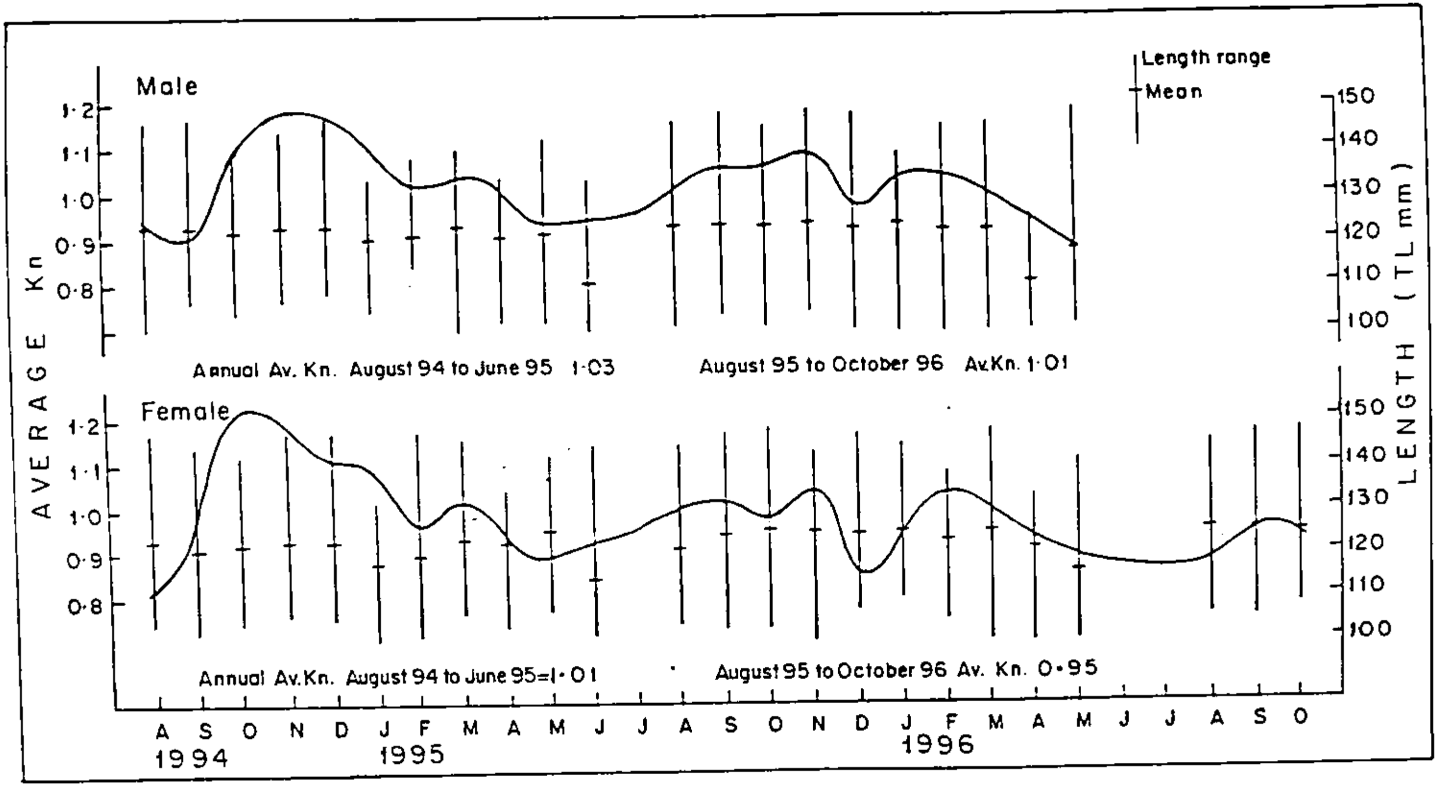


Fig. 6.4 Monthly variation in the condition factor in males and females of C.macrostomus during 1994 to 1996

Table 6.1 TEST OF EQUALITY OF REGRESSION LINES

Species: *Cynoglossus macrostomus*

Transformation applied log(Y) = a + log(X)

ANOVA TABLE

Source	DF	SS-X	SP	SS-Y	b	DF	SS	MS	F
Male	340	14.9348	47.2505	153.6685	3.164	339	4.178	0.01233	
Female	329	13.0799	40.6435	134.4274	3.107	328	8.134	0.02480	
Total						667	12.313	0.01846	
Pld W	669	28.0147	87.8940	288.0960	3.137	668	12.335	0.01847	
difference between slopes						1	0.022	0.02221	1.20
Between	1	0.1034	0.2026	0.3969					
W + B	670	28.1181	88.0966	288.4929	3.133	669	12.478	0.01865	
Difference between corrected means						1	0.143	0.14297	7.74

Source	Mean-X	Mean-Y	a	b	r
Male	4.759	2.026	-13.02977	3.16378	0.986311
Female	4.734	1.977	-12.73267	3.10734	0.969272
Pooled	4.747	2.002	-12.86942	3.13309	0.978135

Table 6.2 TEST OF EQUALITY OF REGRESSION LINES

Species: *Cynoglossus arel*

Transformation applied log(Y) = a + log(X)

ANOVA TABLE

Source	DF	SS-X	SP	SS-Y	b	DF	SS	MS	F
Male	123	1.0415	3.1805	10.6680	3.054	122	0.955	0.00783	
Female	90	1.1449	3.3466	10.7069	2.923	89	0.924	0.01039	
Total						211	1.879	0.00891	
Pld W	213	2.1863	6.5271	21.3749	2.985	212	1.889	0.00891	
Difference between slopes						1	0.009	0.00933	1.05
Between 1		0.0736	0.1955	0.5195					
W + B	214	2.2599	6.7226	21.8944	2.975	213	1.896	0.00890	
Difference between corrected means						1	0.008	0.00766	0.86

SOURCE	MEAN-X	MEAN-Y	a	b	r
Males	5.461	4.029	-12.64902	3.05395	0.954200
Females	5.499	4.128	-11.94467	2.92315	0.955859
POOLED	5.477	4.071	-12.22171	2.97478	0.955717

Table 6.3 Length-weight relationships in soles, halibut and flounders reported by various authors.

Species	Sex	Nos.	a	b	Area	Author/s
Psettodes erumei	M	581	0.000003	3.216	Orissa	Das &
" "	F	564	0.000003	3.214	"	Mishra (1989)
Pseudorhombus arsius	M	385	0.000006	3.115	"	
" "	F	376	0.000004	3.176	"	
Synaptura commersoniana	F	31	0.000000.59	3.478	"	
Cynoglossus canarieneis	M	-	0.028	3.138	Nigeria	King (1996)
C.brevis	P	27	0.05	3.156	Alleppey	Edwards *et al*
C.cynoglossus	P	137	0.004	3.155	"	" (1971)
C.lida	P	74	0.004	3.096	"	"
C.puncticeps	P	82	0.004	3.161	"	"
C.macrostomus	M	761	0.000004327	3.0417	Mangalore	Victor (1978)
"	F	657	0.00001415	2.7886	"	"
	P	1418	0.000007872	2.9145	"	"
C.dubius	M	231	0.0018	3.2926	Calicut	Seshappa
	F	186	0.0023	3.217		
C.bilineatus	M	75	0.0029	3.1667		(1981 a)
	F	83	0.0023	3.2489		
C.semifasciatus	M	265	0.0089	2.7712		
	F	361	0.0070	2.9024		
C.lida	M	94	0.0769	3.2151	Seshappa & Chakrapani	
	F	119	0.0772	3.2260	(1981)	
C.macrostomus	P	150	0.00003759	2.618	Calicut	Ferozkhan & Nandakumaran (1993)
C.macrostomus	M	340	0.000002194	3.16378	Cochin	Present study
"	F	329	0.000002953	3.10734	"	" "
"	P	669	0.000002576	3.13309	"	" "
C.arel	M	124	0.0000033	3.05395	"	" "
"	F	91	0.0000065	2.92315	"	" "
"	P	215	0.0000049	2.97478	"	" "

M = male, F = female and P = pooled.

CHAPTER 7

FISHERY

CHAPTER 7

FISHERY

INTRODUCTION

Among the demersal fishes of India, flatfishes constitute an important fishery which until recently could not be exploited adequately due to the lack of suitable gear. Although Norman (1927 and 1928) described 91 species of flatfishes, it is only a very small number of species that contribute to any substantial catches. In fact only a single species, the Malabar sole *Cynoglossus macrostomus* Norman, has been contributing a regular fishery of commercial importance along the Kerala and Karnataka coasts. Though the Halibut and flounders contribute to a fishery in some of the maritime states in India, the quantum of landings compared to that from Pacific and Atlantic Oceans, is meager and further the species encountered along the Indian coasts are mostly smaller in size.

Among soles the Malabar sole *Cynoglossus macrostomus* almost constituted a single species fishery in Kerala and Karnataka coast. Other soles such as *C.arel*, *C.bilineatus*, *C.puncticeps* and *C.dubius* occur as stray catches seasonally. Species of *Sole* and *Synaptura*, members of Soleidae occasionally come in small quantities in the miscellaneous inshore catches. *Psettodes erumei* known as the Indian halibut also occur in small quantities along both east and west coasts and are fished from slightly deeper waters compared to the soles. The flounders like *Pseudorhombus arsius, P. javanica, P. elevatus* and a few other species are also represented in the catch occasionally along both the coasts. Many other forms belonging to various families of Heterosomata occur as miscellaneous catch. The average annual landing of flatfishes during 1985-96 was 37,322 tonnes forming 1.8% of the total marine fish landings in India. The soles constituted 93.2% followed by halibuts (6%) and flounders (0.8%). The average annual landings in Kerala was 16,026 tonnes contributing 42.9% of the all India flatfish production. The soles constituted 15,603 t (97.3%), halibut 220 t (1.4%) and flounders 203 t (1.3%).

The Malabar sole, *Cynoglossus macrostomus* Norman is distributed on the east coast also and is essentially a shallow water form though it migrates and get scattered about in the relatively deeper waters of the fishing ground during the off season. The Malabar coast in Kerala is well known for the flatfish fishery and the Malabar sole locally known as *Manthal* (known as *Nangu* in South Kanara) is the most dominant species contributing more than 95 per cent of the flatfish fishery. The importance of this species has been pointed out by Bhimachar and Venkataraman (1952) and Seshappa and Bhimachar (1955). Rao (1967) stated that on the west coast, the soles are next in importance only to oil sardine, mackerel and shrimp fisheries in the magnitude of catch. The region between Mulki in South Kanara and

Quilon in south Kerala is important for sole fishery. The heaviest landings, however, are confined to the region between Edakad and Kadapuram on the Malabar coast. Tholasilingam *et al* (1973) stated that from the shallow and intermediate depths along the southwest coast, flatfishes formed important constituents. Grace mathew (1992) described the fishery of flatfishes along the west coast of India. Ferozkhan and Nandakumaran (1993) while studying the population dynamics of the Malabar sole gave a brief account of the fishery of flatfishes.

A review of the literature indicated that the fishery statistics and account on the fishery of flatfishes are widely scattered and the present study attempts to bring out a comprehensive account on flatfish fishery in various maritime states of India with special reference to Kerala. In Kerala the Malabar sole is an essential component in the trawl landings. Though there is no target fishing the species occurs in the shrimp trawl landings almost through out the year unlike many of the other finfish varieties. In the minitrawl, an innovative gear introduced along the coast of Alleppey in Kerala also the Malabar sole constitutes the second dominant item in the catch next to the shrimp *Karikkadi*. The ever increasing fleet of trawlers, their wide operational range and the operation of innovative gear like the mini trawlers have resulted in structural changes in the landings of many finfishes including the Malabar sole. Compared to the previous years the landings of Malabar sole have considerably increased in recent years. The present work assumes importance in that the effort, catch, catch per unit effort (c/e), and seasonal pattern of abundance of the Malabar sole in the trawler landings at Cochin and Neendakara (Quilon) and also with respect to the mini trawl operations at Ambalapuzha have been studied for a period of three years from January 1994 to December 1996 and the results are discussed.

MATERIAL AND METHODS

Time series data on fishery of flatfishes in different maritime states from 1956 to 1996 were collected from the *Bulletins and Marine fisheries information service T&E series* published by the Central Marine Fisheries Research Institute. The trend of fisheries in each state is described with special reference to Malabar sole fishery in Kerala. The composition of Halibut, flounders and soles in each state with respect to the period 1985 to 1996 have been analysed. Data on flatfishes landed by private trawls operating at Cochin and Neendakara Fisheries Harbors and from the minitrawls at Ambalapuzha were collected and analysed monthwise, seasonwise with reference to effort, catch and catch per unit effort (c/e) for three year period from January 1994 to December 1996. Weekly trips were made for observation on the trawl landings at Fisheries Harbour Cochin and fortnightly observations Were carried out on the trawl landings at Neendakara (Quilon) and minitrawl landings at Ambalapuzha. To estimate the monthly catch, the average weight of catch per unit effort on observation days was multiplied by the number of units in operation on that day and the total for all observation days were then raised to the total number of actual fishing days in that particular month.

FISHERY OF FLATFISHES IN INDIA

The flatfish production in India from 1956 to 1996 have been considered (Table 7.1). The total flatfish production was 9,122 t in 1956 and 41,361 t during 1996. A lowest catch of 3,687 t was observed during 1957 and a highest of 63,444 t during 1992. Compared to the fifties the landings registered 17.2% increase during the last four decades. On an average the flatfishes constituted 0.7 to 2.8% of the total marine fish production in India. A characteristic feature is the variability in abundance of the fishery, a phenomenon generally noticed in pelagic fisheries like oil sardine and mackerel. The total flatfish production and the percentage contribution to the all India marine fish landings are given in Figure 7.1.

FIVE YEARLY TREND IN THE FISHERY: The average annual catch for each five year period was 10,026t (1956-60); 9,776t (1961-65); 9,708 t (1966-70); 13,340 t (1971-75); 12,070 (1976-80); 27,491 t (1981-85); 29,672 t (1986-90) and 45,880 t (1991-95). The five yearly average production trends indicated that the production of flatfishes was 10,026t during 1956-60 which slumped to 9776 t and 9708 t during the next successive five yearly averages of 1961-65 and 1965-70 respectively. The production reached an average of 13,340 t during 1971-75 registering 37.4% increase over 1965-70 period. But during the next five year period 1976-80 the production slumped by 9.5%. The landings remarkably increased by 128% during 1981-85 compared to that of 1976-80. From 1981 onwards a general trend of increase in landings was observed. The production figure reached 29,672 t during 1986-90 recording 7.9% increase over the previous five year. A further improvement by 54.6% was seen during 1991-95 period compared to the landings during 1986-90.

DECADAL AVERAGE PRODUCTION: The data on annual production of flatfishes were further analysed on a decadal basis. The decadal average production was 9,901t, 11,524t, 19,781t and 37,776 t during 1956-65, 1966-75, 1976-85 and 1986-95 respectively. The successive decadal increase over 1956-65 period were 16.4%, 71.7% and 91% respectively. The current decadal average (37,776t) during 1985-96 indicated nearly 4 fold increase compared to the production (9,901t) during 1956-65).

FLATFISH LANDINGS IN MARITIME STATES OF INDIA

Time series data on flatfish landings from Kerala, Karnataka and Tamil Nadu are available from 1956 to 1996. But from other states the data availability is from 1960 (Table 7.1). Again, during the fifties, only the pooled data from West Bengal and Orissa are available. For describing the statewise annual average landings the data from 1970-96 and for indicating the major components of the flatfish fishery, the data from 1985 to 1996 were analysed.

EAST AND WEST COASTS

The average annual all India landings of flatfishes during 1970-96 was 25,815 t and west coast contributed 22,655t forming 87.8% and east coast 3,160 t forming 12.2%. On the east coast West Bengal and Orissa, Andhra Pradesh, Tamil Nadu and Pondicherry contributed 1.1%, 2.9%, 7.5% and 0.7% respectively. On the west coast 45.5% of the total all India production of flatfishes came from Kerala, followed by Karnataka (13.8%), Maharashtra (13.6%), Gujarat (11%) and Goa (3.6%).

WEST BENGAL AND ORISSA: During 1960 to 1996 the annual landings varied from a lowest catch of 6 t during 1976 to 812 t during 1986. The average landings during 1970 to 1996 was 276 t. This constituted 1.1% of the total flatfish production in India. Fig.7.2 gives the annual landings of West Bengal and Orissa from 1980-1996. It may be seen from Table 7.1 that the annual landings were low from 1960 to 1981. The yearly landings were less than 100t during most of the period. From 1982 the landings increased and crossed 800 t, but thereafter declined to a low in 1990. But further it evinced an increase in production as indicated in Figure 7.2.

ANDHRA PRADESH: The yearly landings up to 1996 are given in Figure 7.2 and Table 7.1. The lowest landings of 56 t was during 1976 and the highest 2,213t was observed in 1981. The annual landings were less than 300t prior to 1975 and it crossed 2,000t by 1981. The landings never crossed this level afterwards but stabilised around 1,000 t during 1991-96 period.

Tamil Nadu: The yearly production figures are available from 1956 to 1996 (Table 7.1). But upto 1968 the data from Pondicherry have been merged with the state. As in any other states the fishery showed large scale fluctuations in the annual production trends. The annual landings from 1956 to 1996 are given in Table 7.1 and Figure 7.4. The lowest production of 119 t was in 1958 and highest of 3,253 t during 1982. Though the production crossed 1,000t during 1961, the annual landings were less than this during most of the year upto 1977. From 1988 the annual landings were above 2,000t. The annual average (1970-96) was 1945 t forming 7.5% of the total flatfish production in India.

PONDICHERRY: The average landings during 1970-96 was 172 t which constituted 0.7% of the total flatfish production in India. The annual production varied from 48 t in 1974 to an all time highest catch of 320 t during 1984. The yearly landings were less than 200 t during most of the period (Fig. 7.5 & Table 7.1).

KARNATAKA: The production statistics are available from 1956 to 1996. The average landings during 1970-96 was 3,551 t which contributed 13.8% of the total flatfish production in India. The lowest landing of 162 t was during 1962 and highest 18,185 t in 1992. Except in 1958 and 1968 the landings were less than 1,000t upto 1971. By 1974 the landings crossed 2,300t, but declined again. Except for the record catch of 18,000t during 1992 the landings mostly fluctuated between 2,500 t to 7,800 t during 1983 to 1996 (Table 7.1 & Figure 7.6).

GOA: The average production was 939 t forming 3.6% of the total flatfish landings in India. A lowest figure of 16 t was observed in 1975 and a highest 3,118 t during 1993. The annual landings showed wide fluctuations (Table 7.1 & Figure 7.7).

MAHARASHTRA: In the flatfish fishery map of india Maharashtra occupied the third position by contributing 3,512t that formed 13.6%. The landings fluctuated from 18 t in 1963 to 7,500t in 1995. During 1970 to 80 the landings fluctuated from 487 t to 2,737 t. Remarkable increase in landings was noticed from 1982 (Table 7.1 & Figure 7.8).

GUJARAT: The state contributed 11% of the flatfish production with an average landing of 2839 t during 1970-96. During 1960 to 1971 the landings were less than 100 t during most of the years. The fishery started improving from 1972 onwards. Though there was decline in the landings during 1977 to 1979 the catch steadily improved with characteristics fluctuations and reached an all time peak of 7,561t in 1995 (Table 7.1 & Figure 7.9).

COMPOSITION OF FLATFISH LANDINGS

The composition of flatfish landings were worked out based on the average production trends during 1985-1996 (Table 7.2). Out of 37,322 t of flatfish landings in India the soles constituted (34,799 t) 93.2%, Halibut (2,221t) 6.0% and flounders (302 t) 0.8%. On the east and west coasts also the soles followed by the halibut dominated the flatfish landings. Along the east coast soles constituted 82.1%, halibut 15.6% and flounders 2.3%. Whereas on the west coast soles contributed 94.7%, followed by halibut 4.7% and flounders 0.6% of the flatfishes.

In West Bengal and in Orissa the average flatfish landings were 69t and 409t respectively and was entirely comprised of soles. The average annual flatfish landing was 1,039t, and soles, halibut and flounders constituted 78.9%, 14.2% and 6.9% respectively in Andhra Pradesh. In Tamil Nadu, soles formed 79.5%, halibut 19.4% and flounders 1.1% out of 2,556t of flatfishes. No flounders were landed in Pondicherry. Soles and halibut constituted 90.2% and 9.8% respectively.

Along the west coast, Kerala contributed on an average 16,026 tonnes to the all India production of 37,322 tonnes of flatfishes during 1985-96 (Figure 7.12). Soles formed 97.3%, halibut 1.4% and flounders 1.3% in this state (Figure 7.13). Flounders were not observed in the flatfish landings along coast of other maritime states of west coast. In Karnataka out of 6,168t of flatfishes landed the soles constituted 99.3% and halibut 0.7%. In Goa the average flatfish landing was 1,337t. Soles and halibuts constituted 99.3% and 0.7% respectively. Though soles dominated the flatfish landings, the exploitation of halibuts were highest in Gujarat followed by Maharashtra. In Gujarat 662 t of halibuts were landed which formed 16.5% and the soles 3,339 t forming 83.5%. In Maharashtra halibut constituted 621 t (11.2%) and soles 4,903 t (88.8%).

FLATFISH FISHERY IN KERALA

FISHING GROUNDS: The fishing ground for flatfishes and other demersal fishes on the west coast of India are spread over two diverse geographical regions - the southwest region comprising of Kerala, Karnataka and Goa and the northwest region comprising of the coasts of Maharashtra and Gujarat - where the physical characteristics of the coastal waters differ considerably from each other. While the southwest coast experiences strong upwelling and consequent environmental changes during the monsoon seasons, the northwest region is characterised by strong tidal currents and a much wider continental shelf. The fishing crafts and gears operating in these two diverse regions also mostly have evolved to suit the prevailing physical condition of the sea and the resource availability. In general, the indigenous fishery is based primarily on a few varieties of active gears on the southwest coast and passive gears on the northwest coast.

Presently along Kerala coast there is no gear that exclusively exploit flatfishes. In the trawlers operating from major centres like Calicut, Cochin, Munambam, Quilon and other centres the Malabar sole is an essential bye-catch than any other fish. The minitrawls at Ambalapuzha and neighboring areas in the Alleppey District, aims at exploiting the *Karikkadi (Parapenaeopsis stylifera)* from the inshore areas and the Malabar sole is the second dominant component in the landings.

FISHING GEAR

Trawl: Trawlnets of various designs and sizes operated by small mechanised vessels of 8-14 m are the most important gear used for exploiting flatfishes. Four-seam or two-seam shrimp trawls of 12-18 m head rope length having code-end mesh sizes of 20-25 mm are operated. The fishing ground extends upto about 60-70 m depth. But flatfishes are mainly caught from within 40 m depth zone. The trawling season commences by middle or end of August and continue upto the ban period starting from June for a period of 45 days. Kerala, with a coastline of 590 km constitute less than 10% of the entire coastline. The coastal waters of Kerala is now experiencing one of the highest fishing pressures in the country as there are about 4,500 small trawlers operating from various centres. This has brought about a quantum jump in the marine fish production including the Malabar sole.

Minitrawl: The minitrawler or *Murivallom* is an innovative craft introduced along the Alleppey coast during 1988. Presently about 3000 units are in operation. The minitrawl is an effort to copy the mechanised trawler and is a motorised country craft *(Vallom)* of 10 m in length, 150 cm in width and operate without any winch facility. The craft is motorised with an 8 to 9.9 HP OBE. The gear called minitrawl has a code end mesh varying from 14-20 mm.

The gear is used for bottom and subsurface trawling in the inshore belt upto 2-5 km. Fishing is carried out throughout the year except during the southwest monsoon period from June to August. Fishing season commences on the first of the Malayalam month (*Chingam*) which falls on August end or beginning of September. The gear targets to exploit the shrimp, the *Karikkadi*, *Parapenaeopsis stylifera*. The next dominant catch is the Malabar sole *Cynoglossus macrostomus*.

FISHERY

The average landings of flatfishes in Kerala was 11,814 t forming 45.8% of the total flatfish landings in India during 1970-1996. During 1985-96 period the average flatfish landing in Kerala was 16,026 t forming 42.9% of the all India flatfish production. Data on flatfish landings in the state are available from 1956 onwards (Table 7.1). The landings varied from 2,726t in 1957 to 28,445 t in 1992 during the period 1956-96 (Figure 7.14). The contribution of flatfishes to the total fish catch in Kerala varied from 0.9 to 8.4% The landings reached 7,600t in 1956 which was 10.5 and 60.9 times higher than the landings observed in Karnataka and Tamil Nadu during the same period. By 1957 the landings plummeted to 2,700t, but increased subsequently to 10,000t in 1958 and 12,000t in 1960, all the while fluctuating between 3,000t to 13,000t up to 1983. During 1984 the landing was 17,800t. Though the landings were less during the subsequent years, it reached an all time peak of 28,000 t during 1992. For the subsequent two years the landings remained stable around 20,000t but declined to 12,000 t and 16,000 t during 1995 and 1996 respectively.

The flatfish landings in Kerala is constituted by soles, halibut and flounders. But soles were the most dominant group that contributed to a fishery of commercial importance. During 1985 to 1996 out of the average 16,026t of flatfishes landed the soles constituted 15,603t forming 97.3%, followed by halibut 220 t (1.4%) and flounders 203 t (1.3%). The halibut is constituted by *Psettodes erumei* which is called the Indian halibut. The flounders also contributed to stray catches. The species encountered were *Pseudorhombus arsius, P. javanica, P. elevatus* and a few other species.

The trawl fishery at Cochin

On an average more than 200 trawlers were in operation at Fisheries harbour Cochin. Data on effort (E), Catch (C) and catch per unit effort (C/E) of trawlers for a period of three years from January 1994 to December 1996 have been collected and analysed. In general, the trawling season commences by about middle or end of July and lasts till the end of May or middle of June. The operations are suspended during this ban period from middle of June for 45 days.

Fishery during 1994: During 1994 the total flatfish landings amounted to 1,415t forming 2.8% of the total fish landings of 50,331t. The annual C/E was 14 kg. The average monthly landings of flatfishes during the period was 111 t. The catch was composed of soles, flounders and halibut in the order of abundance constituting 1,331t, 78t and 6t respectively. The soles which formed 94% of the flatfishes were constituted by the malabar sole *Cynoglossus macrostomus.* The occasional stray catches of other species of *Cynoglossus* noticed were found insignificant to constitute a fishery. The monthly catch of soles varied from 8t in May to 7,16t in August. The C/E varied from a lowest of 0.08 kg in May to 38.7 kg in August. The landings and C/E were higher during the second half of the year (Table 7.3).

Fishery during 1995: The flatfish landing during the year was 316t at a C/E of 5 kg and formed 0.96% of the total fish landings. The landings plummeted to 1,099t indicating nearly 78% decrease over last year. Halibuts did not occur. Soles and flounders constituted 81% and 19% respectively. The monthly catch of soles varied from 2t in September and November to 44t in May. The lowest monthly C/E of 0.8 kg was in November and a highest value of 9.9 kg was observed during March. The flatfishes formed 0.1 to 3.9% in the monthly total fish landings by the trawlers (Table 7.4).

Fishery during 1996: The flatfishes constituted 579 t of which soles, halibut and flounders contributed 565 t, 10 t and 4 t forming 97.6%, 1.7% and 0.7% respectively. Flatfishes formed only 0.96% of the total fish landings by the gear. The C/E was 5 kg. Compared to 1995 the flatfish landings improved by 1.7 times but was less by 836 t compared to 1994. The monthly landings varied from 4 t in November to 153 t In August. During August the flatfishes formed 3.7% of the total fish landings. The monthly C/E varied from 1.7 kg in November to 35 kg in September. Though the highest monthly landing was in August, the highest C/E of 35 kg was in September with 73t of flatfishes landed during this month (Table 7.5) (Plate IV).

An analysis of the effort input (units) indicated that the highest effort of 94,148 was during 1994. The effort input was 51,208 units during 1995 and 56,260 units during 1996. During 1995 the effort input came down by 46% and in 1996 by 44.5% compared to 1994. It is interesting to note that inspite of slight increase in the effort level during 1996 compared to 1995, the total fish landings were less compared to 1995. This indicated that there was a general decline in the abundance of all fishes in the fishing ground. This decline started after 1994. Consequently there was reduction in the effort input by the trawlers.

FLATFISH FISHERY AT NEENDAKARA (Quilon)

The trawl fishery at this centre for the years 1994, 1995 and is described in detail (Tables 7.6, 7.7 and 7.8).

Fishery during 1994: As in any other region, the shrimps and cephalopods were the target groups by the trawlers and the soles formed a bye-catch. But soles occurred throughout the year unlike most of the other fin fishes (Table 7.6).

The total flatfish landings during the year 1994 was 717t which formed 1.4% of the total fish landings. The flounders and halibut constituted only a minor fishery forming 6 t and 5 t respectively. The soles constituted 706 t forming 98.5% of the total flatfish landings. The sole landings were mainly composed of the Malabar sole *(Cynoglossus macrostomus)*. Others like *C. bilineatus*, *C. arel* and *C. puncticeps* occurred in nominal quantities and did not constitute a fishery. The monthly catch of soles varied from 24 t in June to 176 t during August. The annual C/E was 8.9 kg with the monthly value fluctuating from 4.3 kg in April to 13.3 kg in December.

<u>Fishery during 1995</u>; A total of 582 t of flatfishes comprising of flounders (16 t) and soles (566 t) constituted the fishery which formed 1.7% of the total fish landings. The monthly catch varied from a lowest of 8 t in October to 230 t in August. During August the flatfishes formed 2.2% of the total fish landings. The annual C/E was 8.5 kg and monthly C/E fluctuated between 1.5 kg in October to 34.6 kg in January (Table 7.7).

<u>Fishery during 1996</u>: An estimated 1,047t of flatfishes at a C/E of 12.7 kg was landed forming 2.1% of the total fish landings. The landings of halibut (3t) and flounders (1t) were negligible. The soles constituted 99.6% of the total flatfish landed. The monthly catch varied from 6 t in July to 280 t in August and the monthly C/E from 6.5 kg in November to 19.3 kg in August (Table 7.8).

The effort input of 78,897 units in 1994 came down to 66,028 units in 1995 showing 16.3% decrease. But during 1996 the effort input was 81,906 units recording 24% increase over the previous year. The total fish catch was 50,374t at a C/E of 638 kg during 1994 compared to 32,859t at a C/E of 498 kg in 1995. Though the effort input in 1996 increased by 3.8% compared to 1994, the total catch during 1996 decreased by 3.1%.

The annual landings during the three year period indicated that the highest annual landings of 1,331 t was at Cochin during 1994 compared to the highest landing of 1,047t during 1996 at Neendakara. The annual landings were low at both centres during 1995. Further at Neendakara the third quarter landings were highest. The same trend was observed at Cochin, except during 1995.

MINITRAWL FISHERY AT AMBALAPUZHA

The details of effort, total fish catch, flatfish catch and C/E of minitrawls for a three year period from January 1994 to December 1996 are described (Tables 7.9, 7.10 & 7.11).

Fishery during 1994: During the year 1994 a total of 249.8t of flatfishes at a C/E of 8.6 kg was landed contributing 21.1% of the total landings by the gear. The monthly landings varied from 10.6 t in April to 107.4 t in September. The lowest C/E of 3.7 kg was in April and highest of 14.9 kg. in September. During November also a high C/E of 12.6 kg was realised. The monthly percentage contribution varied from 8.4% in May to 31.9% in January (Table 7.9).

Fishery during 1995: The total flatfish landings amounted to 127.8 t at a C/E of 6.1 kg which formed 9.4% of the total catch of the gear. The highest monthly catch of 48.4 t at a C/E of 7 kg was in September, followed by 21.8 t at a C/E of 8.3 kg in May. The lowest catch of 1.6 t at a C/E of 3.5 kg was in November. The monthly percentage contribution varied from 6.6% in September to 36.5% in December. Though the highest catch was in September the C/E of 11.8 kg was highest in October (7.10).

Fishery during 1996: An estimated 118.5 t of flatfishes at a C/E of 6.2 kg was landed contributing 17.1% of the total landings by the gear. The lowest landing of 980 kg was in September and a highest of 62 t was observed during October. The monthly C/E varied from 0.8 kg in September to 23.3 kg in October. The monthly percentage contribution of the resource varied from 6.9% to 35.8% of the total landings by the gear (7.11).

The analysis of the three years data indicated that the flatfish (Malabar sole) landings decreased from 1994 to 1996. A total of 249.8t of Malabar sole landed during 1994 plummeted to 127.8 t in 1995 indicating 49% decrease over last year. So also the landing of 118.5 t of flatfishes in 1996 indicated a decline by 52% over 1994 and 7.3% over 1995. It may be noted here that the effort input also came down from 28,983 units in 1994 to 20,805 units in 1995 and to 19,144 units in 1996. The decline in the effort during 1996 was to the tune of 33.9% compared to 1994 and by 7.9% compared to that in 1995. A C/E of 8.6 kg noticed during 1994 decreased to 6.1 kg in 1995 indicating nearly 29.0% reduction. But it was promising to note that the C/E improved to 6.2 kg in 1996. Though the effort input was highest during 1994 the total fish landings registered an increase in 1995 by 168 t (+14%) over 1184.6 t of 1994 in spite of the reduction in effort by 28.2% in 1995. The annual C/E of 65kg for all fish combined was the highest during 1995 compared to other years. The total fish landings was only 691.5 t in 1995, the lowest compared to the other two years.

Seasonal pattern of abundance at Cochin, Neendakara and Ambalapuzha.

COCHIN : The monthly landings by the trawlers were further analysed quarterwise (Tables 7.12, 7.13 & 7.14). The highest catch was during the third, followed by 4th, Ist and 2nd quarters in 1994. During the third quarter 836 t at a C/E of 27.3 kg was observed which formed 62.8% of the annual total landings of flatfishes. Flatfishes constituted 3.8% of the total fish during this quarter. The fourth quarter realised 249 t constituting 18.8% of the annual flatfish landed. The C/E was 15.2 kg. This was followed by 143 t at a C/E of 5.9 kg noticed during the Ist quarter. The lowest of 103 t at a C/E of 4.5 kg was during the 2nd quarter.

Compared to the previous year the quarterwise landings depicted a different picture during 1995 where the highest catch was during 1st quarter as against the third quarter observed during the previous year. The first quarter was followed by 2nd, 4th and 3rd quarters. During the Ist quarter 88 t were landed compared to 143 t during 1994. The decrease was to the tune of 38%. The landings during the Ist quarter formed 34.4% of the yearly flatfish landings. The 2nd and 4th quarters landed 75 t and 65 t forming 29% and 25% respectively of the total annual flatfish landed. The third quarter landings amounted to only 28t. Though the landings were high during the Ist quarter, the highest C/E of 6.3 kg was during the 4th quarter followed by 5.6 kg in the first, 4.5 kg in the 2nd and 3.2 kg in the third quarter.

During 1996, the quarterwise abundance was similar to that observed during 1994. The highest landings were during 3rd, followed by 4th, 2nd and Ist quarters. During the third quarter 226 t of flatfishes at a C/E of 22.8 kg formed 2.3 % of the total catch by the trawlers. This was followed by 142 t in the 4th quarter at a C/E of 11.7 kg. The Ist quarter landings of 141 t was nearly equal to the 4th quarter landings but the C/E was 7.9 kg compared to 11.7 kg in the 4th quarter. The landings of 56 t during the 2nd quarter was the lowest with a C/E of 3.4 kg.

NEENDAKARA : During 1994, the highest catch was observed during 3rd, followed by 4th, Ist and 2nd quarters. During the 3rd quarter 277 t at a C/E of 8.7 kg contributed 39.2% of the annual flatfish landings. The second quarter landed 184 t at a C/E of 10.8 kg which contributed 26.1% of the annual flatfish production. The landings during the Ist and 2nd quarters amounted to 153 t and 92 t respectively. Though the highest catch was during the 3rd quarter, the C/E was high (10.8 kg) during the Ist and 4th quarters (Table 7.15).

During 1995, slight change in the seasonal abundance was observed. The 3rd quarter recorded the highest landings, followed by Ist, 2nd and 4th. During the previous year the 4th quarter was second dominant with respect to the landings. The landings were 400 t, 75 t, 57 t and 34 t forming 70.7%, 13.2%, 10.1% and 6.0% during 3rd, Ist, 2nd and 4th quarters respectively. The catch per unit effort also followed the same pattern of abundance (Table 7.16).

During 1996, the highest landings were during the 3rd, followed by 2nd, Ist and 4th quarters. During the 3rd quarter 435 t at a C/E of 18.4 kg was landed. The second quarter landing was 220 t followed by 218 t during the 4th quarter. The lowest of 170 t was in the Ist quarter. The third, 2nd, 4th and Ist quarters contributed 41.7%, 21.1%, 20.9% and 16.3% to the total flatfishes during the year (Table 7.17).

SEASONAL ABUNDANCE

Further, pooling of the data into premonsoon (February to May), monsoon (June to August) and post monsoon (September to January) at Cochin indicated that during 1994-95 the monsoon period recorded a highest landings of 892 t forming 70% of the annual flatfish production. This was followed by postmonsoon period with a landing of 293 t (23.1%) and premonsoon period with 88 t(6.9%). But during 1995-96 the trends were different in that the highest landings of 141 t (45.4%) was during the post monsoon followed by 131 t (42.3%) during the premonsoon. The landings during monsoon season was only 38 t (12.3%). The production trends indicated that there is considerable interannual variations during different seasons also (Table 7.18).

The grouping of monthly data into premonsoon, monsoon and post-monsoon at Neendakara indicated that during 1994-95, the highest landings of 272t (39%) was observed during the postmonsoon followed by 253 t (36%) during monsoon and 175 t (25%) during the premonsoon period. At Cochin, the monsoon period landings were highest during 1994-95. But at Neendakara, during 1995-96, the monsoon period landings were highest forming 349 t (62.6%) followed by 125 t (22.4%) during the post monsoon and 83 t (15%) during the premonsoon. Again at Cochin, 1995-96, the post monsoon season with a highest landing dominated followed by premonsoon and the monsoon period with the lowest (Table 7.18).

At Ambalapuzha, since there is no fishing during the monsoon, the monthly landings were grouped into premonsoon (January to May) and post monsoon (September to December).

The analysis indicated that the post-monsoon has been found to be more productive during all the three years studied. During 1994 the landings constituted 80.6 t during the premonsoon season forming 32.3% and during the post monsoon 169 t contributing

67.7%. The C/E of 11.5 kg obtained was high during the postmonsoon compared to 5.6 kg recorded during the premonsoon season. The flatfishes constituted 14.2% and 27.4% to the total landings of minitrawls (Table 7.19).

During 1995 and 1996 also the landings were on the higher side during the postmonsoon season. The landings amounted to 48.6 t and 79.2 t during pre and postmonsoon season in 1995. Nearly 62% of the landings were during postmonsoon season. This was reflected in the high C/E of 7.4 kg during the postmonsoon compared to 4.8 kg obtained during the other season. But the contribution of flatfishes to the total landings by the gear was higher (15.4%) during premonsoon 7.6% during the post monsoon.

Nearly 67% (79.3 t) of flatfishes were landed during the postmonsoon season in 1996. Compared to the earlier years (1994 & 1995) the C/E was less, but still the post monsoon period dominated with a C/E of 4.1 kg compared to 3.6 kg recorded during premonsoon season. So also the contribution of flatfishes to the total landings by the gear also was high (23.1%) during postmonsoon compared to 9.7% during the other season.

LENGTH COMPOSITION

The mean fish length (mm), mean weight (g) and the size range of Malabar sole exploited by the trawlers at Cochin and Neendakara and by the minitralers at Ambalapuzha are given in Table 7.20.

The size of Malabar sole in the trawl landings at Cochin ranged from 35-165 mm. The mean length of the fish during the post monsoon period of 1994 varied from 108 mm to 121 mm. By January 1995 there was a fall in the mean fish size to 82mm which continued upto April. Again during the postmonsoon season the mean fish size was higher compared to that noticed during the premonsoon season of 1996. The preadults (upto 90 mm) constituted 87% during January 1995, 85% during February, 66% in March and 68% in April. By May the percentage of preadults decreased to 11.6%, but by June increased to 73%. The percentage contribution of preadults were again higher in October and 87% in November 1995. The overall size groups obtained indicated that the fishery is supported by 0 year and 1 year old fishes of the size range 95-130 mm.

At Neendakara, in trawls Malabar sole had a size range of 55-165 mm, that varied during different months but the pattern of size groups observed was similar to that in Cochin.

Younger size groups generally occurred by November/December. As in Cochin the fishery was supported by '0' year and one year old fishes.

At Ambalapuzha it is purely an inshore fishery. The minitrawls are operated in the inshore belt upto 5 km. Malabar sole of the size range 55-150 mm were encountered. But large sized specimens were poorly represented and the higher size limit was less than 130 mm during most of the months. This is reflected in the mean fish length (size) and weight during different months. The mean fish length varied from 80 mm to 112 mm during 1994, from 81 mm to 118 mm during 1995 and 82 mm to 113 mm during 1996. But during most of the months the mean fish length was below 90 mm. The fishery is thus constituted by '0' year old fishes.

RECRUITMENT

There are two pulses in recruitment. The new recruits of October/November enter the fishery by December onwards. The new recruits of the second batch of spawning enter the fishery by March/April. This is reflected in the higher percentage occurrence of juveniles and pre-adults to the tune of 87% in January, 85% in February, 66% in March and 68% in April. After the closure of the fishery during the monsoon, the fishing starts by August/September. The percentage of preadults occurring gradually increase and constitute upto 87% in November. These represents the new recruits of the premonsoon spawning.

ECONOMIC IMPORTANCE

Judged by the magnitude of the fishery that the species supports, the Malabar sole *(C. macrostomus)* occupies an important place among the marine food fishes in Kerala. Although the large growing species like *Psettodes erumei* (Indian halibut); *Pseudorhombus arsius, P. elevatus* and *P. javanicus* (Flounders); *Cynoglossus bilineatus* and *C. arel* have good demand as table fishes, the small growing Malabar sole was preferred only in certain pockets in Kerala till recently because of the difference in consumer preference and taboos attached to many a sea foods by the people in India. There were times when large shrimps like *Penaeus indicus*, *P. monodon*, *P. semisulcatus* etc. were not consumed by people in Kerala as these sea food items were feared to cause cholera. Another example is the tunas (*Euthynnus affinis* & *Auxis thazard*) that are landed in good quantities at Mangalore and Cochin. Locally there is no consumer demand for this commodity. The entire lot is transported to markets in southern Kerala. The mud crab, *Scylla serrata* till about 15-20 years back was considered a poor man's food. Now they are exported alive to Singapore. Cephalopods like *Sepia pharaonis*, *Loligo duavucelli* and *Octopus* spp. were once considered trash and people were hesitant to eat them. The ribbonfishes (mainly *Trichiurus lepturus*) till recently were sundried and fresh consumption was meager. Export of this item to China has made this item dearer now. The oil sardine (*Sardinella longiceps*) known as *Kudumbampularthi* (Supporter of family) is a fish much relished by the people of Kerala and Karnataka. But the species landed in large quantities along the Tamil Nadu coast has no markets there as the locals discard this fish. Hence the entire catch of oil sardine is transported to Kerala. Again the large growing flatfish *Cynoglossus arel* has good demand in Kerala as a table fish, but is considered trash along the south east coast of India. It is funny that this fish is sundried there for making fish meal. Keralites settled at Veraval are happy to get large size mackerel (a size not so common along Kerala coast) at a very low price of 50 paise per piece because eating mackerel is frowned upon by locals. Mackerel nicknamed as *Malbari bangda* is preferred only by the *Malabarees i.e.* the Keralites. Again, the Wahoo, *Acanthocybium solandri* has no takers among the local people in Lakshadweep because certain markings on the body of this fish resembles Arabic numerals.

But things have changed a lot. Presently with the development of a full fledged mechanised fleet, flatfishes (mainly Malabar sole) are regularly landed at all centres along the Kerala coast. Demand for fish is on the increase as a consequence of increase in population and also due to change in the consumer palate. Even fishes that were termed trash and discarded some years back have become dearer or these commodities are transported to markets where these items are preferred. Presently, part of the flatfishes landed are used for fresh consumption. The remaining quantities are salted and sundried. Small processing units also purchase the soles, for salting and sundrying. The thin and compressed body with low fat content make this fish ideal for salt curing and sundrying (Plate V).

Seshappa and Bhimachar (1955) indicated the economic importance of the Malabar sole. They presented the total landings of the Malabar sole along the Calicut coast and the value realised during 1931-32 to 1950-51. The highest landing during 1950-51 was 4,90,000 *maunds* (one *maund* = 40 kg) which realised

Rs. 15.4 lakhs. During the previous period (1949-50), though the landing was less (4,40,000 *maunds*) a higher value of Rs.17.5 lakhs was obtained indicating the importance of the sole fishery.

At Fisheries Harbour Cochin, 1,331t; 256t; and 565t of Malabar sole were landed during 1994, 1995 and 1996 respectively the value of which works out to Rs.66.6 lakhs, Rs.12.8 lakhs and Rs.28.3 lakhs. The landings at Neendakara during the corresponding period was 566t; 1,043t and 706t which fetched a revenue of Rs.28.3 Lakhs, Rs.52.2 lakhs and Rs. 35.3 lakhs respectively. At Ambalapuzha the sole landings amounted to 250t in 1994, 128t in 1995 and 118t in 1996 and the revenue realised was Rs.10.0 lakhs, Rs.5.1 lakhs and Rs.4.7 lakhs respectively. The income generated from the sole fishery in Kerala was Rs.6.2 crores in 1994, Rs.6.3 crores in 1995 and Rs.5.5 crores in 1996. Apart from this the associated activities like salting, sundrying, packing, tranporting and marketing provide employments for many. All these speak for the economic importance of the sole fishery in the state. It is now an accepted commodity even in the kitchen of middle and high class society people. A 100 g packet of dried sole costs Rs.12/- in a famous Super Market (Varkey's) in M.G. Road at Ernakulam is a testimony to the economic importance of the Malabar sole. One kg of heigenically dried and packed sole costs Rs.120 a kg. The item is in short supply indicating a steady demand !

DISCUSSION

The flatfish fishery in India is constituted by soles, flounders and halibuts. But the soles dominated forming 93.2 per cent of the total flatfish landed. In Kerala, the soles constituted nearly 97.3 per cent of the total flatfish landed in the state. The sole fishery in Kerala is almost entirely constituted by a single species, the Malabar sole (*Cynoglossus macrostomus* Norman). The co-occurring other *Cynoglossus* species do not contribute to a fishery of commercial importance. Seshappa (1973), considering the total catches of the Malabar sole at Vellayil in Calicut during 1959 to 1963 reported that the best catch was in September 1962, poor in 1963 and no catch was observed during September in 1959 and 1961. October was the month that yielded relatively good catches through out with highest monthly catch rate of 438 kg(in boat-seines) in 1961 and the lowest monthly catch rate was in October 1963. The month, November made very good contribution to the catches during 1960 and 1963, some contribution in 1959 and no contribution during the other two years. He further pointed out that the mechanised boats with indigenous trawl type nets have taken over the fishing activities from the *Paithu vala* during 1966-67 and 1967-68 period. The Malabar sole has been found to be one of the dominant components of these trawl catches, and the landings were high during some months of the off season also, there being little or no catch during the monsoon months of June to August.

Rao (1967) based on the quarterwise landings during 1960-61 period indicated that the peak landings were obtained during July to September followed by the period October-December. The sudden increase and decrease in the sole landings is typical of the fishery all along the coast and is connected with large scale shoaling of the species in the surface and subsurface waters of the inshore area in enormous numbers. This phenomenon is known to fishermen as *Manthayilakom* and is taken advantage of by them in the large scale capture by employing boat seines (*Tattum vala* and *Paithu vala*); cast nets (*Veechu vala*) and shore seines (*Nona vala*).

Grace Mathew *et al*. (1990) made interesting observations in the flatfish fishery exploited by trawlers at Cochin. Over the years 1984 to 1988 the peak catch occurred mostly during the month of June, although in some years there seemed to be slight shift in the period of peak landing. During 1984 and 1985, the peak was in July, where as in 1987 the peak landing was in June. In 1988, the month of peak landing was slightly earlier in May. However, the flatfish fishery seemed to attain a peak only after the monsoon had set in along this coast. Ferozkhan and Nandakumaran (1993) reported that the average landings of flatfishes was 783t at Calicut during 1986-1991 contributing 5.8 per cent of the State's sole landings. Considerable yearly fluctuations in the production trends were noticed. The major portion of the catch was obtained with in a short period immediately after the commencement of the fishing season from October and extending to January.

In the present study the annual average landings of Malabar sole in the trawlers during the 3 year period from 1994 to 1996 was 717 t at Cochin and 771 t at Neendakara (Quilon). The average yearly production by the mini trawlers at Ambalapuzha was 165 t. Considerable inter annual, intra-annual and seasonal variations have been noticed in the present study also.

PLATE IV

Malabar sole from shrimp trawls at Cochin

Malabar sole for sale in the local markets

PLATE V

Sundrying of Malabar sole at Ambalapuzha

Dried and packed Malabar sole

Fig. 7.1 Yearly landings of flatfishes (in tonnes) in India (1956-1996)

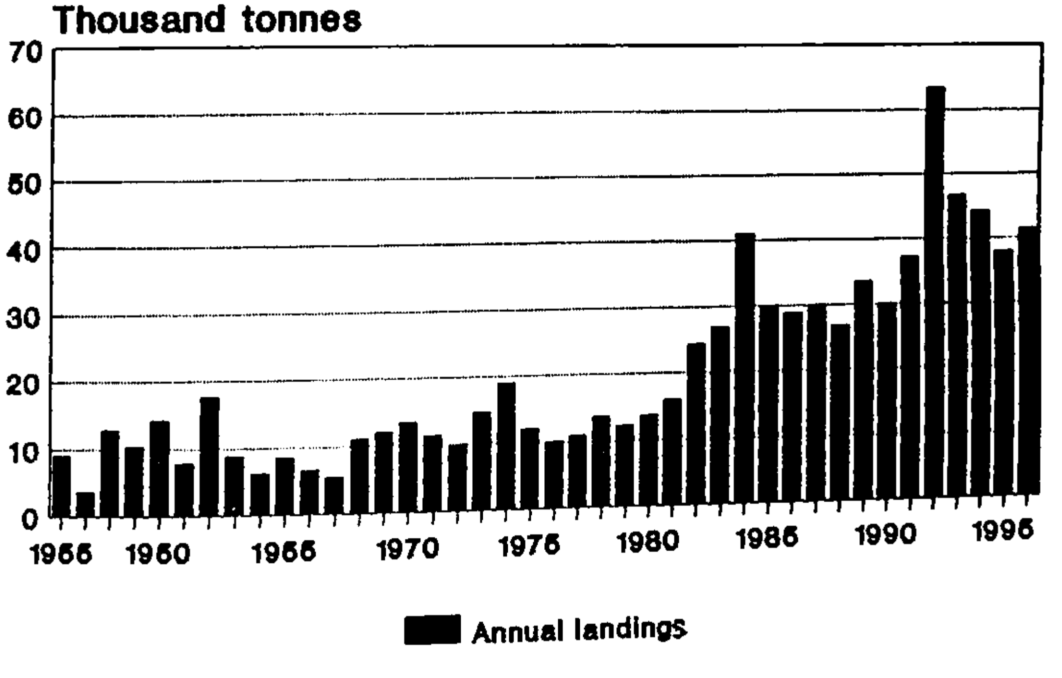


Fig 7.2 Year wise landings of flatfishes in West Bengal and Orissa

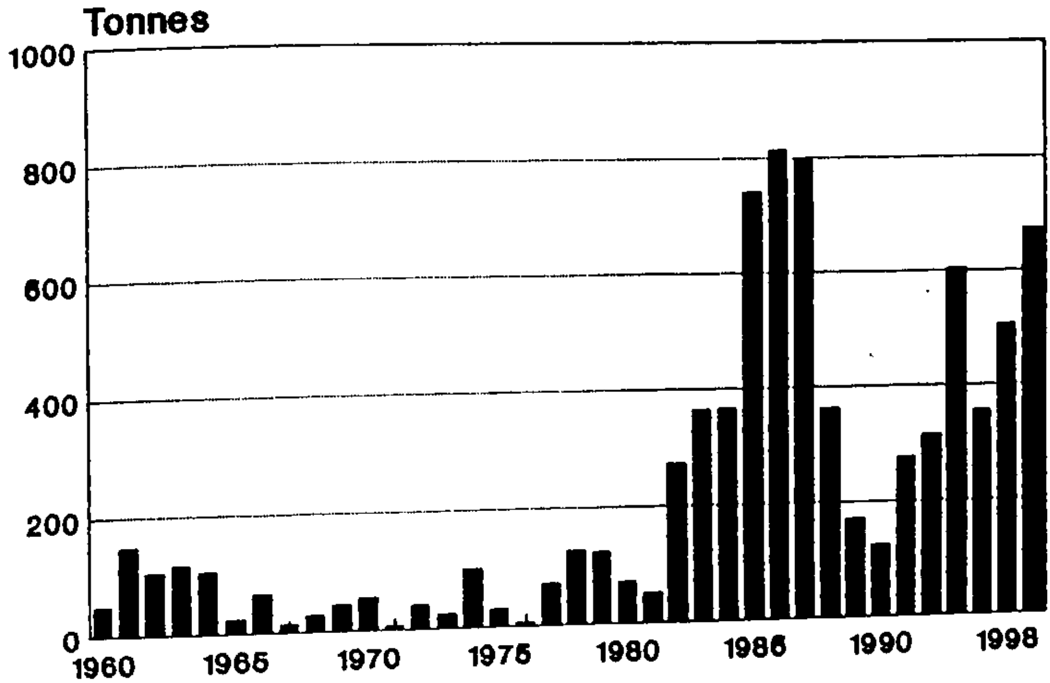


Fig.7.3 Year-wise landings of Flatfishes in Andhra Pradesh

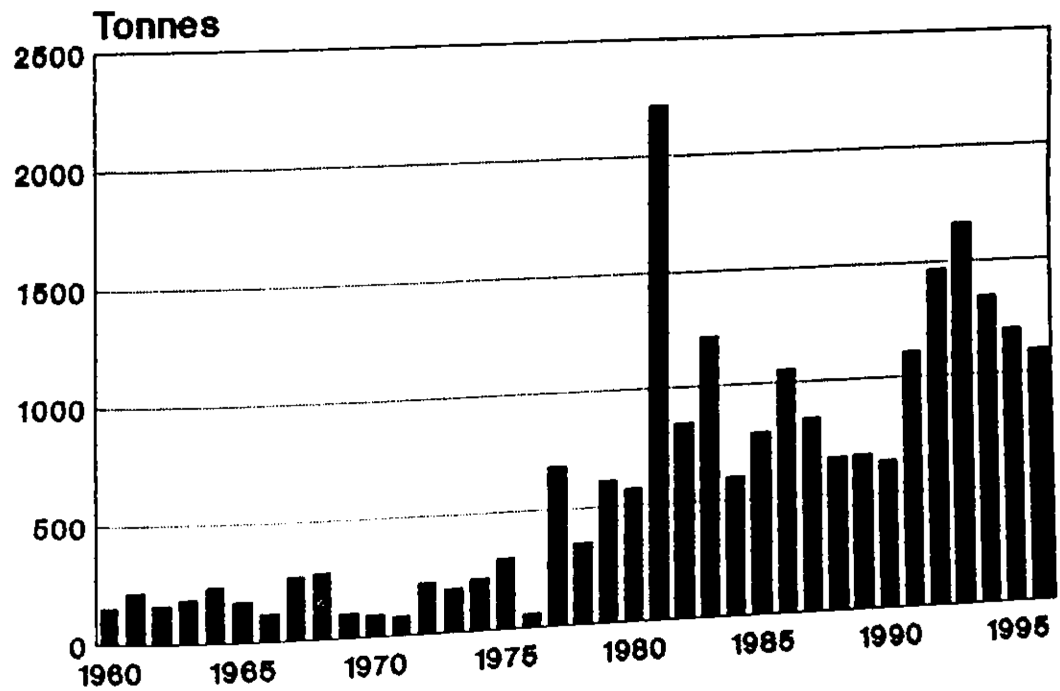


Fig. 7.4 Year-wise landings of Flatfishes in Tamil Nadu (tonnes)

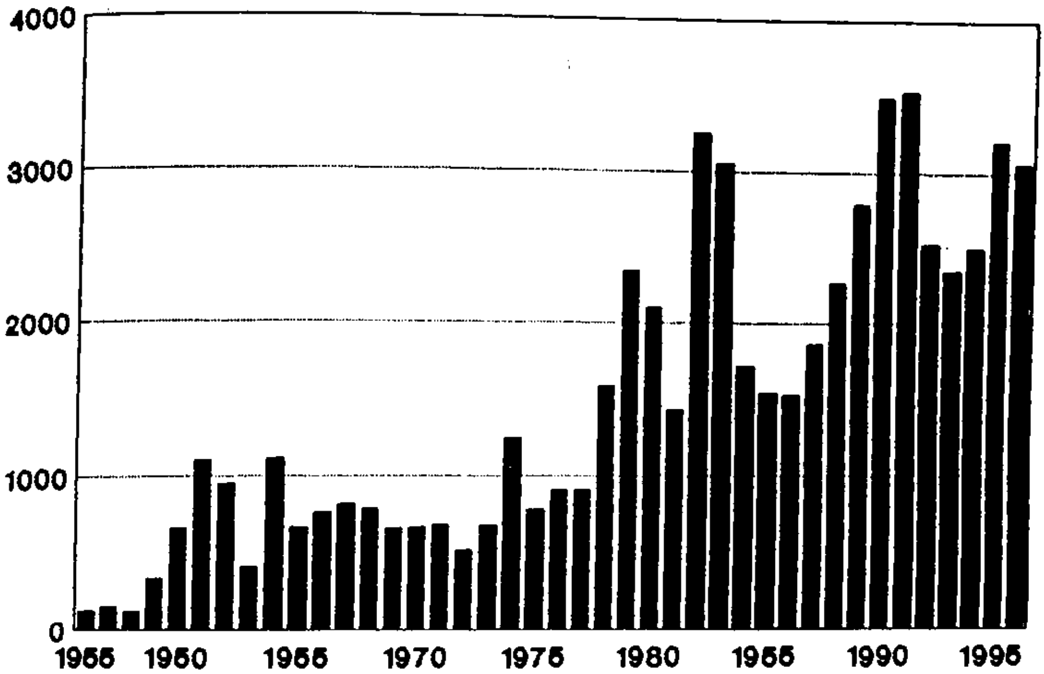


Fig. 7.5 Year-wise landings of Flatfishes in Pondicherry

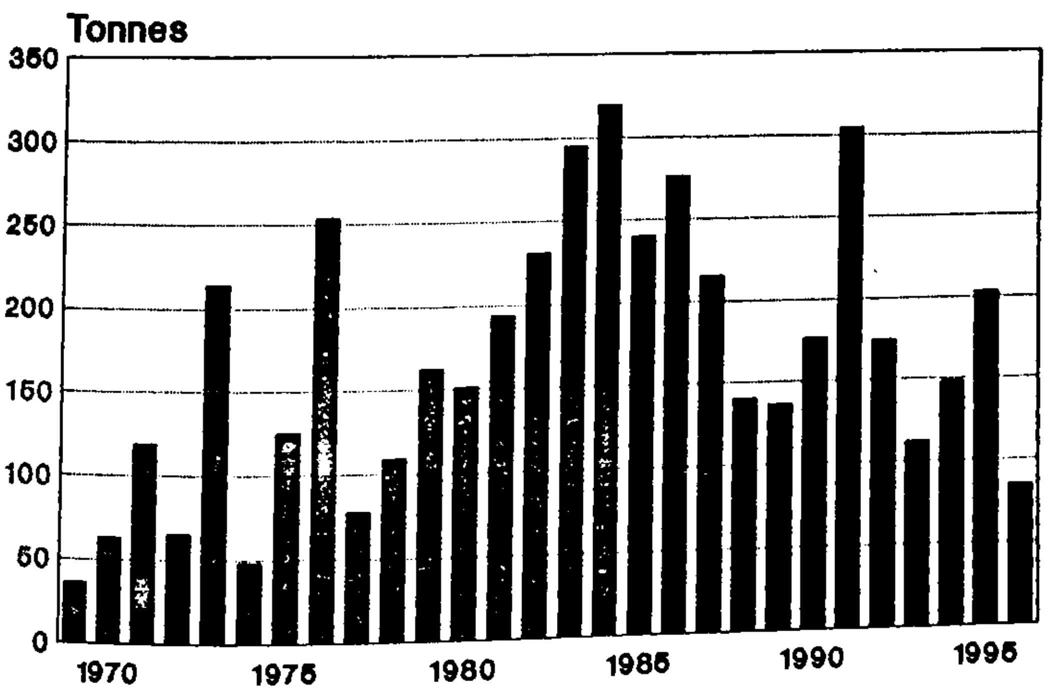


Fig.7.6 Year-wise landings of Flatfishes in Karnataka

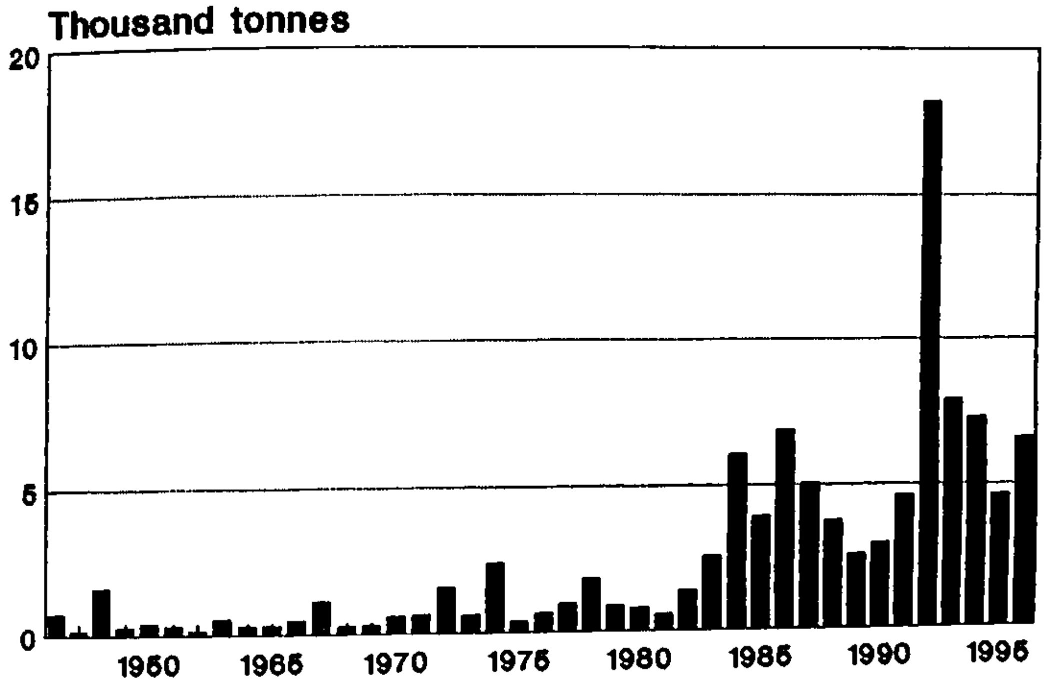


Fig.7.7 Year-wise landings of Flatfishes in Goa

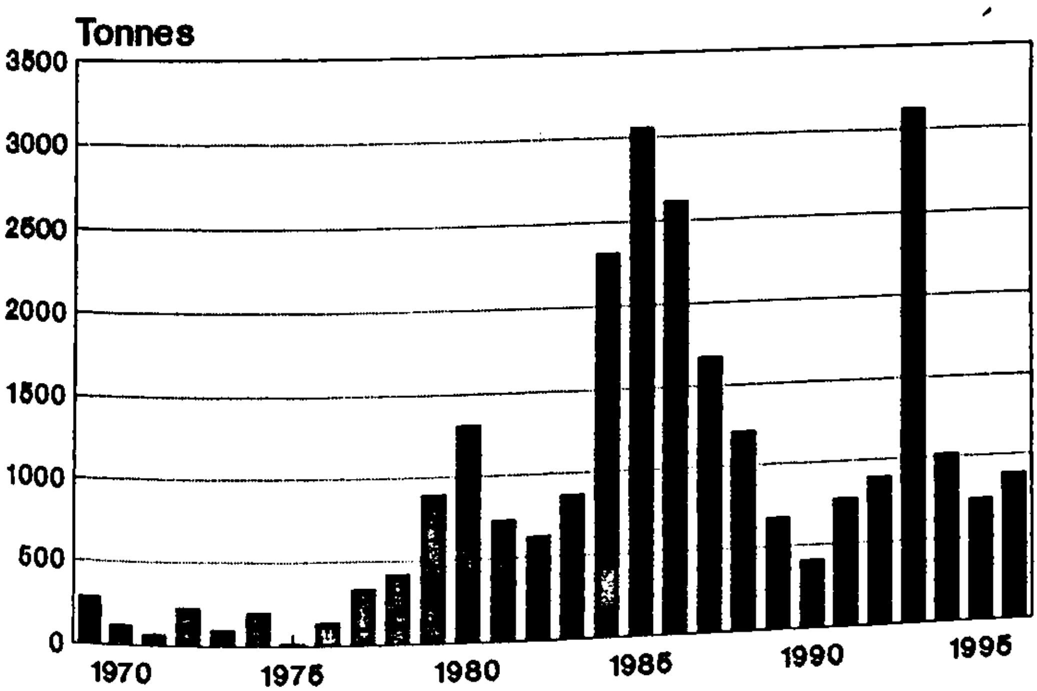


Fig. 7.8 Year-wise landings of flatfishes in Maharashtra

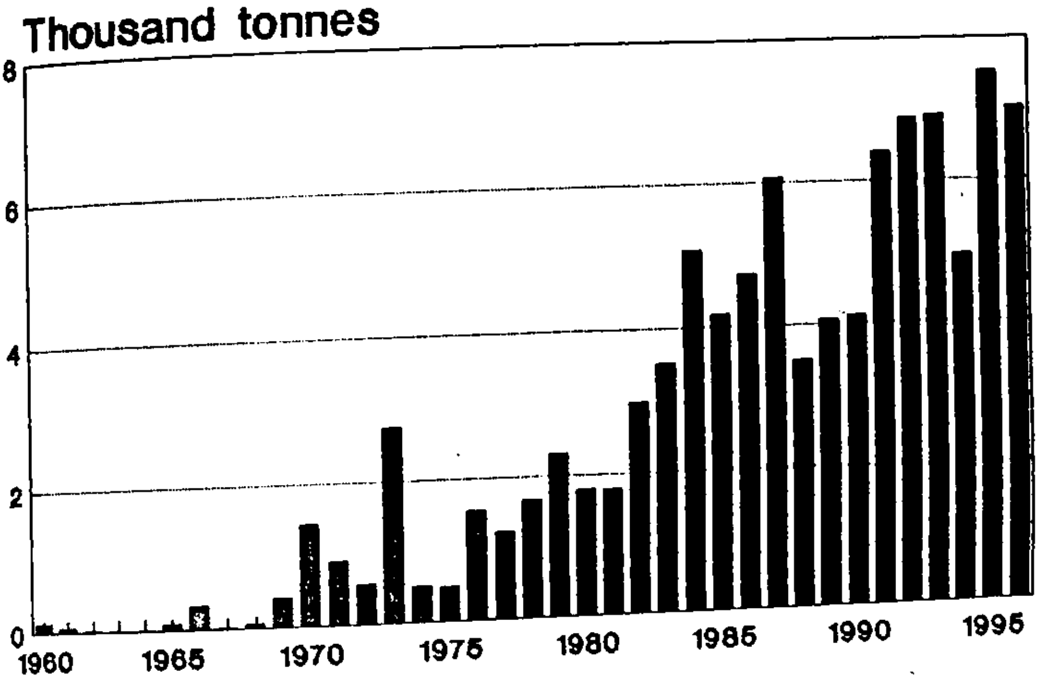


Fig. 7.9 Year-wise landings of Flatfishes in Gujarat

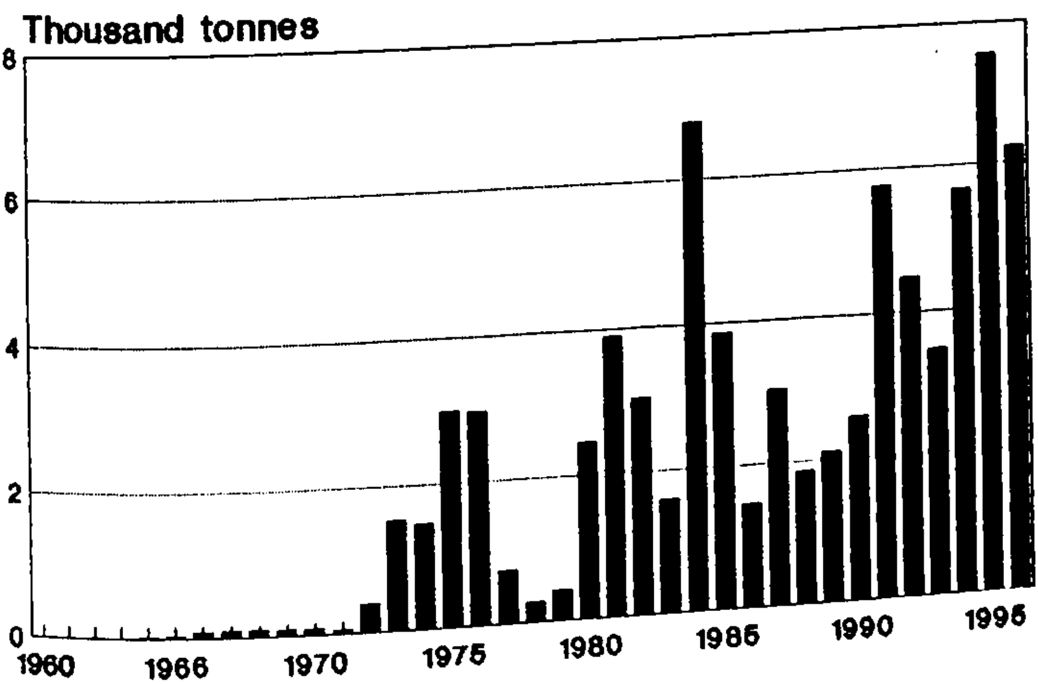


Fig. 7.10 Composition of flatfish landings along the east coast (tonnes)

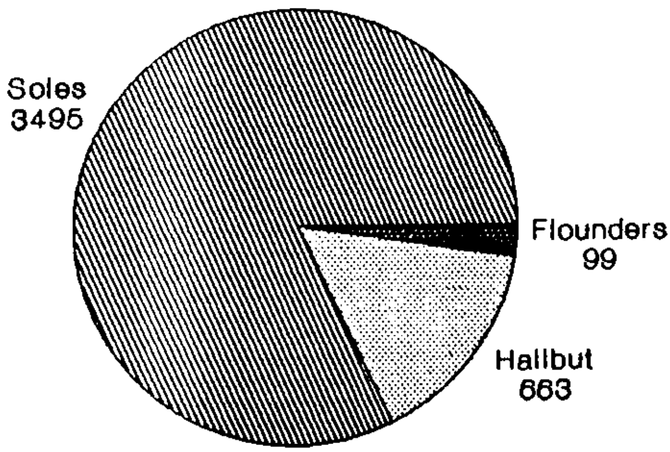


Fig. 7.11 Major components of Flatfish landings along west coast (in tonnes)

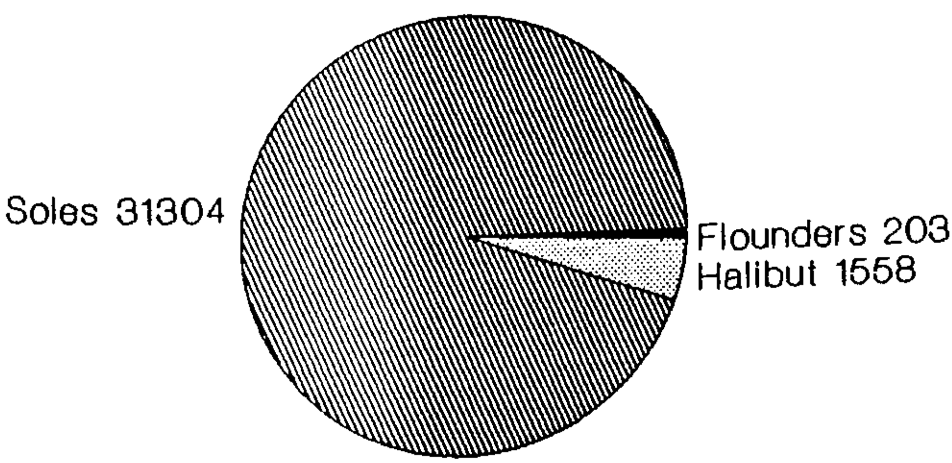


Fig. 7.12 Contribution of Kerala to the flatfish production in India (tonnes)

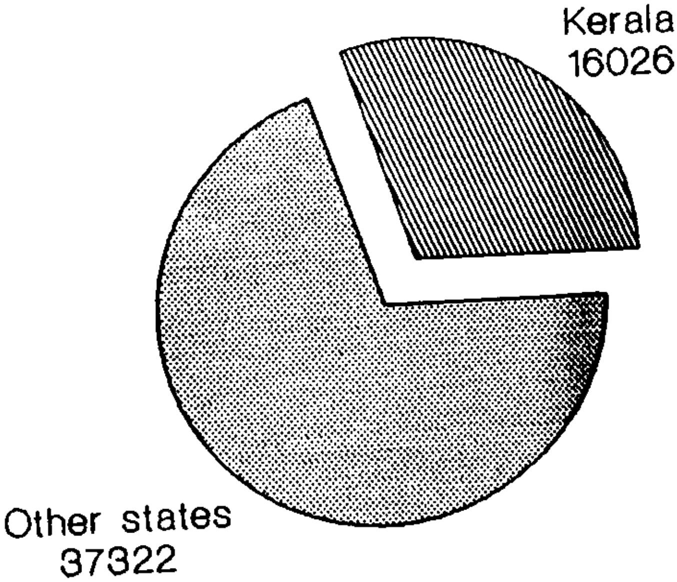


Fig. 7.13 Major components of flatfish landings in Kerala (tonnes)

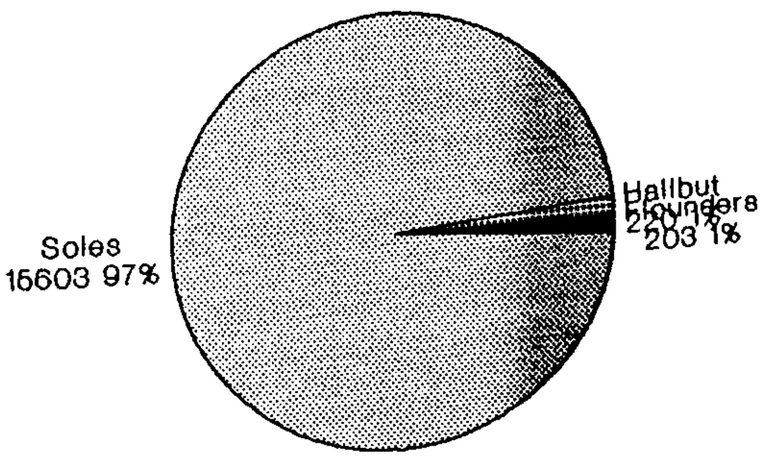


Fig. 7.14 Year-wise landings of Flatfishes in Kerala

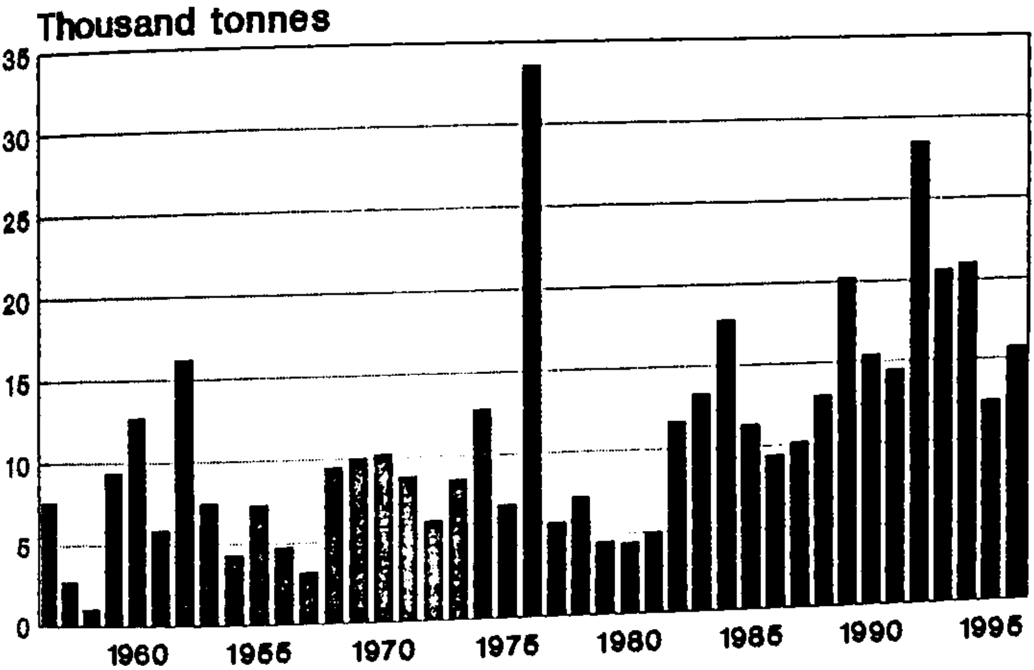


Table 7.1 Year-wise flatfish production (tonnes) in the different maritime states of India (1956-1996)

Year	W.B.& OR	A.P	T.N.	PON	KL	KN	GO	M.H	GJ	Total	% in all India
1956	-	-	125	-	7614	723	-	-	-	9122	5.0
1957	-	-	156	-	2726	172	-	-	-	3687	0.9
1958	-	-	119	-	1039	1606	-	-	-	12856	3.7
1959	-	-	341	-	9374	264	-	-	-	10360	4.9
1960	51	157	666	-	12715	388	-	120	6	14107	3.7
1961	150	218	1106	-	5882	307	-	61	4	7728	2.2
1962	106	162	948	-	16189	162	-	25	10	17602	8.4
1963	119	188	411	-	7485	552	-	18	8	8781	3.7
1964	107	236	1112	-	4324	324	-	18	25	6146	1.4
1965	25	170	672	-	7312	318	-	84	44	8625	2.2
1966	67	117	769	-	4736	478	-	335	89	6591	1.4
1967	14	271	819		3201	1121	-	31	103	5560	0.9
1968	29	281	792	-	9495	275	-	61	102	11035	2.7
1969	45	103	662	36	10039	325	284	410	86	11990	3.4
1970	57	91	672	63	10212	628	119	1440	82	13364	2.6
1971	8	79	689	119	8807	656	64	904	54	11380	1.9
1972	41	215	518	65	6119	1594	221	553	392	9718	2.1
1973	24	187	683	214	8551	626	95	2737	1525	14642	3.0
1974	100	220	1247	48	12771	2377	196	502	1456	18917	3.0
1975	30	305	785	125	6932	373	16	487	2991	12044	1.6
1976	6	56	909	254	33567	637	137	1553	2969	10088	1.1
1977	72	680	908	78	5778	985	335	1245	729	10810	1.7
1978	127	347	1580	109	7276	1820	417	1676	268	13620	1.9
1979	125	610	2337	162	4487	874	893	2304	411	12203	1.4
1980	72	573	2094	151	4394	782	1311	1797	2459	13633	1.6
1981	51	2213	1431	194	5034	545	727	1784	3885	15864	1.8
1982	273	842	3253	231	11603	1380	619	2978	3026	24205	3.6
1983	363	1210	3054	295	13323	2559	864	3505	1584	26757	3.5
1984	365	597	1714	320	17806	6033	2313	5078	6792	41018	4.5
1985	740	784	1536	240	11332	3911	3051	4172	3847	29613	3.5
1986	812	1052	1526	276	9435	6831	2610	4734	1444	28720	2.5
1987	796	838	1856	215	10197	5037	1670	6061	3023	29693	3.4
1988	362	658	2260	140	12965	3720	1209	3511	1852	26677	2.8
1989	170	665	2789	136	20247	2546	667	4056	2109	33385	3.1
1990	125	636	3496	176	15427	2936	411	4105	2575	29887	2.3
1991	275	1109	3538	304	14496	4604	770	6409	5763	37268	2.6
1992	313	1464	2526	174	28445	18185	891	6872	4474	63344	5.1
1993	602	1662	2341	112	20618	7870	3118	6906	3463	46692	3.6
1994	354	1340	2497	148	20999	7227	1018	4942	5671	44196	3.7
1995	504	1191	3211	203	12385	4597	732	7518	7561	37902	2.3
1996	672	1097	3060	85	15768	6555	881	7004	6239	41361	2.0
Av.	276	767	1945	172	11814	3551	939	3512	2839	25815	
%	1.1	2.9	7.5	0.7	45.8	13.8	3.6	13.6	11.0		

W.B =West Bengal, OR=Orissa, A.P.= Andhra Pradessh, T.N=Tamil Nadu, Kl=Kerala
KN=Karnataka, Go=Goa, M.H.=Maharashtra, GJ=Gujurat.
Av. = Average for 1970 to 1996. (Av. = Average for the years 1970 to 1996)

Table 7.2 Major groups contributing the fishery of flatfishes (Average landings 1985-96 in tonnes)

Maritime	Halibut	Flounders	soles	Total
West Bengal	-	-	69 (100%)	69
Orissa	-	-	409 (100%)	409
Andhra Pradesh	148 (14.2%)	72 (6.9%)	819 (78.9%)	1039
Tamil Nadu	497 (19.4%)	27 (1.1%)	2032 (79.5)	2556
Pondicherry	18 (9.8%)	-	166 (90.2%)	184
Total East coast	663 (15.6%)	99 (2.3%)	3495 (82.1%)	4257
Kerala	220 (1.4%)	203 (1.3%)	15603 (97.3%)	16026
Karnataka	46 (0.7%)	-	6122 (99.3%)	6168
Goa	9 (0.7%)	-	1337 (99.3%)	1346
Maharashtra	621 (11.2%)	-	4903 (88.8%)	5524
Gujarat	662 (16.5%)	-	3339 (83.5%)	4001
Total west coast	1558 (4.7%)	203 (0.6%)	31304 (94.7%)	33065
All India	2221 (6.0%)	302 (0.8%)	34799 (93.2%)	37322

Table 7.3 Monthly effort, catch (tonnes), catch per unit effort and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Cochin Year: 1994

Month	Effort (Units)	Halibut	Flounders	Malabar sole C (t)	c/e kg	%	Total flat-fishes	Total all fish
Jan.	7826	-	-	78	9.9	3.2	78	2473
Feb.	7392	4	6	32	0.4	1.0	42	3113
Mar.	8901	-	1	33	3.7	0.9	34	3756
Apr.	7722	-	7	15	1.9	0.4	22	4080
May	9019	2	5	8	0.1	0.2	15	5219
Jun.	6233	-	-	80	12.8	2.0	80	3993
Jul.	3586	-	7	96	26.8	3.3	102	2902
Aug.	18519	-	33	716	38.7	5.2	749	13813
Sep.	8550	-	8	24	2.8	0.4	32	628
Oct.	3911	-	2	60	15.3	4.3	62	1399
Nov.	7068	-	7	117	16.6	4.2	124	2794
Dec.	5421	-	2	72	13.3	5.0	74	1421
Total	94148	6	78	1331	14.1	2.6	1415	50331

Table 7.4 Monthly effort, catch (tonnes), catch per unit effort and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Cochin Year: 1995

Month	Effort (Units)	Halibut	Flounders	Malabar sole C (t)	c/e kg	%	Total flat-fishes	Total all fish
Jan.	7035	-	2	20	2.8	0.8	22	2,455
Feb.	4967	-	4	32	6.4	1.8	36	1,767
Mar.	3644	-	-	36	9.9	3.9	36	915
Apr.	3724	-	-	19	5.1	1.2	19	1,553
May	8217	-	3	44	5.4	0.9	47	4,436
Jun.	4555	-	2	12	2.6	0.4	14	3,112
Jul.	63	-	-	-	-	-	-	64
Aug.	6850	-	45	26	3.8	0.4	71	1,016
Sep.	1829	-	2	2	1.1	1.1	4	1,505
Oct.	3318	-	2	23	6.9	1.3	25	1,713
Nov.	2543	-	-	2	0.8	0.6	2	915
Dec.	4463	-	-	40	9.0	3.1	40	1,276
Total	51208	-	60	256	5.0	1.0	316	26,690

Table 7.5 Monthly effort, catch (tonnes), catch per unit effort and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Cochin Year: 1996

Month	Effort (Units)	Halibut	Flounders	Malabar sole			Total flat-fishes	Total all fish
				C (t)	c/e kg	%		
Jan.	6851	-	-	74	10.8	2.9	74	2,533
Feb.	5134	-	2	38	7.4	2.2	40	1,710
Mar.	5838	1	2	29	4.9	1.7	32	1,705
Apr.	5471	1	-	25	4.6	1.4	26	1,801
May	7598	5	-	25	3.3	0.7	30	3,377
Jun.	3285	1	-	6	1.8	0.4	7	1,490
Jul.	1689	-	-	-	-	-	-	310
Aug.	6130	-	-	153	24.9	3.7	153	4,109
Sep.	2083	1	-	73	35.0	5.7	74	1,275
Oct.	5026	1	-	73	14.5	1.8	74	4,003
Nov.	2388	-	-	4	1.7	0.4	4	1,038
Dec.	4767	-	-	65	13.6	4.3	65	1,504
Total	56260	10	4	565	10.0	2.3	579	24,855

Table 7.6 Monthly effort, catch (tonnes), catch per unit effort and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Neendakara Year: 1994

Month	Effort (Units)	Halibut	Flounders	Malabar sole			Total flat-fishes	Total all fish
				C (t)	c/e kg	%		
Jan.	4519	-	-	46	10.2	3.0	46	1541
Feb.	4464	-	-	47	10.5	2.6	47	1774
Mar.	5146	-	-	60	11.7	2.4	60	2469
Apr.	6785	-	-	29	4.3	0.6	29	4643
May	6952	1	-	39	5.6	1.1	40	3523
Jun.	1998	-	-	24	12.0	2.2	24	1087
Jul.	6204	-	-	53	8.5	0.8	53	6767
Aug.	15639	-	4	176	11.3	1.4	180	12514
Sep.	10905	4	-	48	4.8	0.5	52	9953
Oct.	5356	-	-	43	8.0	1.8	43	2406
Nov.	6318	-	-	69	10.9	3.0	69	2276
Dec.	5421	-	2	72	13.3	5.1	74	1421
Total	78897	5	6	706	8.9	1.4	717	50374

Table 7.7 Monthly effort, catch (tonnes), c/e (kg) and catch and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Neendakara Year: 1995

Month	Effort (Units)	Halibut	Flounders	Malabar sole C (t)	Malabar sole c/e kg	Malabar sole %	Total flat-fishes	Total all fish
Jan.	1155	-	-	40	34.6	4.6	40	863
Feb.	1996	-	-	15	7.5	4.7	15	314
Mar.	3732	-	-	20	5.4	2.5	20	811
Apr.	4679	-	1	18	3.8	1.2	19	1495
May	8424	-	2	30	3.6	1.0	32	3058
Jun	3180	-	-	9	2.8	1.0	9	902
Jul.	3501	-	-	110	31.4	3.3	110	3349
Aug.	15941	-	13	230	14.4	2.2	243	10490
Sep.	9338	-	-	60	6.4	1.3	60	4774
Oct.	5503	-	-	8	1.5	0.9	8	4211
Nov	4560	-	-	9	1.9	0.5	9	1675
Dec.	4019	-	-	17	4.2	1.9	17	917
Total	66028	-	16	566	8.5	1.7	582	32859

Table 7.8 Monthly effort, catch (tonnes), c/e (kg) and catch and catch composition of flatfishes in the shrimp trawlers

Centre: Fisheries Harbour, Neendakara Year: 1996

Month	Effort (Units)	Halibut	Flounders	Malabar sole C (t)	Malabar sole c/e kg	Malabar sole %	Total flat-fishes	Total all fish
Jan.	3336	-	-	31	9.2	3.2	31	973
Feb	7534	-	-	62	8.2	2.8	62	2188
Mar.	7833	-	-	77	9.8	2.8	77	2725
Apr.	8711	1	-	115	13.2	3.2	116	3582
May	7452	-	-	80	10.7	2.6	80	3095
Jun.	2360	-	-	25	10.6	2.8	25	889
Jul.	473	-	-	6	12.7	2.5	6	238
Aug.	14448	-	-	280	19.3	1.9	280	14840
Sep.	8768	-	-	149	17.0	2.3	149	6534
Oct.	9321	-	-	114	12.2	1.8	114	6247
Nov.	4756	2	1	31	6.5	0.8	34	3923
Dec.	6914	-	-	73	10.5	2.0	73	3572
Total	81906	3	1	1043	12.7	2.1	1047	48806

Table 7.9 Monthly effort (Units), catch (kg) and c/e (kg) of flatfishes in the minitrawls at Ambalapuzha

Year: 1994.

Month	Effort	Catch	c/e	%	Total fish	c/e
Jan.	1958	11312	5.8	31.9	35454	18.1
Feb.	2460	14750	5.9	13.0	112605	45.8
Mar.	3210	27629	8.6	19.9	138834	43.3
Apr.	2876	10570	3.7	12.2	86899	30.2
May	3815	16385	4.3	8.4	194501	50.9
Jun.	-	-	-	-	-	-
Jul.	-	-	-	-	-	-
Aug.	-	-	-	-	-	-
Sep.	7169	107448	14.9	28.9	371668	51.8
Oct.	3055	16835	5.5	20.4	82658	27.1
Nov.	2665	33469	12.6	31.5	106094	39.8
Dec.	1775	11388	6.4	19.7	57906	32.6
Total	28983	249786	8.6	21.1	1184619	40.9

Table 7.10 Monthly effort (Units), catch (kg) and c/e (kg) of flatfishes in the minitrawls at Ambalapuzha

Year: 1995.

Month	Effort	Catch	c/e	%	Total fish	c/e
Jan.	1050	5067	4.8	22.8	22225	21.2
Feb.	3125	13850	4.4	16.3	85131	27.2
Mar.	1155	2930	2.5	13.3	21965	19.0
Apr.	2160	5015	2.3	15.8	31785	14.7
May	2640	21780	8.3	14.1	154585	58.6
Jun.	-	-	-	-	-	-
Jul	-	-	-	-	-	-
Aug.	1125	12365	10.9	14.8	83391	74.1
Sep.	6900	48360	7.0	6.6	727835	105.5
Oct.	1200	14209	11.8	6.7	209014	174.2
Nov.	450	1558	3.5	16.8	9298	20.7
Dec.	1000	2675	2.7	36.5	7328	7.3
Total	20805	120809	6.1	9.4	1352557	65.0

Table 7.11 Monthly effort (Units), catch (kg) and c/e (kg) of flatfishes in the minitrawls at Ambalapuzha
Year: 1996.

Month	Effort	Catch	c/e	%	Total fish	c/e
Jan.	1960	6474	3.3	16.2	39870	20.3
Feb.	1495	3520	2.4	15.9	22175	14.8
Mar.	780	2906	3.7	24.4	11886	15.2
Mar.	2990	12071	4.0	17.8	67907	22.7
May	3706	14185	3.8	6.9	206754	55.8
Jun.	-	-	-	-	-	-
Jul.	-	-	-	-	-	-
Aug	-	-	-	-	-	-
Sep.	1218	980	0.8	35.8	2740	2.2
Oct.	2665	62004	23.3	22.0	281262	105.5
Nov.	910	2870	3.2	18.9	15110	16.6
Dec.	3420	13467	3.9	30.7	43837	12.8
Total	19144	118477	6.2	17.1	691541	36.1

Table 7.12 Sole landings (Kg) by trawlers during different quarters
1994
Fisheries Harbour, Cochin

	Quarters			
	I	II	III	IV
Effort (units)	24119	22974	30655	16400
Catch of soles in kg	143000	103000	836000	249000
c/e in kg	5.9	4.5	27.3	15.2
% in annual sole landings	34.4	29.3	10.9	35.4
% in total fish	1.5	0.8	3.8	4.4

Table 7.13 Sole landings (Kg) by trawlers during different quarters

Fisheries Harbour, Cochin 1995

	Quarters			
	I	II	III	IV
Effort Units	15646	16496	8742	10324
Catch of soles kg	88000	75000	28000	65000
c/e kg	5.6	4.5	3.2	6.3
% in annual sole landings	34.4	29.3	10.9	25.4
% in total fish	1.7	0.8	0.3	1.7

Table 7.14 Sole landings (Kg) by trawlers during different quarters

Fisheries Harbour, Cochin 1996

	Quarters			
	I	II	III	IV
Effort (Units)	17823	16354	9902	12181
Catch of soles kg	141000	56000	226000	142000
c/e kg	7.9	3.4	22.8	11.7
% in annual sole landings	24.9	9.9	40.0	25.2
% in total fish	2.4	0.8	4.0	2.2

Table 7.15 Sole landings (Kg) by trawlers during different quarters

Fisheries Harbour, Neendakara 1994

	Quarters			
	I	II	III	IV
Effort (units)	14129	15735	31938	17095
Catch of soles in kg.	153000	92000	277000	184000
c/e kg	10.8	5.8	8.7	10.8
% in Annual sole landings	21.7	13.0	39.2	26.1
% in Total fish	2.6	1.0	0.9	3.0

Table 7.16 Sole landings (Kg) by trawlers during different quarters

Fisheries Harbour, Neendakara 1995

	Quarters			
	I	II	III	IV
Effort (units)	6883	16283	28780	14082
Catch of soles in kg	75000	57000	400000	34000
c/e kg	10.9	3.5	13.9	2.4
% in annual sole landings	13.2	10.1	70.7	6.0
% in total fish	3.8	1.0	2.1	0.5

Table 7.17 Sole landings (Kg) by trawlers during different quarters

Fisheries Harbour, Neendakara 1996

	Quarters			
	I	II	III	IV
Effort (units)	18703	18523	23689	20991
Catch of soles in kg	170000	220000	435000	218000
c/e in kg	9.1	11.9	18.4	10.4
% in annual sole landings	16.3	21.1	41.7	20.9
% in total fish	2.9	2.9	2.0	1.6

Table 7.18 Malabar sole landings (t) in the trawlers during different seasons at Cochin and Neendakara 1994-1996

Centre	Pre-monsoon (tonnes)	Monsoon (tonnes)	Postmonsoon (tonnes)
COCHIN			
1994-95	88 (6.9%)	892 (70.0%)	293 (23.1%)
1995-96	131 (42.3%)	38 (12.3%)	141 (45.4%)
NEENDAKARA			
1994-95	175 (25.0%)	253 (36.1%)	272 (38.9%)
1995-96	83 (14.9%)	349 (62.7%)	125 (22.4%)

Premonsoon - Feb. to May; Monsoon - June to Sep.; and
Postmonsoon - October to January.

Table 7.19 Sole landings by the minitrawls at Ambalapuzha during the two halves of the years 1994 to 1996

	January to May			September to December		
year	E	C (kg)	c/e (kg)	E	C (kg)	c/e
1994	14319	80646	5.6	14664	169140	11.5
%	49.4%	32.3%		50.6%	67.7%	
1995	10130	48642	4.8	10675	79167	7.4
%	48.6%	38.1%		51.4%	61.9%	
1996	10931	39156	3.6	8213	77321	4.1
%	57.1%	33.0%		42.9%	67.0%	

Table 7.20 Mean length (mm) and mean weight (g) of malabar sole at Cochin, Neendakara and Ambalapuzha.

	Mean fish length (mm)			Mean fish weight (g)			Size range (mm)		
Year	Cohn	Ndkra	Amblpza	Cohn	Ndkra	Amblpza	Cohn	Ndkra	Amblpza
Aug.'94	109.4	108.0	-	5.8	8.1	-	80-160	80-120	-
Sep	111.8	121.4	-	6.2	9.3	-	90-145	80-150	-
Oct.	117.3	140.0	111.8	8.6	14.6	6.5	75-160	115-160	55-145
Nov.	121.1	-	104.5	10.2	-	7.2	80-145	85-145	45-140
Dec.	116.8	108.1	80.2	8.8	6.3	3.1	70-150	60-145	60-110
Jan.'95	82.3	116.0	82.8	3.1	8.7	3.2	55-135	50-150	60-115
Feb.	85.5	100.2	81.3	3.2	4.8	2.5	55-145	55-135	65-100
Mar.	95.2	119.3	101.3	4.6	8.4	5.8	65-145	80-155	70-135
Apr	95.8	95.9	87.1	4.7	4.4	3.5	60-160	75-135	60-115
May	124.6	81.6	118.4	7.7	2.9	3.5	55-155	70-110	55-130
Jun.	85.8	-	-	2.2	-	-	60-140	-	-
Jul.	-	-	-	-	-	-	-	-	-
Aug.	116.9	-	114.2	7.3	-	7.7	90-150	-	70-150
Sep.	121.3	122.4	105.4	9.2	9.4	6.6	60-150	40-150	60-145
Oct.	116.1	139.8	115.9	8.1	5.1	7.7	50-155	105-160	70-150
Nov.	87.9	128.9	84.0	3.7	8.1	3.7	35-145	65-160	60-125
Dec.	127.9	88.3	85.0	11.0	3.8	3.4	100-155	55-155	60-135
Jan.'96	102.5	101.0	84.5	6.3	5.4	3.7	65-150	60-165	60-130
Feb.	84.0	104.5	81.8	3.1	6.9	2.6	50-130	65-155	60-105
Mar.	120.9	97.1	85.7	8.8	4.9	3.3	65-155	70-140	65-110
Apr.	89.8	90.3	92.1	3.5	3.3	3.7	65-130	70-125	70-105
May	96.4	98.1	89.2	2.9	3.9	3.2	70-130	80-155	55-115
Jun.	-	-	-	-	-	-	-	-	-
Jul.	-	-	-	-	-	-	-	-	-
Aug.	120.5	-	-	7.5	-	-	90-160	-	-
Sep	-	111.8	107.2	-	5.8	5.2	-	80-145	75-130
Oct.	116.8	115.9	113.0	7.1	5.7	6.8	85-185	85-450	85-140

Cohn = Cochin, Ndkra = Neendakara, Ambalpza = Ambalapuzha