STUDIES ON THE NEMIPTERID FISHES (PISCES : NEMIPTERIDAE) OF COCHIN COAST

THESIS

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DOCTOR OF PHILOSOPHY

By
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1989

CERTIFICATE

This is to certify that this thesis is an authentic record of research work carried out by Smt. Sophy John. T. M.Sc. under my supervision and guidance in the Department of Industrial Fisheries, Cochin University of Science and Technology in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY and that no part thereof has been submitted for any other degree.

6/4/89

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DECLARATION

I, Sophy John. T.,do hereby declare that the thesis entitled "STUDIES ON THE NEMIPTERID FISHES (PISCES : NEMIPTERIDAE) OF COCHIN COAST" is a genuine record of research work done by me under the supervision and guidance of Dr. M. Shahul Hameed, Professor, Department of Industrial Fisheries, Cochin University of Science and Technology and has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any university or institution.

Cochin-16

April, 1989

Sophy
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CHAPTER 1

GENERAL INTRODUCTION

GENERAL INTRODUCTION

1.1 PREAMBLE

Fish forms about half of the total number of vertebrates and provides food for millions as a substantial source of protein. It is rich in vitamins and also contains variable quantities of calcium, phospherous and nutrients which are important to human health and growth. Also, it serves as a raw material for animal feed. They offer sport for the angler and many species are kept as pets by aquarists. In addition to this, fisheries provide a valuable contribution to economic augmentation in the form of increased chance of employment, industrial income and foreign exchange.

Fishes of the family Nemipteridae of the order Perciformes constitute a good fishery in coastal and neritic regions in the world and naturally have attained considerable attention from fishery biologists. They are widely encountered in the Indo-Pacific region from South Japan to East Africa and the Red Sea (Wongratana 1972; Eggleston, 1972; Hoda, 1976). Dentex (Cuvier and Valenciennes, 1830; Bleeker, 1851; Fowler, 1904) Nemipterus (Swainson, 1839), Synagris (Gunther, 1859; Day, 1878; Fowler, 1938), Anomura, Odontoglyphis and Euthyopteroma (Fowler, 1904) were the various generic names used to describe this particular group of fish. Recently the generic name Nemipterus is accepted by the taxonomists working in this field.

Day (1878) reported five species of Nemipterids from Indian waters under the genus Synagris (Klein) Gunther, namely Synagris striatus; S. tolu, S. bleekeri, S. notatus and S. japonicus. Weber and de Beaufort (1936) described twenty species of Nemipterids from Indo-Australian Archipelago. Wongratana (1973) recorded a number of Nemipterids from Indo-Pacific region. Rajagopalan et al. (1975), Murthy (1978) and Sophy and Hameed (1983) recorded Nemipterus mesoprion and Nemipterus delagoae from Indian waters.

Nemipterids are small or moderately sized, slightly compressed, pink coloured fishes. They are characterised by terminal mouth with canine teeth on the upper jaw. Front of the head scaleless, scales beginning above eye and on cheek. Scales on body ctenoid and easily shed. Dorsal fin single and its first spine prolonged into a filament in certain species. A medium sized auxiliary scale present above each pelvic fin. Caudal fin forked or emarginate and the upper lobe often with a filament.

Nemipterids are commonly called threadfin breams. Japanese threadfin bream (English), Cohana japonaise (French) and Baga japonesa (Spanish) are the vernacular names used to describe Nemipterids. In India the various names to describe Nemipterids are Kilimeen/Puthiyaplakora (Malayalam), Thullukendai (Tamil), Sallengunti (Telugu), Madmal (Kannada), Rani (Konkani) and Bammi (Marathi).

The Nemipterids are exploited all along the Indian coasts in varying quantities. The identification of many species were doubtful because of the confusion in nomenclature. Though Rajagopalan et al. (1975) and Murthy (1978) have clarified the confusion to some extent, the identification of Nemipterids still pose many problems. In the current inquiry, detailed studies have been undertaken to establish the systematic position of Nemipterus spp. available at Cochin waters.

Detailed information on the biology of fishes is an essential prerequisite for their proper conservation, management and exploitation. An amplified knowledge on the biology is fundamentally essential to plan sound management policies for rational utilization of Nemipterid fishes along the Indian coast. Any information on the biochemical composition of fishes will be of immense use in assessing their nutritive value. The importance of understanding body composition during growth is essential in production studies. Detailed work on Nemipterid fishes has been done in other parts of the world whereas along the Indian coast not much work has been carried out. Hence the present investigation is undertaken on the systematics of Nemipterids available at Cochin and the biology and biochemical aspects of N. japonicus and N. mesoprion.

1.2 NEMIPTERID FISHERY IN INDIA

India has a coast line of about 7,500 km including the Andaman Nicobar islands with nearly 3000 fishing villages along the coast.

The marine fish caught from the inshore waters by indigenous craft as well as by large mechanized vessels are landed at 1500 fish landing centres.

The total estimated catch of marine fishery resources during the year 1983-84 along the coasts of India was 1.63 million tonnes as compared to 1.47 million tonnes in 1982-83, showing an increase of 12%, but in 1984-85 the exploited resources was only 1.56 million tonnes, showing a reduction of 7%. The marine fish production for the past 15 years (1971-1986) shows fluctuations; the minimum landing was reported in 1972 (0.98 million tonnes) and maximum in 1984 (1.631 million tonnes) (Anon, 1986).

The present exploitation is confined to the contiguous zones, where the exploited varities are mainly sardine, mackerel, tuna, catfish, elasmobranchs, wide variety of sciaenids, leiognathids, clupeiods, prawns and deep-sea shrimps. Nemipterids form one of the major demersal fishery resources of India and are exploited by small commercial trawlers along both east and west coasts and it forms about 2% of the total marine landings. The average annual landings of Nemipterids are more in west coast than in east coast. Kerala state accounts for the maximum catch (35%) of Nemipterids followed by Maharashtra (21%), Gujarat (5%) and other maritime states. The present fishing grounds data have revealed that threadfin breams are more abundant in the depth range of 75-125 m and the catch of these fishes contribute to about 75% of the total catch from this depth range (Anon, 1986).

In Andhra Pradesh, an estimated landings of 1,700 tonnes of Nemipterids were accounted annually. At Waltair, these fishes formed about 14% of the total trawl landings while they constituted only about 6% at Kakinada. The peak period in this region was December - March. Along the coast of Tamil Nadu an annual average of 740 tonnes of Nemipterids were landed which formed about 15% of the total trawl landings and June - September was the peak period. Along the Maharashtra coast an estimated annual average of 3,000 tonnes of threadfin breams were landed and the catches were heavy during February - May. Along the Gujarat coast an estimated annual average of 2,700 tonnes of these fishes were landed and there were two peaks, one in March and the other in October (Anon, 1986).

Information regarding the eggs and larvae of Nemipter the Indian coast is scanty. Five to six species contribu the fishery along the east coast whereas only two to three contribute to the fishery along the west coast. *N. japonic* most dominant species along both the coasts, followed by *N.m* These two species together contribute 70-100% of the N landings at different trawl landing centres of Kerala.

1.3 NEMIPTERID FISHERY IN COCHIN

At Cochin an estimated annual average of about 9,800 Nemipterids are landed. In this region the trawlers operating in relatively deeper waters and very heavy landings of threadfin breams are obtained during July - September. The catch of these months accounts for over 80% of Nemipterids. The total Nemipterids landed by the mechanized boats at Cochin Fisheries Harbour during 1983-84 were about 1,030 tonnes and at Integrated Fisheries Project were 6,355 tonnes and during 1984-85 the total landings from Cochin Fisheries Harbour were 5,348 tonnes and from Integrated Fisheries Project were 5,350 tonnes. An increased yield of threadfin breams can be obtained from the relatively deeper waters beyond the present trawling grounds, by employing the maximum effort during monsoon months (Anon, 1986).

1.3.1 Craft and Gear employed

Prior to the introduction of mechanized fishing in our country, traditional fishing methods were in vogue and many types of fishing craft and gear were employed. Among the craft the main types are the dug out and plank built canoes. These craft employ all types of indigenous fishing gear developed by the fishermen such as long lines, gill nets, boat seines, shore seines, etc. which are designed to suit the local fishing conditions and to exploit the resources. The various indigenous fishing gear are not capable of catching Nemipterids, as their zone of action is limited only to a few meters in depth and a short distance from the shore. The type of gear that could have landed them are the shore seines and some of the boat seines particularly 'iraguvala', the two-boat seines, operated along the east coast. But being non-mechanized, they could not extend their range of operation. This clearly indicates that Nemipterus species were incidental catches in many of the fishing gear, like shore and boat seines, when these fishes approach the shore. This situation has changed with the introduction of demersal trawling from small mechanized boats. These boats could easily reach depths far beyond that of the traditional craft but limited upto 60 meters depth.

Several attempts have been made for the introduction of trawling in India. Although it was initiated in 1902 this method was taken up on a commercial scale only in the latter half of the fifties in Cochin (Kuriyan, 1965) and subsequently spread to other parts.

Besides these, medium and large trawlers capable of reaching depths beyond the scope of the small trawlers are also used for this fishing. The size of the trawl employed by the vessels depend on the horse power of the engine fitted in the trawler (Miyamoto, 1958). Satyanarayana et al. (1962) suggested the size of gear suitable for the small class of vessels. Subsequently many modifications and improvements were made in the design and construction of trawlers used by these vessels by Central Institute of Fisheries Technology. Recently the Bay of Bengal Programme has introduced two-seam bottom trawl (Pajot et al. 1982) which is getting accepted by the operators of small mechanized vessels in the country. When trawling gained momentum, the catch of Nemipterids increased many fold. During the initial period, when trawling was mainly aimed at shrimps, Nemipterid fishes were considered as trash fishes and often thrown over board. When the Catch Per Unit Effort of prawn decreased these fishes were brought to shore and presently command a very high price in many parts of the country.

1.3.2 Check list of Nemipterid fishes of Cochin coast

Nemipterus, *Scolopsis* and *Parascolopsis* were included in the family Nemipteridae by Fischer and Bianchi (1984) from Western Indian Ocean. Of these, only *Nemipterus* could be collected from Cochin waters.

The various representatives of Nemipterids identified from Cochin waters are listed below:

Family	:	Nemipteridae
Genus		*Nemipterus*, Swainson, 1839.
Species		(1) *N. japonicus* (Bloch, 1795)
		(2) *N. mesoprion* (Bleeker, 1853)
		(3) *N. tolu* (Valenciennes, 1830)
		(4) *N. delagoae* (Smith, 1949)

1.3.3 Seasonal abundance and size groups

Nemipterus japonicus (Bloch) : This species constitutes a good fishery (about 2% of the total catch) throughout the year with a peak occurrence from July to October; and the size ranges are between 100 to 285 mm (Total length). Peak fishery coincides with monsoon. The fish with maturing and mature gonads are found during this season.

Nemipterus mesoprion (Bleeker): This species also forms a good fishery along Cochin coast. Though represented throughout the year, peak landings are observed from August to October along with N. japonicus. The fish with mature gonads are observed abundantly during this period. The size ranges recorded during this period are 80 to 195 mm (T.L.).

Nemipterus tolu (Valenciennes): This species does not form a fishery along Cochin waters, however they are found along with the other Nemipterids during February - May. The minimum size recorded for these fishes are 53 mm (T.L.) and maximum 187 mm (T.L.). The maturing fishes are obtained at that period.

Nemipterus delagoae (Smith): This species are rarely seen along with other Nemipterids in Cochin, but its occurrence appears to be seasonal, being limited to February, March and April. The minimum size ranges recorded for these species are 90 mm (T.L.) and maximum 150 mm (T.L.)

1.4 REVIEW OF PREVIOUS RESEARCH WORK

The genus Nemipterus was first erected by Swainson (1839) on Dentex (Cuvier and Valenciennes, 1830). Anomura, Odontoglyphis Euthyopteroma (Fowler, 1904) are the other generic names used to describe these group of fishes before Swainson. Gunther (1859) established the genus Synagris for Nemipterus and later it was synonimized with Nemipterus by Weber and de Beaufort (1936).

Day (1878) reported five species of Nemipterids from Indian waters under the genus _Synagris_ (Gunther, 1859). Weber and de Beaufort (op. cit) included twenty species of _Nemipterus_ from the Indo-Australian Archipelago. Earlier studies on the taxonomy of Nemipterids were of Smith (1949) from South African waters, Munro (1955) from Ceylon and New Guinea, Fischer and Whitehead (1974) from Eastern Indian Ocean and Western Central Pacific, Wongratana (1973) from Thailand waters, Senta and Tan (1975) from Andaman waters and Weber and Jothi (1977) from Malaysian waters.

The recent taxonomical reports on this group of fishes from Indian waters are those of Rajagopalan et al. (1975), Murthy (1978), Indra (1981) and Sophy and Hameed (1983).

Some observations on the biology of various Nemipterids were made from different parts of the world, nevertheless the available information is rather meagre and scanty. Except for _N. japonicus_, a detailed investigation on the biology of Nemipterids has not been attempted from Indian waters despite their contribution to commercial fishery. This lacuna is perhaps due to the fact that the identification of many species based on morphology is often difficult.

Information on the food and feeding habits of _N. virgatus_ (Li Kwan-Ming, 1954; Eggleston, 1970 and 1972), _N. bathybus_ (Eggleston, 1972) _N. hexadon_ (Isarankura, 1968), _N. japonicus_

(Kuthalingam, 1865; George et al. 1968; Krishnamoorthi, 1971; Eggleston, 1972; Vinci, 1982; Murthy, 1983 and 1984; Krishnaveni, 1986), N. delagoae (Madan Mohan and Velayudhan, 1983) and N. peronii (Sainsburg and Whitelaw, 1985) are available from different waters. Except the work of George et al. (1968) there is no report on the food and feeding of these group of fishes from Kerala coast.

Age and growth studies on Nemipterids are limited. Available information on age and growth are those of N. virgatus (Eggleston, 1970-1972), N. bathybus (Eggleston, 1972), N. hexadon (Isarankura, 1968), N. japonicus (Eggleston, 1972; Murthy, 1984; Krishnamoorthi, 1971; Manikayala Rao and Srinivasa Rao, 1986; Krishnaveni, 1986), N. mesoprion (Murthy, 1981) and N. peronii (Sainsburg and Whitelaw, 1985). All the authors except Manikayala Rao and Srinivasa Rao (1986) adopted length frequency method but were not successful in their study with hard parts. There is no report on age and growth study of this group of fishes from Kerala coast.

Length - weight relationship in N. japonicus from Cochin coast has been studied by Vinci and Nair (1974). This was studied in N. mesoprion from Andhra-Orissa coast by Murthy (1981) and from Madras coast by Vivekanandan and James (1988).

Studies on the breeding biology of Nemipterus species are scarce from the west coast of India. The detailed study on breeding biology of N. japonicus are by Krishnamoorthi (1971) and Krishnaveni (1986) from the east coast of India. The available literature on some aspects of maturation and spawning are those on N. virgatus (Li Kwan-Ming, 1954; Eggleston, 1972), N. bathybus (Eggleston, 1972), N. peronii (Sainsburg and Whitelaw, 1985) and N. mesoprion (Weber and Jothi, 1977; Murthy, 1981). Practically no information is available on the eggs and larvae of this group of fishes.

The Nemipterid fishery of Andhra - Orissa coast have been described by Krishnamoorthi (1971). Senta and Tan (1975) have reported the fishery comprising the size composition of this group of fishes from South China and Andaman Seas. Information is also available on the population identification on N. japonicus by Krishnaveni (1986) from Indian coast and on N. marginatus by Pauly and Martosubroti (1980) from Western Kalimantan, South Sea. Krishnaveni (1986) has also reported the proximate composition of N. japonicus based on material collected from Portonovo waters.

1.5 RESEARCH APPROACH

The available literature reveals that biological and biochemical studies on Nemipterus spp. are scarce and poorly known. In some cases, their validity is doubtful because of the prevailing confusion in taxonomy. In the present investigation attempts are made to inquire about the biological and biochemical aspects of N. japonicus and N. mesoprion, which contribute to a fishery of considerable importance in Kerala coast.

The results are presented in eight sections.

The first section is a general introduction including a review of previous work on this genus. It also contains an account of the distribution of Nemipterus spp. and their fishery along the Indian coast in general during the period of investigation, with notes on their landings.

The second section deals with the systematics of the Nemipterid fishes along Cochin coast.

The third section deals with the qualitative and quantitative analyses of the food items, feeding behaviour and feeding intensity in relation to season, size, sex and stages of maturity.

The fourth section incorporates the findings on the age and growth rates of N. japonicus and N. mesoprion. The growth parameters are represented using Von Bertalanffy's equation.

In the fifth section length-weight relationship of the two species are dealt with.

The sixth section embodies the results on the breeding biology of the two species covering details on the spawning season, spawning frequency, size and age at first maturity, seasonal variation in relative condition factor, sex ratio and fecundity.

The seventh section includes the results of the present study on the proximate composition of muscle, liver and gonads of *N. japonicus* and *N. mesoprion* based on the maturity stages and length groups.

Synthetic resume followed by reference is given at the end.

CHAPTER 2

SYSTEMATICS

SYSTEMATICS

2.1 INTRODUCTION

The correct identification of a species is a necessary precedent to the investigation of any aspect of the biology, fishery and distribution of the fish. The major comprehensive studies on the classification of fishes of the Indo-Pacific region are those of Hamilton (1822), Gunther (1859-1870), Day (1865-1878), Weber and de Beaufort (1911-1951), Smith (1949), Koumans (1953), Munro (1955), Fischer and Whitehead (1974) and Fischer and Bianchi (1984). Our knowledge on the fishes of Malabar-Cochin area dates from Day (1878), who described several species of fishes from this area.

Fishes of the family Nemipteridae constitute an important fishery along the Cochin coast. So far, the systematics of this group of fishes are not established clearly. Fischer and Whitehead (1974) identified 57 species under the family Nemipteridae from Eastern Indian and Western Central Pacific Ocean. Of this, only four species were represented in the Cochin area. In the present work an attempt has been made to study in detail the Nemipterid fishes of this region.

Day (1878) reported five species of threadfin breams from Indian waters under the genus Synagris (Klein) Gunther, namely Synagris striatus, S. tolu, S. bleekeri, S. notatus and S. japonicus. The fishes of the Indo-Australian Archipelago by Weber and de Beaufort (1936) includes twenty species of Nemipterus. Recent reports of Nemipterid fishes from Indian coast are those of Rajagopalan et al. (1975), Murthy (1978) and Sophy and Hameed (1983).

2.2 MATERIALS AND METHODS

The materials for the present study were collected from the trawl catches of the Integrated Fisheries Project and Fisheries harbour, Cochin, during the period from February, 1982 to July, 1984. The colour and pigmentation of fresh specimens were recorded, but detailed observations were made on preserved specimens. All measurements were taken from point to point on the left side of the fish. A pair of dividers and vernier calipers were used for the measurements and it was rounded off to the nearest millimeter. The morphometric data are presented in percentages of standard length, except the snout length, orbit diameter and inter-orbital distance, which are given in percentages of head length. Meristic counts, teeth counts and vertebral counts were made on Alizarin stained materials. Measurements and counts were taken according to Holden and Raitt (1974). The gill raker numbers were noted on the first left gill arch.

2.3 SYSTEMATIC DESCRIPTION

Class	:	Osteichthyes
Sub class	:	Teleostomi
Super order	:	Acanthopterygii

Order	:	Perciformes
Sub order	:	Percoidei
Family	:	Nemipteridae

2.3.1 Characters of Taxonomic value

Body oblong and slightly compressed. Mouth terminal, moderate with rows of small conical teeth and a few canines in front and none on palate and vomer. Dorsal fin continuous, with 10 spines and 8-11 soft rays. Anal fin with 3 spines and 5-8 soft rays. Pelvic fin with 1 spine and 5 soft rays. A medium sized auxiliary scale present above each pelvic fin. Pelvics and upper lobe of caudal often with filamentous rays. Caudal forked and front of head naked, scales beginning above eyes and on cheek, cheek with 3 or more rows of scales. Scales on body large, ctenoid and deciduous.

2.3.2 Key to Genera

Body rather elongate and moderately compressed, covered with fairly large scales, easily shed. Suborbital with a spine. Mouth moderate, teeth small and conical, canine teeth present at least in upper jaw. Dorsal fin with 10 spines and 9 soft rays. Anal fin with 3 spines and 7 soft rays. Caudal fin forked. Scales on preopercle, opercle and body ctenoid. Preopercle with 3 oblique rows of scales, its flange naked......Nemipterus Swainson.

Nemipterus Swainson, 1839

Dentex Cuvier and Valenciennes 1830, Bleeker 1873, Fowler 1904.

Synagris Gunther, 1859; Day, 1878; Fowler, 1938.

Anomura, Odontoglyphis Fowler, 1904.

Euthyopteroma, Fowler, 1904.

2.3.3 a) Key to species

Upper lobe of caudal fin prolonged into a filament. Dorsal spines normal, canines anteriorly in upper jaw only, the lower jaw with uniform villiform teeth; dorsal fin base with a longitudinal yellow band; anal fin with two or several yellow streaks and a brilliant spot on shoulder. Anal fin with several irregular or wavy longitudinal yellow streaks, shoulder spot and caudal filament yellow; first spine of dorsal fin little longer than suborbital depth, or more than vertical diameter of eye..... N. japonicus (Bloch, 1795).

Nemipterus japonicus (Bloch 1795) Plate 1.

Sparus japonicus: Bloch, 1791

Synagris japonicus: Day, 1878, Fowler, 1938, Gunther 1859.

Dentex bipunctatus: Cuvier and Valenciennes, 1830

Dentex blochii: Bleeker, 1851

Dentex tambulus: Cuvier and Valenciennes, 1830

Description

Based on 25 specimens ranging from 76.5 to 223 mm Standard Length (S.L) (108-279 mm T.L).

Fin formula - D X, 9; A III, 7; P 17 - 18; V I, 5; C 17.

Body measurements expressed in percentages of standard length. Greatest body depth 32.37-33.63 (M = 33.00); head length 31.21-33.63 (M = 32.42); snout to D fin origin 34.68-37.22 (M = 35.95); snout to P fin origin 31.21-33.86 (M = 32.53); snout to V fin origin 33.53-35.87 (M = 34.70); snout to A fin origin 61.85-62.78 (M = 62.31); base of D fin 50.67-50.86 (M = 50.76); base of A fin 18.43-18.83 (M = 18.66). Pectoral fin length 31.21-33.86 (M = 32.53). Pelvic fin length 25.56-26.59 (M = 26.07); length of caudal peduncle 18.49-19.28 (M = 18.88); depth of caudal peduncle 9.96-11.56 (10.76); largest dorsal spine length 14.45-14.80 (M = 14.62); length of 3rd Anal spine 11.56-12.11 (M = 11.83). In percentages of head length, snout length 30-35.18 (M = 32.59); orbit diameter 22.66-29.63 (M = 26.5); Inter orbital width 17.33-22.22 (M = 19.78).

Body slightly compressed. Suborbital depth about equals vertical eye diameter. Teeth in lower jaw very fine, numerous, the outer raw slightly enlarged but no canines: but upper jaw with 6-12 canine in front. Vertebrae 24. Gill rakers 7-8 in upper limb and 7-10 in lower limb. Pyloric caeca 7-9. Colour of viscera yellow. <u>Scales</u>: Lateral line scales 43-48, in transverse 13-14. Scales present all over the body and head except snout; cheeks with 3 rows of scales.

<u>Colour</u>

Dorsal profile dark rosy, silvery ventrally. Upper profile of orbit red and the inter orbital region with a brownish saddle. Both upper and lower lips rosy. 1-3 longitudinal yellow lines above lateral line and 7-9 below and an yellow band along belly. Dorsal fin rosy with an yellow margin and a broad yellow band along the base. Pectoral pinkish. Pelvics yellowish with an yellow auxiliary scale. Anal fin white or light blue with wavy yellow lines. Caudal fin rosy with a long yellow filament on the upper lobe.

Distribution

Nemipterus japonicus is known to occur South Japan to East Africa, Red Sea and Indo-Pacific region (Weber and de Beaufort, 1936).

Remarks

Among threadfin breams, *N. japonicus* is the most widely distributed species, being found from Japan to Red Sea and even in the Eastern part of Mediterranean Sea indicating its wide adaptability to environmental conditions. Of the four species recorded from Cochin waters, *N. japonicus* and *N. mesoprion* can be easily identified by the presence of filamentous caudal fin. *N. japonicus* has a marked resemblance to *N. mesoprion*, but it differs mainly in colour. In *N. japonicus* the caudal filament is yellow, whereas in *N. mesoprion* it is red. In *N. mesoprion*, the head length, and the pelvic fin length are more and the snout length and suborbital lengths are not comparable to those of *N. japonicus* (Murthy, 1978). *N. japonicus* can easily be identified from N. mesoprion by the difference in the pyloric caeca number and the colour of viscera (Sophy and Hameed, 1983).

2.3.3 b) Key to species

Upper lobe of caudal fin prolonged into filament, dorsal spines normal, canines anteriorly in upper jaw only, the lower jaw with uniform villiform teeth, dorsal fin base with a longitudinal yellow streak, shoulder spot and caudal filament rosy red, first spine of the dorsal somewhat shorter than eye diameter........Nemipterus mesoprion Bleeker.

Nemipterus mesoprion Bleeker, 1853. Plate 2.

Dentex mesoprion Bleeker, 1853.

Synagris mesoprion, Fowler, 1938.

Description

Fin formula - D X, 9; A III,7; P 15 - 16; V I, 5; C 17.

Body measurement expressed in percentages of standard length. Greatest body depth 28.2-32.47 (M = 30.57); head length 29.47-33.53 (M = 32.06); snout to D fin origin 29.27-35.86 (M = 32.45); snout to P fin origin 29.45-35.85 (M = 32.66); snout to A fin origin 58.84-64.43 (M = 61.43); snout to V fin origin 32.14-36.46 (M = 34.49); base D fin 50.61-54.45 (M = 52.74); base A fin 17.30-20.44 (M = 19.01). Pectoral fin length 25.89-32.04 (M = 29.27). Pelvic fin length 27.17-43.11 (M = 32.49); dorsal fin height (5th spine) 11.88-14.28 (M = 13.54); anal fin height (3rd spine) 11.57-12.65 (M = 11.98); caudal peduncle length 14.02-19.02 (M = 16.88); depth of caudal peduncle 9.00-11.58 (M = 10.92).

In percentages of head length, snout length 27.39-34.78 (M = 30.45); orbit diameter 28.37-34.78 (M = 23.19).

Body slender, usually deeper than head. Teeth villiform in jaws, the outer row slightly enlarged and conical, 4 to 10 slender canine teeth in front of upper jaw, none on lower jaw. Vertebrae - 24. Gill rakers 6-7 in upper limb and 7-8 in lower limb. Pyloric caeca 7-8; colour of viscera red.

Scales : Lateral line scales 40-45. In transverse 13.

Colour

Orbital rim and snout lip rosy red. Dorsal profile pink; ventral profile silvery white. A bright yellow bloch with pink reflection below lateral line near its anterior end. Base of the spinous dorsal with a blue tinge extending up to head and the abdomen yellowish. Dorsal margin red and the interspinous membrane light yellow. Pectoral pinkish, pelvic distal half slightly pink with basal yellow bloch. Caudal and the filament on the upper lobe red with basal yellow reflection.

Distribution

Nemipterus mesoprion is known to occur in Sumatra, Singapore and along the east and west coasts of India (Weber & de Beaufort, 1936).

Remarks

Nemipterus mesoprion collected from Cochin waters agrees well with the description of Murthy (1978) and Talwar and Kacker (1984). By comparing the specimens from the East and West coasts of India, it is found that the specimens from west coast are more streamlined than east coast (Sophy and Hameed, 1983). Murthy (1978) stated that the colour of the bloch is reddish in N. mesoprion whereas in the specimens collected from Cochin coast, the bloch is bright yellow with pinkish reflection. Talwar and Kacker (1984) reported that the number of lateral line scales are 45-47 and caudal with a short filament whereas in the present study it is observed that the range of lateral line scale is from 40-45 and caudal is with a long red filament.

2.3.3 c) Key to species

Upper lobe of caudal fin normal with no filamentous prolongation. Dorsal fin spines much longer than its soft rays, very slender, interspinous membrane of dorsal fin distinctly and deeply notched.....N. tolu (Valenciennes,1830).

Nemipterus tolu (Valenciennes, 1830). Plate 3

Dextex tolu Valenciennes, 1830; Bleeker, 1851; Fowler, 1904.

Synagris tolu Day, 1878.

Odentoglyphus tolu Munro, 1955.

Dentex mulloides Bleeker, 1852.

Synagris mulloides Gunther 1859; Fowler, 1938.

Dentex obtusus Bleeker, 1860.53.

Description

Based on 20 specimens ranging from 80-130 mm S.L. (90-178 mm T.L.).

Fin formula - D X, 9; A III, 7; P 16 - 17; V I, 5; C 17.

Body measurements expressed in percentages of standard length. B. depth 23.75-31.16; head length 26.25-28.95 (M = 27.6); snout to D fin origin 30.00-32.85 (M = 31.42); snout to P fin origin 26.25-29.71 (M = 27.98); snout to A fin origin 58.74-67.39 (M = 63.07); snout to V fin origin 30.00-34.78 (M = 32.39); base D fin 46.25-55.07 (M = 50.66); base A fin 16.20-18.84 (M = 17.23). Pectoral fin length 20.00-21.73 (M = 20.86). Pelvic fin length 22.5-26.81 (M = 24.65); length of caudal peduncle 15.62-16.66 (M = 16.14); height of dorsal spine (5th spine) 15.62-16.66 (M = 16.14); depth at caudal peduncle 8.12-10.87 (M = 9.49).

In percentages of head length, snout length 28.57-31.43 (M = 29.99); orbit diameter 28.57-34.28 (M = 31.43) inter orbital width 19.04-22.73 (M = 20.89).

Body slender and slightly depressed. Mouth moderate. Teeth in villiform bands in front of both jaws, narrowing laterally to a single row of larger pointed teeth, outer row enlarged with 6-7 canine teeth in front of upper jaw and 6-8 conical teeth in front of lower jaw. Vertebrae 24. Gill rakers 6-8 in upper limb and 7-9 in lower limb, Pyloric caeca 6-8. Colour of viscera dull white.

Scales

Lateral line scales 48-49; transverse scales 13.

Colour

Snout tip and orbital rim pink, dorsal profile pink with nine indistinct brownish saddle like bloches. Ventral profile silvery white. Four fine faint yellow lines along flanks. Dorsal fin with yellow bands and orange margin. Pectorals pink, Pelvics white with an yellow auxiliary scale. Anal translucent, Caudal fin forked with a pinky red upper lobe and a white lower lobe.

Distribution

Nemipterus tolu is known to occur in Singapore, Sumatra, coasts of India, China, Formosa, Philippines, New Calidona and Java (Weber and de Beaufort, 1936).

Remarks

The present specimens agree well with the descriptions by Valenciennes (1830), Fischer and Whitehead (1974) and Talwar and Kacker (1984). N. tolu resembles with N. peronii in many features, but it can be easily identified from N. peronii by the presence of yellowish bloch at the base of the pelvic fin, yellow gill opening and the deeply notched interspinous dorsal membrane.

This species is not very common along Cochin coast and its occurrence is seasonal, during March to August along with N. japonicus and N. mesoprion.

2.3.3 d) Key to species

Upper lobe of caudal fin normal, with no filamentous prolongation. Dorsal fin spines more or less subequal with soft rays. Interspinous dorsal fin membrane entire. Five to seven slightly curved greenish yellow longitudinal streaks below lateral line; anal fin with three longitudinal yellow streaks; tip of upper caudal fin lobe pale rosy.....N. delagoae Smith.

Nemipterus delagoae Smith, 1949. Plate 4.

Nemipterus delagoae Smith, 1949; Fischer and Whitehead, 1974; Rajagopalan et al., 1975; Sophy and Hameed, 1983.

Fin formula - D X, 9; A III, 7; P 15-16; V I, 5; C 17.

Body measurements expressed in percentages of standard length. Greatest body depth 25.00-29.88 (M = 27.46), head length 30.10-32.95 (M = 31.24); snout to D fin origin 29.56-32.22 (M = 30.65); snout to P fin origin 29.11-32.82 (M = 31.22); snout to A fin origin 58.04-64.06 (M = 61.48); snout to V fin origin 31.63-34.37 (M = 32.95); base D fin 47.95-56.01 (M = 52.82); base A fin 18.40-21.49 (M = 19.85); pectoral fin length 21.45-25.88 (M = 24.26); Pelvic fin length 25.72-35.22 (M = 29.38); height of dorsal fin

(5th spine) 11.45-13.51 (M = 12.34); height of anal fin (3rd spine) 9.56-11.49 (M = 10.61); caudal peduncle length 17.75-20.54 (M = 19.15); depth of caudal peduncle 8.87-11.62 (M = 10.31).

In percentages of head length, snout length 31.74-37.28 (M = 34.45); orbit diameter 30.00-35.00 (M = 32.79); interorbital space 21.05-26.47 (M = 23.83).

Body slender, body depth less than head length. Teeth in jaws in several rows. Upper jaw with 3-4 cannine teeth anteriorly in each rows but such teeth are absent in lower jaw. Hind border of preoperculum crenulate. The height of the soft dorsal and spinous dorsal almost the same. The outer ray of pelvic fin elongated and reaching to the origin of anal, vertebrae 24, gill rakers 5-7 in upper limb, 6-7 in lower limb, pyloric caeca 7-9, colour of visceral membrane dull white.

Scale

Lateral line scales 47-49 and in transverse 13.

Colour

The upper half of the body pinkish, becoming silvery at sides and beneath. Four light yellow longitudinal bands below the lateral line. Snout pinkish with a golden patch below. Dorsal fin rosy with an yellow margin and a blue band below it. Pelvics white with an yellow auxiliary scale. Anal fin translucent blue with greenish yellow bands. Caudal fin rosy, yellowish in middle and the tips of upper lobe red and lower lobe white.

Distribution

Nemipterus delagoae is known to occur in both the coasts of India and South Africa (Weber and de Beaufort, 1936).

Remarks

The present specimen of N. delagoae agrees with the original description by Smith (1949) and also with the description of Rajagopalan et al. (1975) in several characters but differs in certain features. According to Smith (1949) the lateral line scales range from 49-50 but in the present specimen the number of lateral line scales range from 47-49. According to Rajagopalan et al. (1975) the number of caudal fin rays were 20, but in the present specimen it is 17. According to Smith (1949) and Rajagopalan et al. (1975) the hind border of preoperculum is naked but in the present specimen the hind border of pre-operculum is found to be crenulate. Smith (1949) stated that the gill raker number of N. delagoae is 7, whereas in the present study it is found that the gill rakers in the first left gill arch varies from 11-14. In the present specimen the head length is more than the body depth whereas Fischer and Whitehead (1974) stated that the head length and body depth are equal.

N. delagoae resembles N. bleekeri in several characters but it can be differentiated from N. bleekeri by the absence of blue spot on the opercle, shorter pectoral and the change in the number of pyloric caeca and colour of viscera (Sophy and Hameed, 1983).

Plate 1. *Nemipterus japonicus* (Bloch)

Plate 2. *Nemipterus mesoprion* Bleeker

Plate 3. *Nemipterus tolu* (Valenciennes)

Plate 4. *Nemipterus delagoae* Smith

CHAPTER 3

FOOD AND FEEDING

FOOD AND FEEDING

3.1 INTRODUCTION

The food and feeding habits of fishes have attracted the attention of fishery biologists even from the earlier days of research and investigations in fishery biology. An initial approach was to obtain information in respect of selective feeding mainly based on the general stomach content analyses. This throws light on the marine food chain in view of competition between species. Investigations of Kohler and Fitzgerald (1969), Legand and Rivaton (1969), Tyler and Pearcy (1975), Johnstone (1917) and Chistensen (1978) were helpful in evaluating a quantitative predator-prey relationship which indicates seasonal, geographic and diurnal variation in food composition (Lear, 1972; Vinogradov, 1972 and Frost, 1954) in enumerating the feeding rate (Popova, 1963), in estimating the energy budget (Keast and Webb, 1966 and Thorpe, 1977) and in modelling energy flow in marine ecosystem (Simenstad et al., 1979). Food being one of the most important factors regulating or influencing the abundance, growth and migration of fishes, any information in this regard will add to the existing knowledge needed for optimum management of fish stock.

Earlier studies on the food and feeding habits of N.japonicus were that of Krishnamoorthi (1971) from Andhra-Orissa coasts and

Krishnaveni (1986) from Portonovo coast in correlation with the seasonal changes. Reports from the Mangalore coast by Kuthalingam (1965), from the northern parts of the South China sea by Eggleston (1972) and from Kakinada coast by Murty (1981) are not in detail. However, no detailed studies have been carried out either on N. mesoprion or on N. japonicus from Cochin coast. Hence, the present study on N. mesoprion and N. japonicus from Cochin coast aims to provide information on the quantitative and qualitative analyses of the food and feeding habits in relation to season, size, sex and stages of maturity.

3.2 MATERIALS AND METHODS

Random samples were collected at weekly intervals from commercial fish landings at Cochin from August 1982 to July 1984. A total number of 1875 specimens of Nemipterus japonicus (770 males, 925 females and 180 juveniles) and 1276 specimens of N. mesoprion (573 males, 555 females and 148 juveniles) were examined. After fully establishing the identity of these fishes, their total length, weight, sex and maturity stages were recorded. The stomach of the fishes were removed, weighed and preserved in 7% neutral formalin for further analyses. The stomach includes that part of the gut between the last gill arch and pyloric caeca. To eliminate the error in the estimate of dietary composition the intestine was excluded from analyses, as the contents were so digested to be identified by visual examination (Randall, 1967; Windell, 1971; Gannon, 1976).

Several methods employed for analysing the food habits of fishes have been reviewed recently by Hyslop (1980). Volumetric and gravimetric techniques are being used more widely for greater accuracy (Windell, 1971). For carnivorous fishes the index of preponderance method of Natarajan and Jhingran (1961) was found most suitable and hence is adopted in this study (Ramanathan, 1977; Venkataramani, 1979; Sivakumar, 1981). The index of preponderance is worked out by using the formula.

$$I = \frac{VO}{\Sigma VO} \times 100$$

(where 'V' and 'O' represent the percentage of volume and occurrence of each food item, and 'I' the index).

Food items were identified to the generic level wherever possible and counted and measured volumetrically by water displacement method. Gastro-somatic index is calculated for _N. japonicus_ and _N. mesoprion_ to study the monthly variations in feeding intensity by using the formula,

$$\text{Gastro-somatic index} = \frac{\text{weight of the gut (gl)}}{\text{weight of the fish (g)}} \times 100$$

The stomachs were classified as 'gorged', when the stomach was expanded with food and its wall being thin and transparent, 'full' when the stomach was filled with food with its wall thick and intact, '3/4 full', '1/2 full', '1/4 full' and 'poor' when the stomach was partially filled with food depending upon their relative fullness. The stomach when devoid of food, was recorded as empty. Care was, however, taken to differentiate the regurgitated ones from the empty stomachs. Shrunken stomachs containing mucus were considered as empty whereas completely empty stomachs with expanded walls were identified as regurgitated and hence discarded (Dan, 1973).

Specimens of N. japonicus and N. mesoprion were categorised as immature (stage I in male and female), maturing (stage II in males and stages II and III in females), fully mature (stage III in males and stages IV, V and VI in females) and spent (stage IV in males and stage VII in females) to detect the food preference, if any, during different levels of maturity. The males and females were examined separately.

3.3 RESULTS

3.3.1 Nemipterus japonicus (Bloch, 1795)

a) Food composition:

The food of N. japonicus consisted of prawns, squilla, teleost fishes, polychaete worms, copepods, crabs, bivalves, gastropods, cephalopods, mysids, ostracods, foraminiferans, fish eggs and larvae in the order of abundance. The composition of the diet is listed in Tables 1 and 2. It is evident from the table that the crustaceans, especially prawns, constituted the most abundant food item, though copepods, mysids, amphipods, ostracods were also present. Decapod crustaceans and their larvae formed a lower percentage. Fishes and polychaetes occupied the second most important food item. Gastropods, bivalves, squids, fish eggs and foraminiferans were consumed in lesser quantities.

b) The food of juveniles and adults:

The food of juveniles and adults were analysed separately. It could be inferred from the table 1 and 2 that the juveniles preferred larval prawns and polychaete worms than any other food items. Teleost fishes, copepods and squilla formed a minor fraction of their diet.

No significant variation could be observed between the food of males and females of *N. japonicus*. Among crustaceans, prawns *Parapenaeopsis stylifera*, *Metapenaeus dobsoni* and *Penaeus* sp. constituted the major part of the diet along with *squilla* sp. Copepods, mysids, amphipods, ostracods and decapod crustaceans and their larvae were also found.

Fishes belonging to *Priacanthus* sp., *Anchovilla* sp., *Cynoglossus* sp., *Pterois* sp. and their larvae were found in fair numbers in their diet. The other species like *Saurida*, *Thryssa* etc. were also noticed very rarely. The polychaete worms also formed a fraction of their food. Some worms belonging to the family Terebellidae and Glyceridae were noticed and other worms could not be identified. Gastropods, bivalves and their veligers, parts of cephalopods, fish eggs and foraminiferans were also observed occasionally in trace quantity in their food.

c) Seasonal variation in diet:

Seasonal variation in the food of N. japonicus during the two year period (from August, 1982 to July, 1984) has been studied. The juveniles were encountered only during the months of October to February. The food of juveniles consisted of small prawns, worms, fishes, copepods and squilla (Table 1 and 2). In the adults a decline in the index of prawns could be noticed from October to January in both the years of study, but during that period polychaete worms constituted the dominant food item. Small fishes formed a major part of the food throughout the period of analysis, but during the months of October and November, they were not encountered in the diet. Mysids were observed during June, July, August and October. Among the gut contents, squilla was not noticed from March to June during the first year of study. But these items were found throughout the year during the second year.

d) Food preference during maturation cycle:

The food preference during the maturity stages of male and female N. japonicus was studied separately. From table 5 it is evident that both male and female fishes appear to have some preference to a particular food during different stages of maturity. Polychaete worms and small prawns were the major food items of fishes with immature gonads. However, during maturation of these fishes, the crustaceans, prawns and squilla were more dominant in the diet along with teleost fishes than the polychaete worms and during this stage it subsisted on a transitional spectrum of food items. It is evident from the table that the mature fishes also preferred the crustaceans and teleost fishes. But the bulk of the food of spent fishes was comprised of polychaete worms and teleost fishes than crustaceans.

e) Gastro-somatic index

The mean gastro-somatic index was calculated for each month to determine the feeding cycle (Fig. 3a). The gastro-somatic index negligibly fluctuated during the breeding period. A significant positive relation existed between the gastrosomatic index and feeding intensity. But a slightly inverse relationship could be noted between the gastro-somatic and gonado-somatic indices.

f) Feeding intensity:

The monthly percentage of stomach fullness such as gorged, full, 3/4 full, 1/2 full, 1/4 full and empty stomachs of *N. japonicus* was analysed during 1982 to July 1984 and is shown in Fig.1.

During both the years the percentage of gorged and full stomachs increased from June onwards and the high values were noticed during August to November, when more of matured and ripe individuals were found in the samples, the peak spawning season. Though the occurrence of poorly fed and empty stomachs were recorded during all the months, high percentage was noticed from February to March, the post spawning period. The minimum percentage of empty stomachs during August and October coincided with the peak spawning season. (Fig. 3b).

3.3.2 *Nemipterus mesoprion* Bleeker 1853 .

a) Food composition:

The major food constituents of *N. mesoprion* could be grouped into crustaceans, fishes, polychaetes and molluscs. Crustaceans were the predominant food item, fishes and polychaetes ranked next and molluscs were found in lesser quantities. Among crustaceans, the penaeid prawns (*Parapenaeopsis stylifera* and *Metapenaeus dobsoni*) and *Squilla* sp. were consumed more. Among fishes *Priacanthus* sp., *Anchovilla* sp. & *Cynoglossus* sp. were predominant. From table 3 and 4 it could be seen that the food of *N. mesoprion* consisted of polychaete worms in considerable quantity.

b) Food of juveniles and adults:

It is apparent from table 3 and 4 that juveniles mainly feed on polychaetes and larval prawns. Fish larvae and small fishes were also represented in fair numbers. Other food items such as squilla, copepods and mysids were also recorded occasionally.

On analysing the stomach contents of adults, no significant variation could be observed between the males and females (Table 3 and 4). Among crustaceans, penaeid prawns (*Parapenaeopsis stylifera*, *Metapenaeus dobsoni* and other *Penaeus* sp.) formed the major food items. Other crustaceans such as crabs, decapod larvae, amphipods, copepods, mysids and ostracods were consumed in lesser quantities.

However, Polychaetes, turbellides and glycerides were also encountered occasionally. The fishes were represented by Anchovilla sp., Cynoglossus sp., Pterois sp. and Priacanthus sp. Some fishes and post larvae of certain fishes were also observed but could not be identified. Gastropods, bivalve veligers, parts of cephalopods, fish eggs and foraminiferans were encountered sporadically, forming a very minor fraction of the diet.

c) Seasonal variation in the food:

Seasonal variation in the food of juveniles and adults of N. mesoprion during the two year period (from August, 1982 to July, 1984) are presented in table 3 and 4. Based on the present study, significant variations in feeding could not be observed in both the years.

It could be seen from the table that the study on the seasonal variation in the food of juvenile is insignificant because the juvenile fishes are noticed only during October to February period. During this period polychaete worms, larval prawns and teleost fishes respectively dominated their food content. Other crustaceans and foraminiferans were seen in lesser quantity.

In the adults throughout the period of observation, the penaeid prawns appeared invariably as a food item (Table 3 and 4). A drop in the index of prawn could be noticed in February, March and June.

During the first year of study Squilla sp. dominated the food from July to February. Among fishes Priacanthus sp. and Anchovilla sp. were observed in the gut contents from September to January whereas Cynoglossus sp. could be observed from October to December in both the years (the breeding period). Other fishes like Pterois sp., Saurida sp. and smaller perches were also encountered sporadically.

Polychaetes were noticed in the diet of these fishes in all the months except from June to September. Juvenile crabs and decapod larvae were found among the food items during the months of March, April, June and July. From February to July the gastropods and bivalve veligers were noticed in the gut contents. The other food items like copepods, ostracods, mysids, foraminiferans and fish eggs were also observed sporadically.

d) Food preference during maturation cycle:

From table 6 it can be inferred that this fish exhibits certain preference to a particular food item during maturation (both males and females). The larval prawns and polychaetes formed the major food items of fishes with immature gonads. Penaeid prawns along with squilla out numbered the gut contents of maturing fishes. The mature fish also prefer crustaceans and small fishes. During spawning season it consumes mostly the fish items. The proportion of various items of the food of spent fishes were similar to that of the immature fishes, of which the prawns constituted the major portion followed by polychaetes.

e) Gastro-somatic index:

The gastro-somatic index showed only small fluctuations during different months of the two year period of study (Fig. 4a). However, no relationship could be established between the gonado-somatic and gastro-somatic indices. No seasonal pattern was apparent during both the years.

f) Feeding intensity:

The feeding intensity during different months are given in Fig.2. During both the years the percentage of gorged stomachs were less in N. mesoprion. Full and 3/4 full stomachs were recorded in the matured and ripe individuals. The empty and poorly fed stomachs were found during the post spawning period. Throughout the year the percentage occurrence of empty stomachs was around 20% showing an inverse relationship with the gastro-somatic index (Fig. 4b).

3.4 DISCUSSION

The juveniles and adults of N. japonicus and N. mesoprion are active predators, feeding on prawns, crabs, squilla, amphipods, ostracods, fishes, bivalves, polychaetes, gastropods, cephalopods and foraminiferans. Like most other perches (Job, 1940) N. japonicus and N. mesoprion are active predators feeding mostly by sight. The large eyes, short snout and the absence of tactile organs also prove that the fishes feed during day light like Nemipterus virgatus and

N. peronii (Eggleston, 1970; Sainsburg and Whitelaw, 1985). The position of the mouth and the short stumpy gill rakers with wide gap in between indicate that these fishes browse and pick food from the ground and are incapable of filtering small particles. The gut of the fishes landed in the morning contained only digested matter suggesting the reduced feeding activity of these fishes during the night (Srinivasa Rao, 1964).

Chacko (1949) reported the presence of phytoplankton and zooplankton in the gut of N. japonicus collected from the Gulf of Mannar. Teleost fishes, anemones, amphipods, prawns, squilla, cephalopods and other miscellaneous items in lesser quantities were observed by Srinivasa Rao (1964) from the gut of N. japonicus obtained from Vizag region. Kuthalingam (1965) reported prawns, crabs, fishes, squilla and algae from the gut of N. japonicus from Mangalore coast. From Cochin coast George et al. (1968) observed amphipods and echiuroids as the major food items of N. japonicus, supplemented by polychaetes, teleost fishes, prawns and small crabs. Krishnamoorthi's (1971) investigation revealed the presence of crustaceans, molluscs, annelids, echinoderms and fishes as major components in the food of N. japonicus. Crustaceans, fishes, cephalopods and lamellibranchs were reported from the gut of N. japonicus by Eggleston (1972) from the northern part of South China sea. No previous studies are available on the food habits of N. mesoprion.

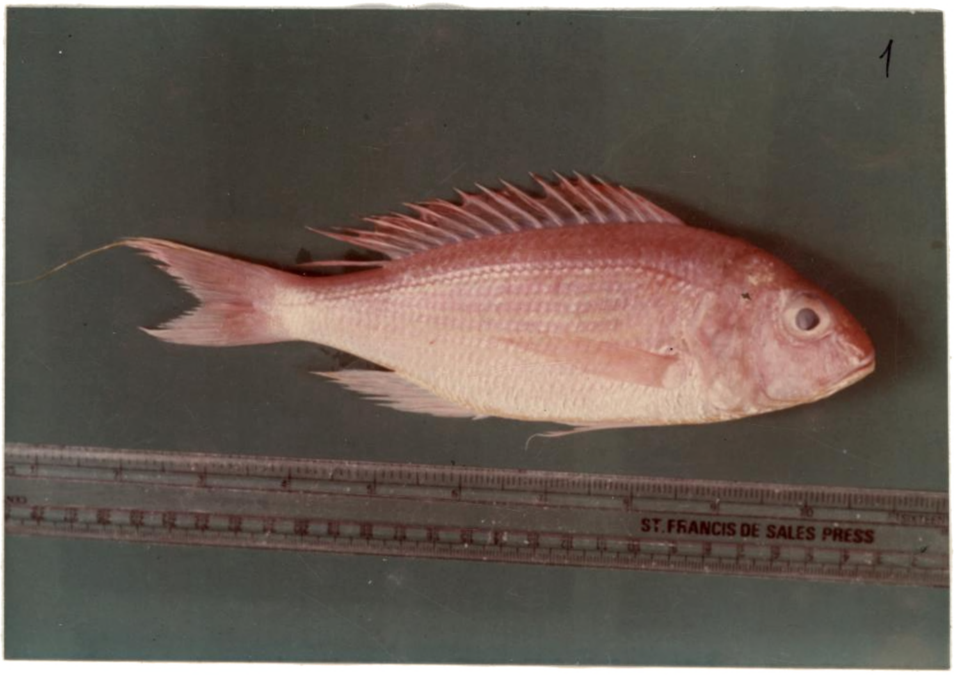
In the present observation it is found that the diet of both N. japonicus and N. mesoprion are similar, the prawns being the major prey organism, as seen in a number of related Nemipterid representatives (Krishnamoorthi, 1971; Eggleston, 1972; Madan Mohan and Velayudhan, 1983; Sainsburg and Whitelaw, 1985). The food items identified from the gut of N. japonicus agreed in general with those of the previous reports, but there are certain differences which may be due to the regional difference determined by the nature of the substratum, availability of food and due to the seasonal differences.

The prawns identified from the gut contents of N. japonicus and N. mesoprion were Parapenaeopsis stylifera, Penaeus sp., Procera sp. and Metapenaeus sp. The crabs identified were Plumurus sp. and Portunus sp., the polychaetes were Glycera sp. and Cumacea sp.

The food of these fishes showed marked variation between adults and juveniles. Most of the food items consumed by the adults were not seen in juveniles. However, the present observation is in agreement with that of Srinivasa Rao (1964) who examined the stomachs of N. japonicus from Andhra coast. As growth proceeds, the fish partly changes their diet consuming large actively swimming prey (Rao and Rao, 1957 and Eggleston, 1972).

Fishes with empty stomachs and poorly fed individuals were less during spawning period but active feeding was noticed before spawning. Feeding intensity was found to be low in immature and maturing forms.

At the beginning of breeding season the fish becomes more voracious but when breeding was progressing in October and November feeding becomes steady. Similar observations were made by Krishnamoorthi (1971) in N. japonicus from the Andhra-Orissa coast. The maximum feeding intensity may be due to the increased requirement of energy for the development of gonad.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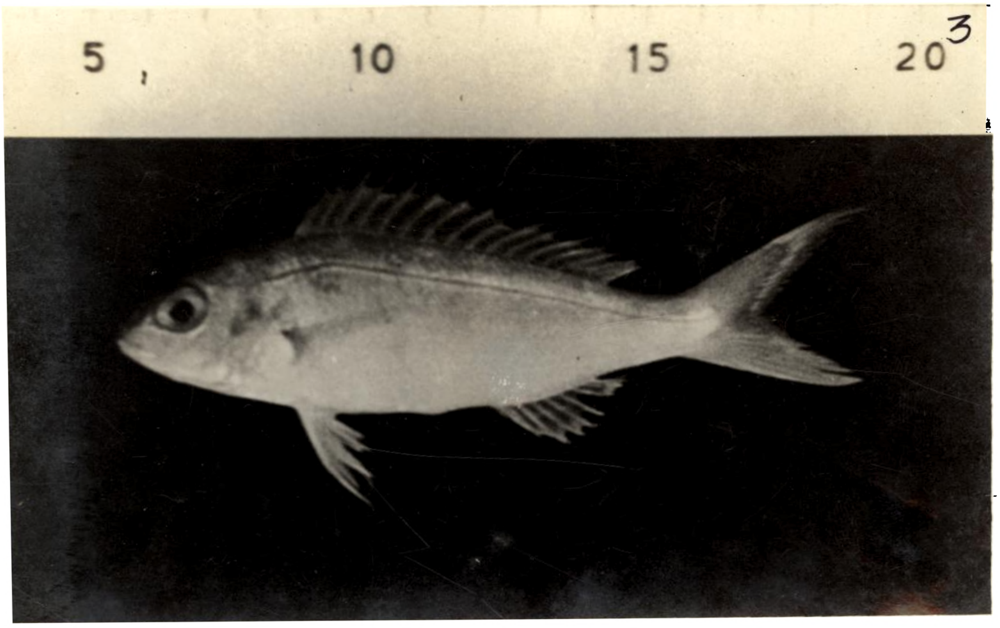
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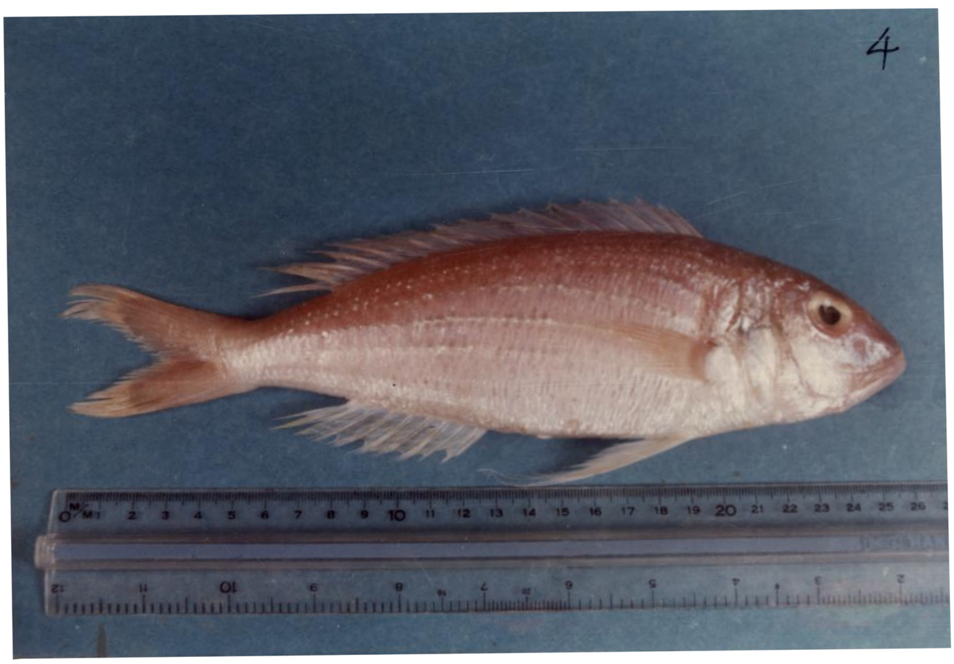
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Table 1 - Percentage index of relative importance value of various food items of <u>Nemipterus japonicus</u> during different months of the year 1982-83.

Food items	August 1982			September 1982			October 1982		
	M	F	J	M	F	J	M	F	J
Gastropods	-	1.8	-	-	-	-	2.1	20.0	-
Bivalves	-	2.4	-	-	-	-	-	-	-
Cephalopods	8.2	3.6	-	1.1	-	-	-	-	-
Turbellids	-	-	-	-	-	-	27.5	30.0	-
Glycerids	-	-	-	-	-	-	14.5	20.0	-
Other worms	5.7	-	-	-	-	-	10.7	20.0	-
Ostracods	1.1		-	2.0	1.0	-	-	1.4	-
Prawns	65.9	70.0	-	50.0	45.0	-	5.5	1.2	-
Crabs	3.1	2.8	-	1.1	-	-	1.1	1.9	-
Mysids	4.2	1.3	-	-	-	-	10.0	1.2	-
Squilla	8.2	3.2	-	31.4	23.4	-	27.2	1.8	-
Copepods	-	3.8	-	1.6	1.9	-	2.4	1.5	-
<u>Priacanthus</u> sp.	-	-	-	-	-	-	-	-	-
<u>Anchovilla</u> sp.	-	-	-	-	10.4	-	-	-	-
<u>Cynoglossus</u> sp.	-	-	-	-	3.6	-	-	-	-
Other fishes	-	10.0	-	10.0	8.6	-	-	-	-
Fish eggs	2.0	-	-	0.9	4.0	-	-	-	-
Foraminiferans	-	1.2	-	0.8	2.1	-	-	-	-
Fish larvae	1.6	-	-	1.1	-	-	-	1.0	-

Table 1 (contd...2)

Food items	November 1982			December 1982			January 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	-	-	-	-	-	-
Bivalves	4.6	-	-	1.8	1.4	-	-	-	-
Cephalopods	-	-	-	-	9.5	-	-	1.6	-
Turbellids	10.6	5.0	-	1.4	-	10.5	-	-	-
Glycerids	18.0	15.0	-	-	-	20.3	-	41.1	-
Other worms	4.8	5.0	63.6	-	-	16.5	2.4	8.4	30.0
Ostracods	-	1.8	-	-	2.2	-	-	-	-
Prawns	-	-	9.0	21.4	-	35.7	6.4	-	60.0
Crabs	-	1.4	-	2.4	-	-	-	4.6	-
Mysids	-	-	-	-	1.4	-	-	1.4	-
Squilla	-	1.0	13.6	-	-	-	50.6	-	-
Copepods	1.7	1.8	-	1.3	-	-	1.0	2.4	-
Priacanthus sp.	0.8	12.6	13.6	-	-	15.5	31.4	38.8	-
Anchovilla sp.	1.6	10.4	-	50.4	68.6	-	-	-	10.0
Cynoglossus sp.	35.2	25.5	-	19.6	-	-	4.2	0.1	-
Other fishes	20.9	20.5	-	-	10.9	-	-	-	-
Fish eggs	1.8	-	-	-	1.6	-	1.0	-	-
Foraminiferans	-	-	-	-	1.1	-	1.8	-	-
Fish larvae	-	-	0.2	1.6	2.3	1.5	1.2	1.6	-

(Table 1 (contd...3)

Food items	February 1983			March 1983			April 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	-	44.4	-	16.6	54.0	-
Bivalves	-	-	-	1.2	-	-	5.6	-	-
Cephalopods	8.0	-	-	20.0	-	-	-	10.0	-
Turbellids	-	4.4	15.0	-	5.6	-	-	-	-
Glycerids	-	5.6	15.0	-	4.4	-	-	-	-
Other worms	-	11.4	15.0	5.0	16.8	-	-	-	-
Ostracods	-	1.6	-	-	-	-	-	-	-
Prawns	42.5	42.8	55.0	30.2	5.5	-	-	-	-
Crabs	-	4.2	-	40.2	10.4	-	-	20.0	-
Mysids	-	3.2	-	-	-	-	-	-	-
Squilla	25.0	-	-	-	-	-	-	-	-
Copepods	12.5	2.3	-	-	1.8	-	16.6	3.0	-
Priacanthus sp.	-	4.8	-	-	-	-	4.0	-	-
Anchovilla sp.	-	1.1	-	-	-	-	16.0	-	-
Cynoglossus sp.	10.0	15.7	-	-	-	-	34.0	13.0	-
Other fishes	2.0	-	-	-	11.1	-	6.0	-	-
Fish eggs	-	1.2	-	1.2	-	-	-	-	-
Foraminiferans	-	-	-	2.2	-	-	-	-	-
Fish larvae	-	1.6	-	-	-	-	1.2	-	-

Table 1 (contd...4)

Food items	May 1983			June 1983			July 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	5.2	-	-	-	-	-	-	-	-
Bivalves	10.8	38.8	-	-	-	-	-	-	-
Cephalopods	15.0	0.5	-	-	-	-	-	-	-
Turbellids	13.0	33.3	-	-	-	-	-	-	-
Glycerids	14.0	-	-	-	-	-	-	5.0	-
Other worms	20.0	-	-	-	-	-	1.9	14.0	-
Ostracods	7.0	12.2	-	-	-	-	-	1.2	-
Prawns	-	-	-	-	-	-	14.2	2.8	-
Crabs	3.8	3.0	-	-	-	-	-	1.6	-
Mysids	-	-	-	-	-	-	9.4	1.4	-
Squilla	-	-	-	-	-	-	44.5	20.5	-
Copepods	7.1	4.1	-	-	-	-	1.3	1.8	-
Priacanthus sp.	-	-	-	-	-	-	1.8	-	-
Anchovilla sp.	3.8	1.0	-	-	-	-	-	-	-
Cynoglossus sp.	-	-	-	-	-	-	10.4	-	-
Other fishes	-	5.6	-	-	-	-	5.6	48.7	-
Fish eggs	-	-	-	-	-	-	-	-	-
Foraminiferans	-	-	-	-	-	-	8.5	1.8	-
Fish larvae	0.3	1.5	-	-	-	-	2.4	1.2	-

Table 2 - Percentage index of relative importance value of various food items of <u>Nemipterus japonicus</u> during different months of the year 1983-84.

Food items	August 1983			September 1983			October 1983		
	M	F	J	M	F	J	M	F	J*
Gastropods	-	3.0	-	8.8	-	-	-	-	-
Bivalves	-	5.0	-	7.2	1.7	-	-	-	-
Cephalopods	7.6	-	-	-	-	-	-	-	-
Turbellids	-	-	-	-	-	-	10.0	18.6	-
Glycerids	-	-	-	-	-	-	12.7	10.0	-
Other worms	-	-	-	-	-	-	20.0	38.0	-
Ostracods	5.0	1.8	-	3.8	4.8	-	-	-	-
Prawns	51.5	60.0	-	40.0	67.3	-	25.0	-	-
Crabs	8.9	1.6	-	3.1	16.6	-	-	3.1	-
Mysids	-	2.0	-	-	-	-	-	2.1	-
Squilla	10.0	20.0	-	12.0	2.6	-	6.2	16.6	-
Copepods	1.8	1.6	-	4.2	3.5	-	12.5	6.5	-
<u>Priacanthus</u> sp.	-	-	-	-	-	-	-	-	-
<u>Anchovilla</u> sp.	-	-	-	4.9	1.1	-	-	-	-
<u>Cynoglossus</u> sp.	-	5.0	-	4.0	-	-	-	-	-
Other fishes	11.7	-	-	10.0	-	-	12.5	4.1	-
Fish eggs		-	-	-	-	-	-	-	-
Foraminiferans	1.3	-	-	1.8	2.3	-	1.1	-	-
Fish larvae	2.0	-	-	0.2	-	-	-	1.0	-

Table 2 (contd...2)

Food items	November 1983			December 1983			January 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	-	-	-	8.0	-	-
Bivalves	3.2	-	-	-	1.2	-	4.0	-	-
Cephalopods	9.6	-	-	-	-	-	5.0	-	-
Turbellids	-	-	10.5	-	-	10.0	10.0	-	-
Glycerids	10.0	-	31.5	23.0	10.0	15.0	15.0	40.0	-
Other worms	4.2	-	58.0	-	-	53.6	13.6	8.1	-
Ostracods	-	-	-	-	3.3	-	-	-	-
Prawns	-	-	-	-	-	14.8	-	-	-
Crabs	2.1	8.2	-	-	1.4	-	1.9	1.4	-
Mysids	-	-	-	-	-	-	-	-	-
Squilla	38.9	20.0	-	15.0	69.0	5.0	20.0	18.5	-
Copepods	5.0	1.8	-	-	1.8	-	2.6	1.6	-
Priacanthus sp.	-	10.0	-	15.5	-	-	3.0	-	-
Anchovilla sp.	15.1	10.0	-	35.0	0.9	-	4.2	6.0	-
Cynoglossus sp.	-	-	-	5.5	10.0	-	3.0	-	-
Other fishes	10.5	42.0	-	4.0	1.6	1.6	1.6	18.4	-
Fish eggs	-	8.0	-	-	-	-	2.0	2.0	-
Foraminiferans	-	-	-	-	0.8	-	5.0	3.0	-
Fish larvae	1.4	-	-	2.0	-	-	1.0	1.0	-

Table 2 (contd...3)

Food items	February 1984			March 1984			April 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	-	4.0	-	-	1.8	-
Bivalves	3.0	1.8	-	-	-	-	10.0	-	-
Cephalopods	-	1.6	-	7.4	1.0	-	2.0	-	-
Turbellids	3.8	10.4	34.0	-	-	-	-	-	-
Glycerids	10.2	6.0	20.0	-	-	-	-	3.1	-
Other worms	16.0	7.0	10.5	14.0	1.0	-	2.0	-	-
Ostracods	0.2	-	-	-	-	-	-	-	-
Prawns	8.0	50.0	25.0	12.0	70.0	-	70.7	40.5	-
Crabs	3.6	-	-	-	-	-	2.4	11.1	-
Mysids	-	-	-	-	-	-	-	-	-
Squilla	50.0	22.2	-	-	-	-	5.6	-	-
Copepods	0.6	-	0.5	5.0	1.6	-	-	27.7	-
<u>Priacanthus</u> sp.	-	-	-	-	11.0	-	-	-	-
<u>Anchovilla</u> sp.	-	-	-	-	-	-	-	-	-
<u>Cynoglossus</u> sp.	-	-	-	-	-	-	2.4	1.4	-
Other fishes	-	-	10	50 0	10.0	-	2.4	5.5	-
Fish eggs	0.6	-	-	10.0	-	-	1.5	3.4	-
Foraminiferans	2.0	1.0	-	1.6	-	-	1.1	4.0	-
Fish larvae	2.0	-	-		1.4	-	-	1.5	-

Tale 2 (contd...4)

Food items	May 1984			June 1984			July 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	25.0	27.0	-	4.6	-	-	-	-	-
Bivalves	-	-	-	3.4	2.1	-	-	-	-
Cephalopods	-	4.1	-	-	-	-	-	6.4	-
Turbellids	2.0	-	-	-	-	-	-	-	-
Glycerids	7.0	-	-	-	-	-	-	-	-
Other worms	6.4		-	-	-	-	-	-	-
Ostracods	3.8	-	-	-	-	-	-	4.2	-
Prawns	-	13.3	-	-	3.9	-	10.0	11.0	-
Crabs	10.4	3.1	-	-	1.5	-	1.6	3.6	-
Mysids	-	-	-	15.7	-	-	-	10.0	-
Squilla	12.1	36.1	-	14.2	44.3	-	16.0	23.0	-
Copepods	11.6	1.8	-	-	1.5	-	1.2	1.8	-
Priacanthus sp.	-	-	-	20.0	16.0	-	15.0	-	-
Anchovilla sp.	-	-	-	10.0	1.0	-	14.0	24.0	-
Cynoglossus	4.6	3.4	-	10.0	3.0	-	14.0	10.0	-
Other fishes	6.4	5.5	-	18.0	18.0	-	23.0	-	-
Fish eggs	0.6	-	-	-	8.7	-	4.0	2.4	-
Foraminiferans	10.1	5.7	-	1.6	-	-	-	2.4	-
Fish larvae	-		-	2.4	-	-	1.2	1.2	-

Table 3 - Percentage index of relative importance value of various food items of <u>Nemipterus mesoprion</u> during different months of the year 1982-83.

Food items	August 1982			September 1982			October 1982		
	M	F	J	M	F	J	M	F	J *
Gastropods	-	-	-	-	2.0	-	-	3.0	-
Bivalves	2.0	-	-	16.0	-	-	1.0	4.0	-
Cephalopods	1.1	-	-	-	2.0	-	-	-	-
Turbellids	-	-	-	-	-	-	5.0	5.0	-
Glycerids	-	-	-	-	-	-	-	30.0	-
Other worms	0.9	3.7	-	-	5.0	-	-	-	-
Crabs	-	-	-	-	-	-	0.8	0.4	-
Prawns	80.0	78.0	-	13.0	64.0	-	2.0	-	-
Ostracodes	3.5	1.1	-	-	-	-	-	-	-
Mysids	-	-	-	-	-	-	2.0	-	-
Squilla	6.5	12.9	-	30.0	12.0	-	55.9	46.0	-
Copepods	3.0	2.0	-	2.0	2.0	-	3.2	10.0	-
<u>Priacanthus</u> sp.	-	-	-	15.0	-	-	6.0	-	-
<u>Anchovilla</u> sp.	-	-	-	10.0	9.0	-	3.0	1.6	-
<u>Cynoglossus</u>	-	-	-	3.1	-	-	16.1	-	-
Other fishes	1.0	2.3	-	8.0	2.0	-	5.0	-	-
Fish eggs	1.0	-	-	3.2	2.0	-	-	-	-
Foraminiferans	1.0	-	-	-	-	-	-	-	-
Fish larvae	-	-	-	-	-	-	-	-	-

Table 3 (contd...2

Food items	November 1982			December 1982			January 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	4.0	3.8	-	6.1	4.0	-	-	10.4	-
Bivalves	-	-	-	4.1	-	-	8.6	-	-
Cephalopods	8.0	10.5	-	4.9	-	-	3.9	8.8	-
Turbellids	18.0	-	32.4	-	-	26.0	-	2.1	30.0
Glycerids	-	8.0	-	-	-	-	-	-	-
Other worms	15.0	10.9	50.5	21.0	23.0	34.0	-	-	40.0
Crabs	-	-	2.0	-	4.0	-	-	-	-
Prawns	5.0	8.4	2.1	6.4	9.0	40.0	-	-	-
Ostracodes	5.3	-	-	-	3.0	-	-	-	-
Mysids	-	-	-	-	-	-	-	-	-
Squilla	-	34.60	-	34.1	30.0	-	41.6	5.0	-
Copepods	1.0	1.8	-	3.0	1.0	-	3.0	2.0	-
<u>Priacanthus</u> sp.	8.0	2.0	-	-	-	-	3.8	-	30.0
<u>Anchovilla</u> sp.	6.7	6.0	-	4.0	1.0	-	-	-	-
<u>Cynoglossus</u> sp.	25.0	4.0	1.0	10.0	10.0	-	-	-	-
Other fishes	-	3.0	4.0	6.4	15.0	-	38.0	60.0	-
Fish eggs	1.0	4.0	-	-	-	-	1.0	-	-
Foraminiferans	2.0	3.0	8.0	-	-	-	-	4.8	-
Fish larvae	1.0	-	-	-	-	-	-	6.9	-

Table 3 (contd...3)

Food items	February 1983			March 1983			April 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	7.4	11.2	-	5.1	4.8	-	-	25.0	-
Bivalves	1.8	-	2.0	3.2	-	-	-	25.0	-
Cephalopods	4.4	-	-	9.6	-	-	-	-	-
Turbellids	5.5	3.8	8.0	4.5	55.0	-	25.0	-	-
Glycerids	-	10.0	-	-	-	-	-	-	-
Other worms	30.7	20.6	20.0	6.8	-	-	-	-	-
Crabs	-	-	-	16.3	-	-	24.6	20.0	-
Prawns	-	-	50.0	-	-	-	10.4	-	-
Ostracodes	1.2	-	-	-	4.4	-	7.0	-	-
Mysids	-	-	-	-	-	-	3.0	15.0	-
Squilla	14.9	25.8	-	-	-	-	-	-	-
Copepods	11.9	6.0	-	5.1	5.6	-	1.5	-	-
Priacanthus sp.	13.4	-	-	-	-	-	-	-	-
Anchovilla sp.	1.3	22.5	-	20.9	10.2	-	-	-	-
Cynoglossus sp.	-	-	-	-	-	-	-	-	-
Other fishes	5.5	-	20.0	14.0	10.5	-	25.0	-	-
Fish eggs	-	-	-	10.0	5.0	-	-	-	-
Foraminiferans	2.0	-	-	2.5	4.5	-	2.3	-	-
Fish larvae		-	-	2.0	-	-	1.2	15.0	-

Table 3 (contd...4)

Food items	May 1983			June 1983			July 1983		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	-	-	-	-	-	-
Bivalves	-	8.0	-	-	-	-	-	-	-
Cephalopods	8.9	-	-	-	-	-	-	-	-
Turbellids	9.8	11.0	-	-	-	-	-	-	-
Glycerids	-	-	-	-	-	-	-	-	-
Other worms	29.2	40.6	-	-	-	-	-	-	-
Crabs	-	-	-	-	-	-	-	-	-
Prawns	20.4	25.4	-	-	-	-	-	-	-
Ostracodes	-	-	-	-	-	-	-	-	-
Mysids	3.2	-	-	-	-	-	-	-	-
Squilla	-	-	-	-	-	-	38.8	60.6	-
Copepods	10.4	11.4	-	-	-	-	-	-	-
Priacanthus sp.	8.8	-	-	-	-	-	48.6	-	-
Anchovilla sp.	-	-	-	-	-	-	-	-	-
Cynoglossus sp.	-	-	-	-	-	-	-	-	-
Other fishes	4.3	3.6	-	-	-	-	-	-	-
Fish eggs	-	-	-	-	-	-	12.6	39.4	-
Foraminiferans	3.1	-	-	-	-	-	-	-	-
Fish larvae	1.9	-	-	-	-	-	-	-	-

Table 4 - Percentage index of relative importance value of various food items of <u>Nemipterus mesoprion</u> during different months of the year 1983-84.

Food items	August 1983			September 1983			October 1983		
	M	F	J	M	F	J	M	F	J *
Gastropods	3.9	-	-	-	-	-	-	-	-
Bivalves	-	-	-	5.5	-	-	-	-	-
Cephalopods	-	-	-	-	1.6	-	-	-	-
Turbellids	-	-	-	9.5	8.0	-	12.6	-	-
Glycerids	3.1	-	-	-	1.0	-	-	-	-
Other worms	-	1.5	-	-	-	-	8.8	10.2	-
Crabs	-	4.2	-	-	3.2	-	3.6	-	-
Prawns	30.6	34.0	-	32.9	20.0	-	16.2	-	50.0
Ostracodes	-	1.6	-	-	1.6	-	4.8	5.5	-
Mysids	36.0	20.0	-	10.0	3.0	-	-	-	4.5
Squilla	-	15.6	-	-	8.1	-	17.0	30.0	-
Copepods	2.8	3.8	-		4.8	-	1.8	2.8	10.5
Priacanthus sp.	-	9.0	-	-	20.0	-	2.6	1.5	-
Anchovilla sp.	-	-	-	10.0	2.6	-	14.1	-	-
Cynoglossus sp.	10.2	-	-	10.0	10.0	-	17.0	30.0	-
Other fishes	13.3	10.3	-	7.0	10.0	-	-	20.0	5.0
Fish eggs	-	-	-	10.5	4.5	-	-	-	-
Foraminiferans		-	-	3.5	-	-	1.5	-	25.0
Fish larvae	0.2	-	-	1.5	1.2	-	-	-	5.0

M - Male
F - Female
J - Juvenile

Table 4 (contd...2)

Food items	November 1983			December 1983			January 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	1.1	-	-	2.0	-	-	-	-	-
Bivalves	-	-	-	-	5.5	-	-	-	-
Cephalopods	1.8	-	-	-	3.1	-	7.9	10.0	-
Turbellids	-	4.5	20.0	5.5	-	-	-	-	-
Glycerids	-	-	-	-	-	-	-	-	-
Other worms	-	10.6	40.0	10.0	-	10.5	10.0	30.0	30.0
Crabs	1.1	-	-	-	-	5.4	5.8	-	-
Prawns	20.0	15.5	25.0	25.0	42.9	40.0	30.0	50.0	50.0
Ostracodes	0.6	-	-	-	-	4.6	-	-	-
Mysids	-	-	-	-	-	-	-	-	-
Squilla	20.0	1.5	-	2.5	-	2.8	5.5	-	-
Copepods	8.0	15.5	5.0	32.0	15.0	10.0	10.0	10.0	10.0
Priacanthus sp.	10.0	16.0	-	-	-	7.3	4.8	-	-
Anchovilla sp.	-	0.5	-	-	-	-	-	-	-
Cynoglossus sp.	25.0	26.0	10.0	15.0	17.6	2.4	4.6	-	-
Other fishes	10.0	5.2	-	5.0	15.0	14.5	10.0	-	10.0
Fish eggs	2.4	-	-	-	-	1.0	4.6	-	-
Foraminiferans	-	1.8	-	-	0.9	2.3	6.8	-	-
Fish larvae	-	2.9	-	3.0	-	-	-	-	-

Table 4 (contd...3)

Food items	February 1984			March 1984			April 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	-	-	-	13.3	18.0	-	-	-	-
Bivalves	2.3	4.3	-	10.0	-	-	-	-	-
Cephalopods	10.7	-	-	-	2.3	-	24.4	10.5	-
Turbellids	20.5	45.4	50.0	10.2	1.3	-	-	-	-
Glycerids	17.5	10.7	-	25.7	20.0	-	-	-	-
Other worms	0.5	-	25.0	3.3	-	-	2.2	5.0	-
Crabs	-	-	-	-	-	-	1.5	-	-
Prawns	-	-	25.0	-	-	-	30.8	60.0	-
Ostracodes	5.8	-	-	-	-	-	-	4.8	-
Mysids	-	-	-	-	-	-	-	-	-
Squilla	2.5	8.2	-	-	-	-	26.5	8.2	-
Copepods	2.0	-	-	12.8	9.1	-	8.1	6.0	-
<u>Priacanthus</u> sp.	-	-	-	-	20.0	-	2.5	-	-
<u>Anchovilla</u> sp.	-	-	-	5.2	3.0	-	-	-	-
<u>Cynoglossus</u> sp.	-	-	-	10.5	20.0	-	-	-	-
Other fishes	37.0	22.5	-	9.0	2.5	-	-	-	-
Fish eggs	-	6.4	-	-	1.5	-	1.8	4.0	-
Foraminiferans	1.2	2.5	-	-	1.2	-	0.9	1.5	-
Fish larvae	-	-	-	-	1.1	-	1.3	-	-

Table 4 (contd...4)

Food items	May 1984			June 1984			July 1984		
	M	F	J	M	F	J	M	F	J
Gastropods	10.2	6.0	-	6.5	-	-	10.8	10.0	-
Bivalves	4.0	-	-	-	-	-	6.0	1.0	-
Cephalopods	6.0	-	-	22.0	18.0	-	-	12.0	-
Turbellids	10.0	32.0	-	-	-	-	4.6	1.8	-
Glycerids	10.0	14.0	-	-	-	-	-	-	-
Other worms	20.0	20.0	-	-	-	-	10.0	10.0	-
Crabs	-	-	-	2.4	3.2	-	2.2	1.2	-
Prawns	10.0	18.0	-	-	-	-	50.0	60.0	-
Ostracodes	5.2	-	-	1.6	1.3	-	-	-	-
Mysids	-	-	-	10.0	5.0	-	3.4	1.6	-
Squilla	10.8	-	-	24.2	16	-	10.0	1.2	-
Copepods	5.5	-	-	1.8	1.5	-	1.8	1.2	-
Priacanthus sp.	-	-	-	3.5	10.1	-	-	-	-
Anchovilla sp.	-	-	-	-	-	-	-	-	-
Cynoglossus sp.	-	-	-	10.0	-	-	-	-	-
Other fishes	2.0	10.0	-	14.0	26.0	-	1.2	-	-
Fish eggs	0.8	-	-	-	10.0	-	-	-	-
Foraminiferans	5.5	-	-	3.4	8.9	-	-	-	-
Fish larvae	-	-	-	0.6	-	-	-	-	-

Table 5 - Percentage index of relative importance value of various food items of <u>N. japonicus</u> in different stages of maturity during August 1982 - July 1984.

Food items	Immature		Maturing		Matured		Spent	
	M	F	M	F	M	F	M	F
Gastropods	0.2	3.0	-	-	0.3	0.3	-	-
Bivalves	0.1	4.0	-	-	1.1	-	-	1.0
Cephalopods	-	-	-	5.6	-	0.3	19.6	6.1
Polychaetes	40.0	36.8	1.0	3.4	-	-	31.4	36.8
Prawns	50.0	40.4	31.2	38.0	26.4	21.4	4.1	-
Crabs	4.0	2.5	5.4	3.2	12.4	3.4	1.2	0.8
Mysids	-	3.0	-	0.4	3.1	0.1	1.1	-
Squilla	4.8	10.3	28.4	21.2	14.1	18.0	-	16.8
Copepods	0.3	-	-	0.6	-	1.2	-	0.1
Fishes	-	-	30.4	27.6	40.2	54.1	28.9	31.2
Fish eggs	0.2	-	1.1	-	1.1	-	8.9	3.1
Foraminiferans	-	-	2.1	-	1.3	2.2	3.8	4.1
Fish larvae	0.4	-	0.4	-	-	-	1.0	-

M - Male
F - Female
J - Juvenile

Table 6 - Percentage index of relative importance value of various food items of *N. mesoprion* in different stages of maturity during August 1982 - July 1984.

Food items	Immature		Maturing		Matured		Spent	
	M	F	M	F	M	F	M	F *
Gastropods	-	1.1	-	0.2	-	0.2	1.1	-
Bivalves	1.2	1.3	0.9	0.2	-	-	2.1	-
Cephalopods	0.8	2.0	1.1	10.3	3.1	0.7	-	-
Polychaetes	51.8	40.0	8.0	1.4	1.6	-	42.8	40.6
Prawns	40.6	36.4	30.6	41.1	20.6	20.9	38.4	51.8
Crabs	-	1.6	8.6	4.9	18.6	7.0	0.6	1.1
Mysids	-	-	7.8	1.1	3.4	1.0	-	-
Squilla	1.8	9.0	30.4	38.6	1.8	16.1	4.0	1.8
Copepods	-	-	1.6	1.1	-	-	-	-
Fishes	3.4	6.3	10.1	0.8	46.1	48.0	-	1.0
Fish eggs	-	0.8	0.9	-	4.8	6.0	6.2	3.6
Foraminiferans	0.1	0.8	-	-	-	0.1	1.6	-
Fish larvae	0.3	0.7	-	0.3	-	-	3.2	0.1

Fig.1 Monthly percentage of feeding intensity in *N. japonicus* during August 1982 - July 1984.

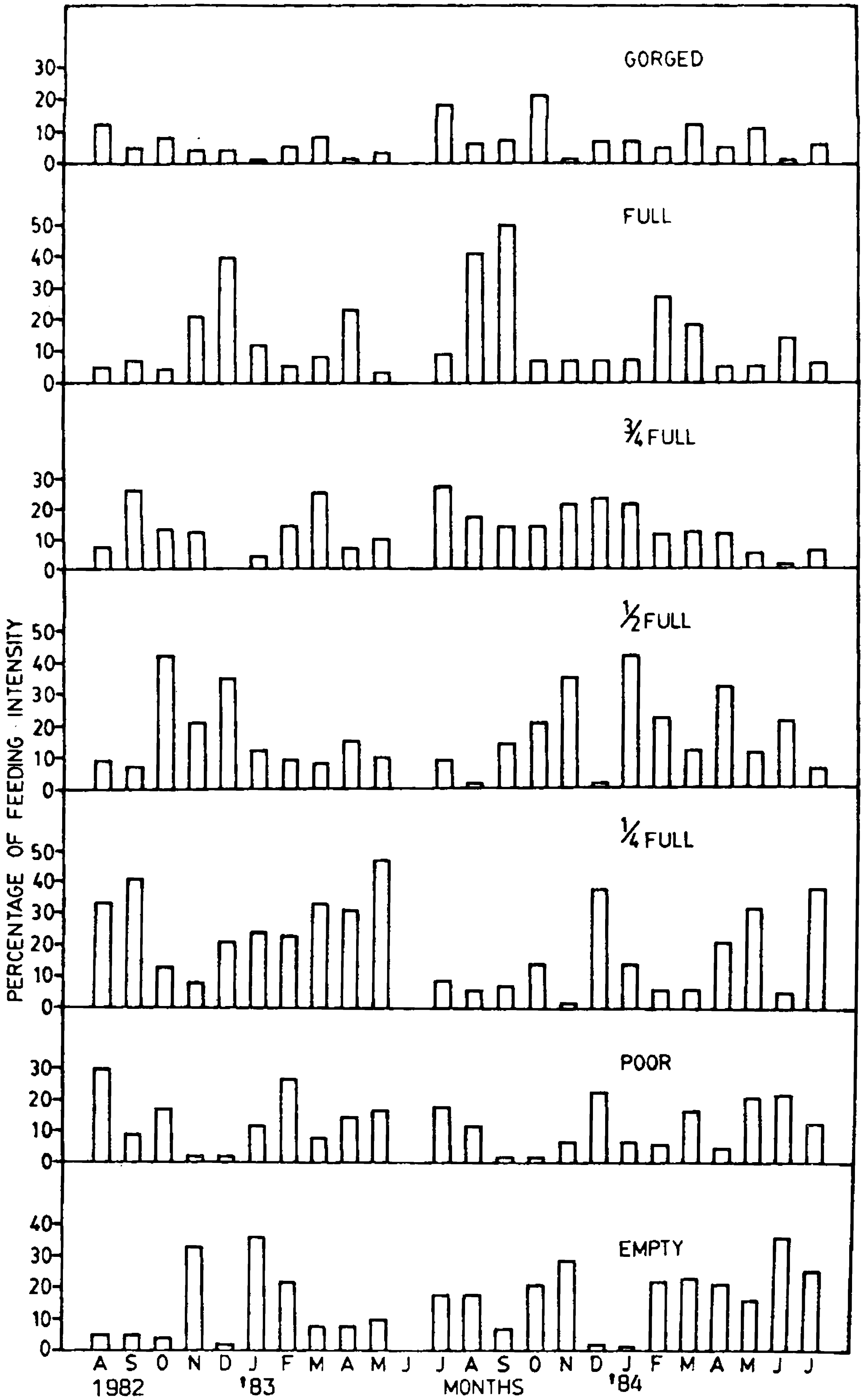
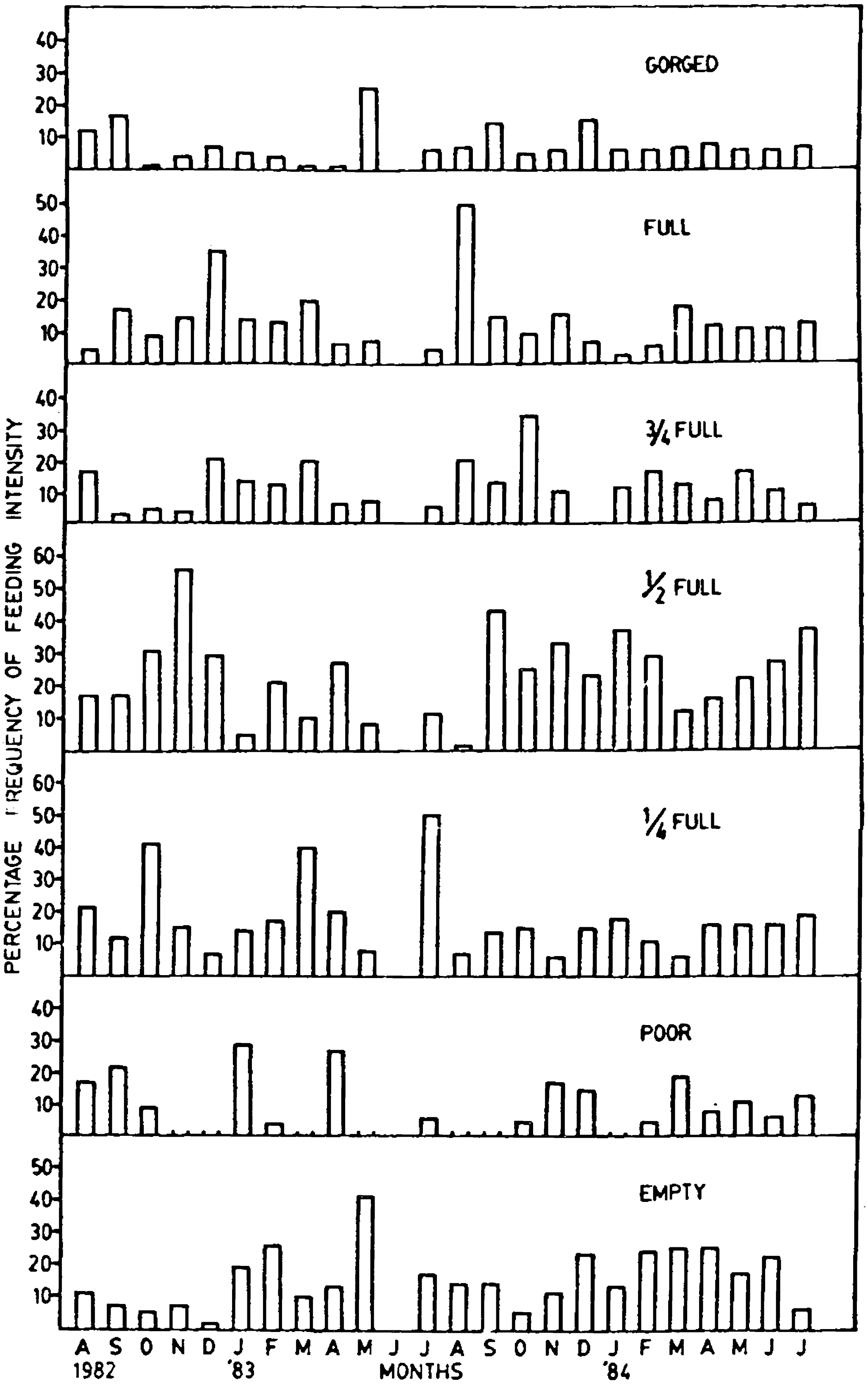

GORGED
FULL
¾ FULL
½ FULL
¼ FULL
POOR
EMPTY
PERCENTAGE OF FEEDING INTENSITY
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84

Fig.1

Fig. 2 Monthly percentage of feeding intensity in *N. mesoprion* during August 1982 - July 1984.



GORGED
FULL
3/4 FULL
1/2 FULL
1/4 FULL
POOR
EMPTY
PERCENTAGE FREQUENCY OF FEEDING INTENSITY
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84

Fig. 2

Fig. 3a Monthly values of gastro-somatic index in *N. japonicus* during August 1982 - July 1984.

Fig. 3b Monthly occurrence of empty stomach in *N. japonicus* during August 1982 - July 1984.

Fig. 4a Monthly values of gastro-somatic index in *N. mesoprion* during August 1982 - July 1984.

Fig. 4b Monthly occurrence of empty stomach in *N. mesoprion* during August 1982 - July 1984.

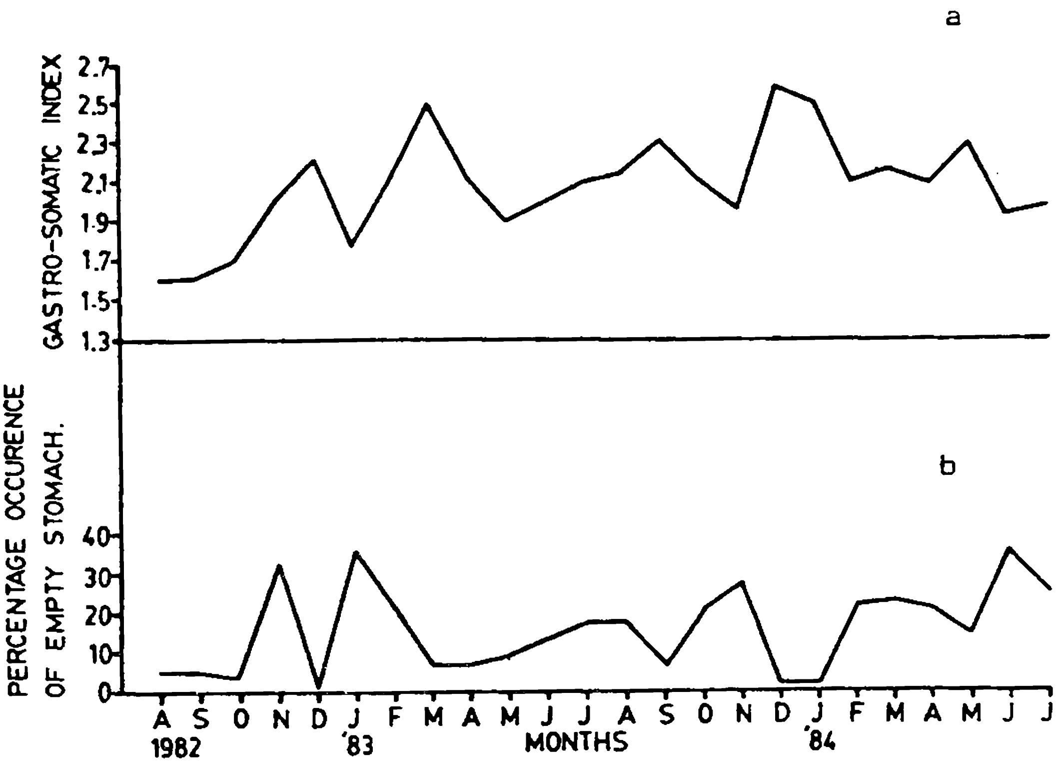

a
GASTRO-SOMATIC INDEX
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
PERCENTAGE OCCURENCE OF EMPTY STOMACH.
b
40
30
20
10
0
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84

Fig. 3

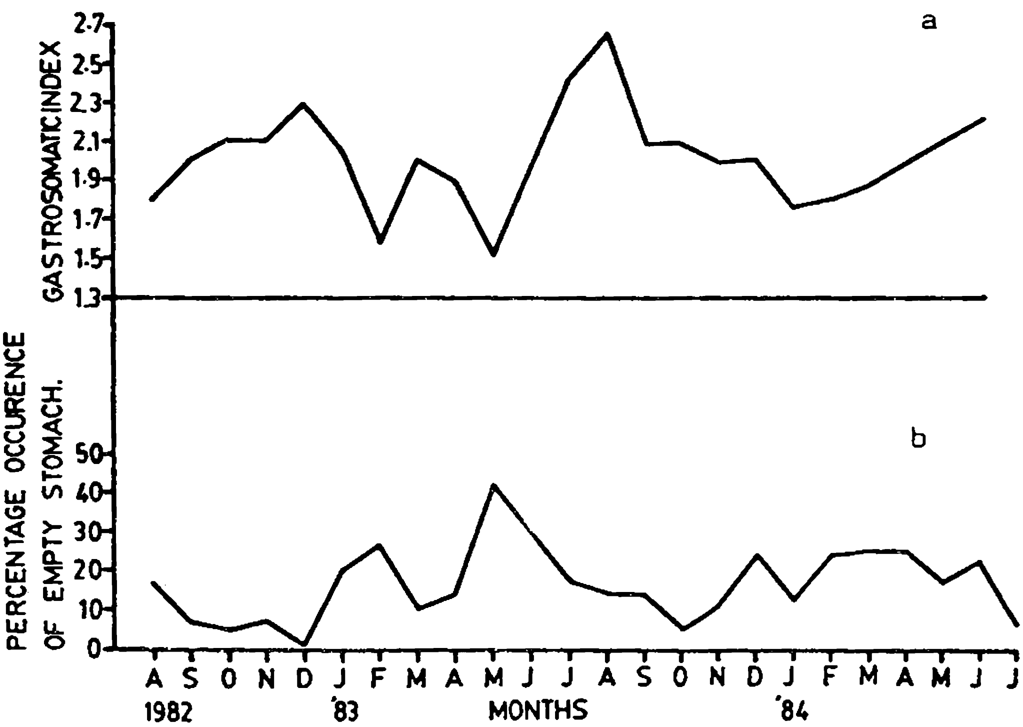

a
GASTROSOMATIC INDEX
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
PERCENTAGE OCCURENCE OF EMPTY STOMACH.
b
50
40
30
20
10
0
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84

Fig. 4

CHAPTER 4

AGE AND GROWTH

AGE AND GROWTH

4.1 INTRODUCTION

The exact age determination of fish is one of the most important factors in their population dynamics. It forms the basis for calculations leading to a knowledge of the growth, mortality, recruitment and other fundamental parameters of their population. Further, for a practical appraisal of fish stocks, it is imperative to establish a reliable method for assessing the age of individual components.

The age and growth of marine teleosts from Indian waters are mainly based on length frequency distribution or by the discontinuities occurred in their skeletal structures (scales, otolith, bones, etc). Qasim (1973), while critically reviewing the earlier works on age and growth by Indian workers, outlined the difficulties in determining the age in tropical fish. A more substantive view of the problem for age determination in tropical fish has been discussed by several authors including, De Bont (1967), Bagenal and Tesch (1978) and Weatherlay and Rogers (1978).

The methods for the age determination of fish are the length frequency distribution and the growth markings on hard parts which are seen in temperate species. The concepts and methodology used for temperate species are not applicable for tropical marine fish which live in a most stable environment and have continuous breeding habits. A few workers (Prabhu (1956), Radhakrishnan (1964), Pillay (1958), Balan (1959), Devaraj (1977), Manikyala Rao and Srinivasa Rao (1986)) have claimed that markings on hard parts can be used for age determination in some tropical fishes.

Investigations on the age and growth of the genus Nemipterus are relatively few in different waters when compared with other genera. Tshung and Druzhinin (1965) studied the age and growth rate of Nemipterus from Northern Vietnam Bay. Ben-Tuvia (1968) reported the size of N. japonicus at different ages from the South Red Sea along the Ethiopian Coast. Eggleston (1970 and 1971) determined the size of N. virgatus and N. bathybus at different ages from northern part of South China Sea. Isarankura (1968) studied the age and growth of N. hexadon and Sainsburg and Whitelaw (1985) have determined the age and growth of N. peronii from Australian waters.

Krishnamoorthi (1971) and Manikyala Rao and Srinivasa Rao (1986) from Andhra-Orissa coast and Krishnaveni (1986) from Portonovo coast studied the age and growth of N. japonicus by applying length frequency distribution. Murthy (1981) studied the age and growth of N. mesoprion from Kakinda coast. No previous attempt has been made to study the age and growth of N. japonicus and N. mesoprion from Cochin waters.

4.2 MATERIALS AND METHODS

Specimens of *N. japonicus* and *N. mesoprion* were collected for the present study from Integrated Fisheries Project for a period of two years (August 1982 to July 1984). A total of 2500 specimens of *N. japonicus* and 2400 specimens of *N. mesoprion* were used for the present study. Standard length from the tip of the mouth to the origin of the caudal fin was measured to the nearest mm and both the sexes were considered separately.

The data were grouped as 10 mm class intervals for each month and since monthly samples were not sufficient enough to trace the growth curve by the computer, data for 3 months were pooled together and the frequency for each class interval was tabulated. The length frequency data were then converted into percentages and histograms were drawn.

Elephan programme (Pauly and David 1981) with correction (Pauly, 1985; Thiam, 1986) was used to estimate the growth parameters. The Elephan 1 method consists of three main steps.

1. The length frequency data are restructured through a series of steps in order to help identification of peaks and trough; which are given by positive and negative points respectively.

2. The programme considers a large number of alternative runs for different values of growth parameter. The best growth curve is that which passes through the maximum number of peaks giving the highest (optimum) number of points.

3. The results obtained as ratio of ESP/ASP (ESP is Explained Sum of Peaks and ASP is Available Sum of Peaks) for different runs are compared and the best set of growth parameters, L_∞ and K of the Von Bertalanffy Growth Formula (VBGF), are adopted.

The VBGF describes the average growth of the sampled population. The VBGF is of the form

$$Lt = L_\infty (1-e^{-k(t-t_o)})$$

where L_∞ and k are asymptotic length and growth constant respectively (t_o is not determined by Elephan 1 and is assumed to be zero, while computing the growth curve).

4.3 RESULTS

4.3 a) Nemipterus japonicus - Male

The length frequency study is based on the analysis of 1300 male N. japonicus and the size varied from 40 mm to 220 mm (SL) and grouped at a class interval of 10 mm. The selected growth parameters are L_∞ = 28.0 cm and K = 1.14 ($year^{-1}$) obtained for the highest ESP/ASP value from the table 7a.

4.3 b) Nemipterus japonicus - Female

About 1200 specimens of N. japonicus (the size varied from 40 mm and 220 mm (SL) and grouped at a class interval of 10 mm) were taken for the length frequency analysis. The selected growth parameters are L_∞ = 27.0 and K = 1.1 ($year^{-1}$) obtained for the highest ESP/ASP value from table 7b.

4.3 c) *Nemipterus mesoprion* - Male

In *N. mesoprion*, 1225 numbers of males ranging from 40 mm to 210 mm size were classified into different size groups with a class interval of 10 mm and the percentage of length frequency were calculated. The selected growth parameters are L_∞= 26.5 cm and K = 0.6 ($year^{-1}$) obtained for the highest ESP/ASP value from the table 8a.

4.3 d) *Nemipterus mesoprion* - Female

In *N. mesoprion* the length frequency study is based on 1275 numbers of specimens, the size varied from 40 mm to 210 mm (SL) and grouped at a class interval of 10 mm. The selected growth parameters are L_∞= 25.5 cm and K = 0.55 ($year^{-1}$) obtained for the highest ESP/ASP from the table 8b.

4.4 DISCUSSION

The computer based method provided in Elephan 1 gave the same best estimates of L_∞= 28.0 cm and K = 1.14 ($year^{-1}$) for *N. japonicus* males and L_∞= 27.0 cm and K = 1.1 ($year^{-1}$) for *N. japonicus* female. For *N. mesoprion* male the L_∞ obtained as 26.5 and K as 0.6 ($year^{-1}$) and for *N. mesoprion* female the L_∞ and K values are 25.5 cm and 0.55 ($year^{-1}$) respectively.

Since age determination is difficult in tropical fishes 't_0' is not estimated in studying the population dynamics of fishes and shell fishes of this region (Venema et al., 1988) and t_0 is set as zero for computation purpose. Substituting the values of these parameters, the growth equation for two species can be as follows:-

N. japonicus (male) $L_t = 28.0 \, (1 - e^{-0.092 \, (t-0)})$

N. japonicus (female) $L_t = 27.0 \, (1 - e^{-0.092 \, (t-0)})$

N. mesoprion (male) $L_t = 26.5 \, (1 - e^{-0.050 \, (t-0)})$

N. mesoprion (female) $L_t = 25.5 \, (1 - e^{-0.045 \, (t-0)})$

Based on the VBG function expressed as total length in cm and K $year^{-1}$ and the base of logaritham ($\log_{10}$) as 10, the quantity, θ can be calculated (Pauly and Munro, 1984).

$$\theta = \log K + 2 \log L$$

The θ enables comparison of growth parameter estimates of one stock with that of another and their compatibility can be assessed. It is also possible to estimate K indirectly for a specific stock of given species from the mean value of θ estimated from other stocks of the same species used in conjunction with an estimate of L_∞ obtained through the method of Weatherall (1986) and is an index of growth performance. The value of θ calculated as,

N. japonicus (male) θ $= \log 1.14 + 2 \log_{10} 28$

$= 0.05 = 2.89 = 2.94$

N. japonicus (female) $\theta = \log 1.1 + 2 \log_{10} 27$

$= 0.04 + 2.86 = 2.9$

N. mesoprion (male) $\theta = \log 0.6 + 2 \log_{10} 26.5$

$= -0.22 + 2.84 = 2.62$

N. mesoprion (female) $\theta = \log 0.55 + 2 \log_{10} 25.5$

$= -0.26 + 2.81 = 2.55$

Eggleston (1972) has observed L_∞ and K values of N. japonicus from Hong Kong waters as 34.1 cm (T.L) and 0.19 ($year^{-1}$) respectively. Krishnamoorthi (1971) from Andhra-Orissa coast calculated the L_∞ value of N. japonicus as 30.5 cm (T.L) and K = 0.314 ($year^{-1}$), whereas Manikyala Rao and Srinivasa Rao (1986) from the same coast observed the L_∞ of N. japonicus as 21.96 cm (S.L) and K = 0.6264 ($year^{-1}$). Krishnaveni (1986) estimated the L_∞ as 44.8 cm (T.L) and K = 0.23 for N. japonicus from Portonovo waters. Murthy (1981) estimated the L_∞ and K value of N. mesoprion from Kakinada coast as 21.9 cm and 0.832 ($year^{-1}$) respectively. The change in the L_∞ and K values may be due to racial difference of the species from different waters.

The lengths at different ages calculated from the Von Bertalanffy Growth Equation are plotted in figures (5 and 6) which indicate that observed and calculated lengths at different ages agree closely. Both N. japonicus and N. mesoprion are fast growing fishes and it is obvious that the Nemipterid fishery of Cochin is supported by the late '0' year and one year age group.

Table 7a (ESP/ASP) 1000 N. *japonicus* male

L/k	1.1	1.12	1.14	1.16
27	469	690	640	592
27.5	537	499	464	763
28	782	694	882	834
28.5	555	628	589	589

Highest ESP/ASP - Value in this run 882 for K =1.14 and L_{∞} = 28.

Table 7b (ESP/ASP) 1000 N. *japonicus* female

L/k	1.1	1.12	1.14	1.16
27	876	424	443	367
27.5	675	664	552	601
28	638	656	876	790
28.5	812	639	652	443

Highest ESP/ASP - Value in this run 876 for K = 1.1 and L_{∞} = 27.

Table 8a (ESP/ASP) 1000 *N. mesoprion* male

L/k	0.6	0.62	0.64	0.66
26	493	511	511	511
26.5	511	428	428	352
27	441	369	288	288

Highest ESP/ASP - Value in the table = 511 obtained for K = 0.6 and L_{∞} = 26.5

Table 8b (ESP/ASP) 1000 *N. mesoprion* female

L/k	0.55	0.60	0.65	0.70
25	384	540	413	524
25.5	683	352	536	510
26	493	649	570	488
26.5	314	314	276	369

Highest ESP/ASP - Value in the table 683 obtained for K = 0.55 and L_{∞} = 25.5

Fig. 5 a) Von-Bertalanffy growth curve for *N. japonicus* male.

Fig. 5 b) Von-Bertalanffy growth curve for *N. japonicus* female.

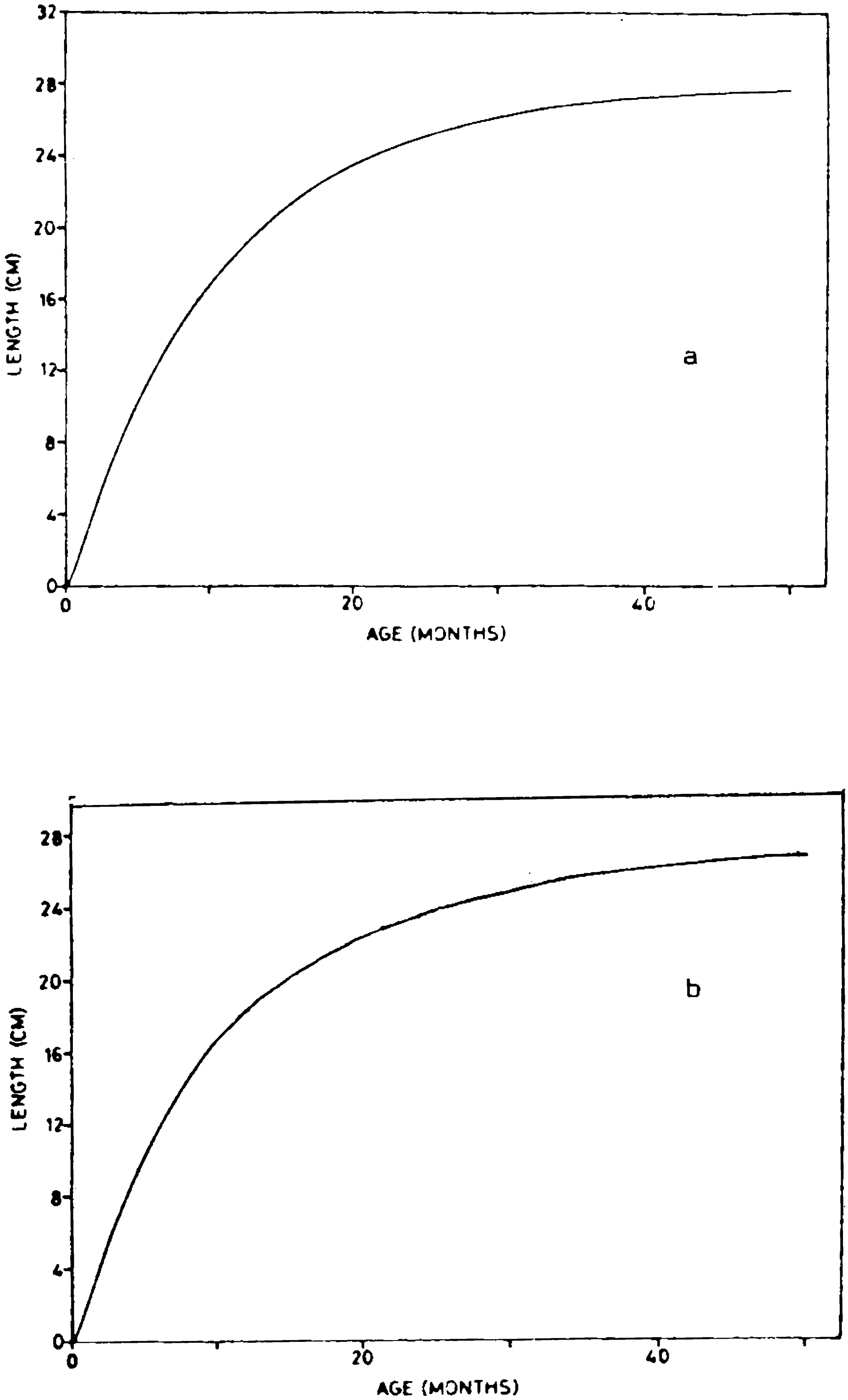
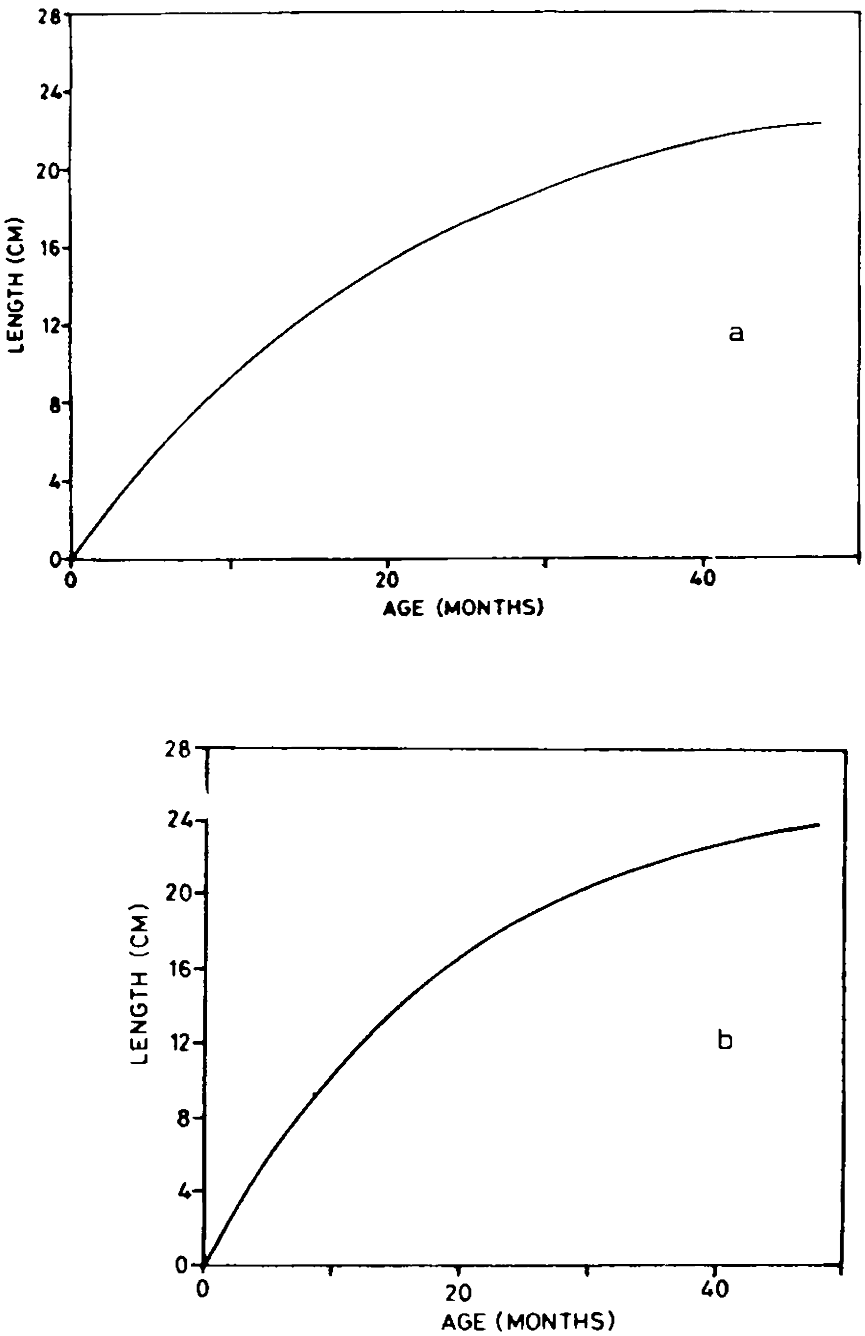

32
28
24
20
16
12
8
4
0
LENGTH (CM)
a
0
20
40
AGE (MONTHS)
28
24
20
16
12
8
4
0
LENGTH (CM)
b
0
20
40
AGE (MONTHS)

Fig. 5

Fig. 6 a) Von-Bertalanffy growth curve for *N. mesoprion* male.

Fig. 6 b) Von-Bertalanffy growth curve for *N. mesoprion* female.



28
24
20
16
12
8
4
0
LENGTH (CM)
0
20
40
AGE (MONTHS)
a
28
24
20
16
12
8
4
0
LENGTH (CM)
0
20
40
AGE (MONTHS)
b

Fig. 6

CHAPTER 5

LENGTH-WEIGHT RELATIONSHIP

LENGTH-WEIGHT RELATIONSHIP

5.1 INTRODUCTION

The relationship between length and weight of fishes is important in the study of fish biology. Mathematical expression between length and weight is used in a situation where either one is unknown. It also helps to measure variation between the expected and observed weight for length of individual fish as indication of fatness, general well being, gonadal development, rate of feeding, degree of parasitization, etc. (LeCren, 1951). Length-weight relationship can also be used to indicate some important events in the life history of fishes such as metamorphosis, maturity and condition (Hoda, 1976).

The length-weight relationship of most fishes can be described by the exponential function.

$$W = aL^{b}$$

where W = Weight, L = Length, a is a constant and b is an exponent lying between 2.5 and 4.0 (Hile, 1936). For an ideal fish maintaining the shape throughout without any change, the value of 'b' is equal to 3.0 (Allen, 1938). Beverton and Holt (1957) reported that the significant variations from isometric growth (b = 3) in fishes are rare.

Since linear transformation is necessary to deal with length as plotted against the log of weight, this equation could be rewritten in terms of logarithmic transformation.

$$\text{Log } W = \log (aL^b) \text{ i.e.}$$

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

where log 'a' represents the point at which the regression line intercepts the log W axis and 'b' represents the slope of the line. This equation can again be rewritten as

$$Y = A + BX$$

where $A = \log a$, $B = b$; $Y = \log W$ and $X = \log L$

The study of length-weight relationship of *Nemipterus* spp. was carried out by Eggleston (1970) from South China Sea; from Malaysia waters by Senta & Tan (1975); from Pakistan coast by Hoda (1976) and in India, from Andhra-Orissa coast by Krishnamoorthi (1971) and Murthy (1981); from Madras coast by Vivekanandan and James (1988); from Portonovo coast by Krishnaveni (1986) and from Cochin coast by Vince and Nair (1974).

Presently the length-weight relationships have been calculated separately for male, female and juvenile *N. japonicus* and *N. mesoprion* by fitting geometrical mean regression lines using the method of least squares for log length and log weight.

5.2 MATERIALS AND METHODS

Random samples were collected from the fish landings of Integrated Fisheries Project and Fisheries Harbour, Cochin every month. The total length of each fish (from the tip of the snout to the end of lower caudal fin ray) was recorded to the nearest mm, and weighed to the nearest mg. Fishes were separated into three categories as males, females and juveniles. Data on 800 specimens of Nemipterus japonicus (412 males, 300 females and 88 juveniles) and 742 specimens of Nemipterus mesoprion (394 males, 248 females and 100 juveniles) were utilized for the present study.

5.3 RESULTS

The regression equations for the length-weight relationship of male, female and juvenile N. japonicus and N. mesoprion were calculated and provided here.

N. japonicus

for male $W = 0.00004175\ L^{2.7831}$

for female $W = 0.00002299\ L^{2.9881}$

for juvenile $W = 0.00001028\ L^{3.0812}$

N. mesoprion

for male $W = 0.00003606\ L^{2.7983}$

for female $W = 0.00002299\ L^{2.8873}$

for juvenile $W = 0.00002713\ L^{3.3489}$

The logarithmic equations for male, female and juvenile *N. japonicus* and *N. mesoprion* were found as follows:

N. japonicus

for male Log W = -4.3794 + 2.7831 log L

for female Log W = -4.8315 + 2.9881 log L

for juvenile Log W = -4.9882 + 3.0812 log L

N. mesoprion

for male Log W = -4.443 + 2.7983 log L

for female Log W = -4.6385 + 2.8873 log L

for juvenile Log W = -5.5665 + 3.3489 log L

In both the species, the exponent values for male and female were less than three indicating that per unit increase in length of fish, the weight increased by less than three times. However in juvenile, it was more than three times.

The regression slopes of male, female and juvenile of the two species were subjected to analysis of covariance (Snedecor and Cochran, 1967) and the results are presented in table 9 to 16. While comparing the regression equation of male, female and juvenile *N. japonicus*, significant differences were observed. Similarly comparison of male with female, male with juvenile and female with juvenile showed significant differences.

In *N. mesoprion* significant differences were obtained on comparing the regression equations of male, female and juvenile, i.e. male with juvenile and female with juvenile. But with regard to male with female it was insignificant. Hence the data of males and females were pooled and a single equation was calculated for the mature specimens of this species from Cochin waters.

$$\text{Log } W = -4.5641 + 2.8163 \log L$$

$$W = -0.00003001 L^{2.8163}$$

The regression lines for male, female and juvenile are presented in figs. 7a and b.

The significance of the variation in the estimate of 'B' for *N. japonicus* and *N. mesoprion* from the expected value (3.0 for ideal fish) was tested by applying the 't' test by using the formula.

$$t = \frac{b - B}{sb}$$

and the calculated values for t

for *N. japonicus*

Male	=	-4.7775
Female	=	-0.5486
juvenile	=	-0.0917

for N. mesoprion

Male	=	-6.1121
Female	=	-3.8729
Juvenile	=	4.8729

and were found to be insignificant at 5% level. Hence the cubic formula $W = aL^3$ could be used to represent the length-weight relationship of both the species.

5.4 DISCUSSION

In the juveniles of both N. japonicus and N. mesoprion, the exponent value was found to be around 3, indicating that the weight increased corresponding to its length. However, significant differences could be found while comparing the regression coefficients of male and female N. japonicus and so separate equations were computed to describe the length-weight relationship of male and female. Krishnamoorthi (1971) tested the significance of difference between the 'b' values of male and female N. japonicus from Andhra-Orissa coast and observed highly significant differences at 5% level. Similarly Murthy (1984) from Kakinada Coast and Krishnaveni (1986) from Portonovo while studying the length-weight relationship of N. japonicus observed significant differences between male, female and juvenile, whereas Vinci and Nair (1974) and Hoda (1976) have tested the differences statistically and found no significance and obtained a general relationship. Thus the present results are in confirmity with the results of Krishnamoorthi (1971), Murthy (1984) and Krishnaveni (1986) but differs from Vinci and Nair (1974) and Hoda (1976).

No significant difference is statistically evident in the regression coefficient values of male and female N. mesoprion and hence a single equation is computed to explain the length-weight relationship of this species. Similarly, Murthy (1981) also observed insignificant differences between the 'b' values of male and female N. mesoprion from Kakinada coast. However, Vivekanandan and James (1988) have observed significant differences in the regression coefficients of male and female N. mesoprion collected from Madras coast.

Table 9 - Sum of squares and products of length-weight data for male and female *Nemipterus japonicus*.

Group	n	ΣX	Σy	Σx^2	Σy^2	Σxy
Male	412	907.90	716.56	2004.76	1281.1824	1590.3802
Female	300	662.38	529.78	1465.0422	958.684	1177.3424

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from the regression for male and female *Nemipterus japonicus*

Group	d.f.	Sum of squares and products			b	Deviation from Regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	411	4.0745	11.3393	34.9246	2.7831	410	3.3636	0.000820
Female	299	2.5513	7.6234	23.1252	2.9881	298	0.3461	0.001161
	Deviation from individual regression					708	3.7097	0.001981
Pooled	710	6.6258	18.9634	58.0498	2.8621	709	3.7755	0.00532
	Difference between regression					1	0.0658	0.0658

Comparison of regression (observed F) = 0.0658/.001981
= 33.2155 (Significant)

d.f. = degrees of freedom

b = Coefficient of allometry or regression.

S.S. = Sum of squares

M.S. = Mean square

x^2, xy, y^2 = Corrected sum of squares and products

Table 10 - Sum of squares and products of length-weight data for juvenile, male and female *Nemipterus japonicus*.

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Male	412	907.90	716.56	2004.76	1281.1824	1590.3802
Female	300	662.38	529.78	1465.0422	958.684	1177.3424
Juvenile	88	164.44	67.68	307.7572	56.9128	127.944

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from the regression for *Nemipterus japonicus* male, female and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	411	4.0745	11.3393	34.9246	2.7831	410	3.3636	0.000820
Female	299	2.5513	7.6234	23.1252	2.9881	298	0.3461	0.001161
Juvenile	87	0.4786	1.4747	4.8607	3.0812	86	0.3167	0.003686
	Deviation from individual regression					794	4.0264	0.005664
Pooled	797	7.1044	20.4374	62.9105	2.8767	796	4.1177	0.005173
	Difference between regression					2	0.0913	0.04565

Comparison of regression (observed F) = 0.0465/0.005664
= 8.05967 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 11 - Sum of squares and products of length-weight data for male and juvenile *Nemipterus japonicus*.

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Male	412	907.90	716.56	2004.76	1281.1829	1590.3802
Juvenile	88	164.44	67.88	307.7572	56.9128	127.9444

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from the regression for *Nemipterus japonicus* male and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	411	4.0745	11.3393	34.9246	2.7831	410	3.3636	0.00082
Juvenile	87	0.4786	1.4747	4.8607	3.0817	86	0.3167	0.00368
	Deviation from individual regression					496	3.6803	0.0045
Pooled	498	4.5531	12.814	39.7853	2.8143	497	3.7223	0.007489
	Difference between regression					1	0.042	0.042

Comparison of regression (observed F) = 0.042/.0045
= 9.33 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 12 - Sum of squares and products of length-weight data of juvenile and female *Nemipterus japonicus*

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Female	300	662.38	529.78	1465.0422	958.684	1177.3424
Juvenile	88	164.44	67.68	307.7572	56.9128	127.944

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from the regression for *Nemipterus japonicus* female and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Female	299	2.5513	7.6234	23.1252	2.9881	298	0.3461	0.001161
Juvenile	87	0.4786	1.4747	4.8707	3.0812	86	0.3167	0.003683
	Deviation from individual regression					384	0.6628	0.001726
Pooled	386	3.0299	9.0981	27.9959	3.0028	385	0.6763	0.001757
	Difference between regression					1	0.0135	0.0135

Comparison of regression (observed F) = 0.0135/0.001726
= 7.8215 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 13 - Sum of squares and products of length-weight data of Nemipterus mesoprion male and female.

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Male	394	858.48	651.88	1874.3856	1110.4164	1431.1661
Female	248	535.42	395.54	1157.2222	641.7688	857.6368

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from regression for Nemipterus mesoprion male and female.

Group	d.f.	Sum of squares and products			b	Deviation of regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	393	3.8579	10.7957	31.8691	2.7983	392	1.6591	0.0042
Female	247	1.2763	3.6851	10.9094	2.8873	246	0.2693	0.0011
	Deviation from individual regression					638	1.9284	0.003
Pooled	640	3.1342	14.4808	42.7785	2.8205	639	1.9360	0.003
	Difference between regression					1	0.0076	0.0076

Comparison of regression (observed F) = 0.0076/0.003
= 2.5333 (Not significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 14 - Sum of squares and products of length-weight data of <u>Nemipterus mesoprion</u> male, female and juvenile .

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Male	394	858.48	651.88	1874.3856	1110.4164	1431.1661
Female	248	535.42	395.54	1157.2222	641.7688	857.6368
Juvenile	100	188.36	74.16	355.0772	58.308	140.6332

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from regression for <u>Nemipterus mesoprion</u> male, female and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	393	3.8579	10.7959	31.8691	2.7983	392	1.6591	0.0042
Female	247	1.2763	3.6851	10.9094	2.8873	246	0.2693	0.0011
Juvenile	99	0.2823	0.9454	3.3109	3.3489	98	0.1448	0.0015
	Deviation from individual regression					736	2.0732	0.0028
Pooled	739	5.4165	15.4262	46.0894	2.8480	2	0.0824	0.0412

Comparison of regression = 0.0412/0.0015
(Observed F) = 27.4667 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 15 - Sum of squares and products of length-weight data of *Nemipterus mesoprion* male and juvenile.

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Male	394	858.48	651.88	1874.3856	1110.4164	1431.1661
Juvenile	100	188.36	74.16	355.0772	58.308	140.6442

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from regression for *Nemipterus mesoprion* male and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Male	393	3.8579	10.7957	31.8691	2.7983	392	1.6591	0.0042
Juvenile	99	0.2823	0.9454	3.3109	3.3489	98	0.1448	0.0015
	Deviation from individual regression					490	1.8039	0.0037
Pooled	492	4.1402	11.7411	35.1800	2.8359	491	1.8837	0.0038
	Difference between regression					1	0.0798	0.0798

Comparison of regression (observed F) = 0.0798/0.0038
= 21.0 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Table 16 - Sum of squares and products of length-weight data of Nemipterus mesoprion female and juvenile.

Group	n	Σx	Σy	Σx^2	Σy^2	Σxy
Female	248	535.42	395.54	1157.2222	641.7688	857.6368
Juvenile	100	188.36	74.16	355.0777	58.308	140.6332

Corrected sum of squares and products of length-weight data, coefficient of allometry and deviation from regression for Nemipterus mesoprion female and juvenile.

Group	d.f.	Sum of squares and products			b	Deviation from regression		
		x^2	xy	y^2		d.f.	S.S.	M.S.
Female	247	1.2763	3.6851	10.9094	2.8873	246	0.2693	0.0011
Juvenile	99	0.2823	0.9454	3.3109	3.3489	98	0.1448	0.0015
	Deviation from individual regression					344	0.4141	0.0012
Pooled	346	1.5586	4.6305	14.2203	2.9709	345	0.4634	0.4634
	Difference between regression					1	0.0493	0.0493

Comparison of regression (observed F) = 0.0493/0.0012
= 41.0833 (Significant)

x^2, xy, y^2 = corrected sum of squares and products

d.f. = degrees of freedom

b = coefficient allometry or regression

S.S. = Sum of squares

M.S. = Mean squares

Fig. 7 a) Logarithmic relationship between length and weight of *N. mesoprion*.

Fig. 7 b) Logarithmic relationship between length and weight of *N. japonicus*.

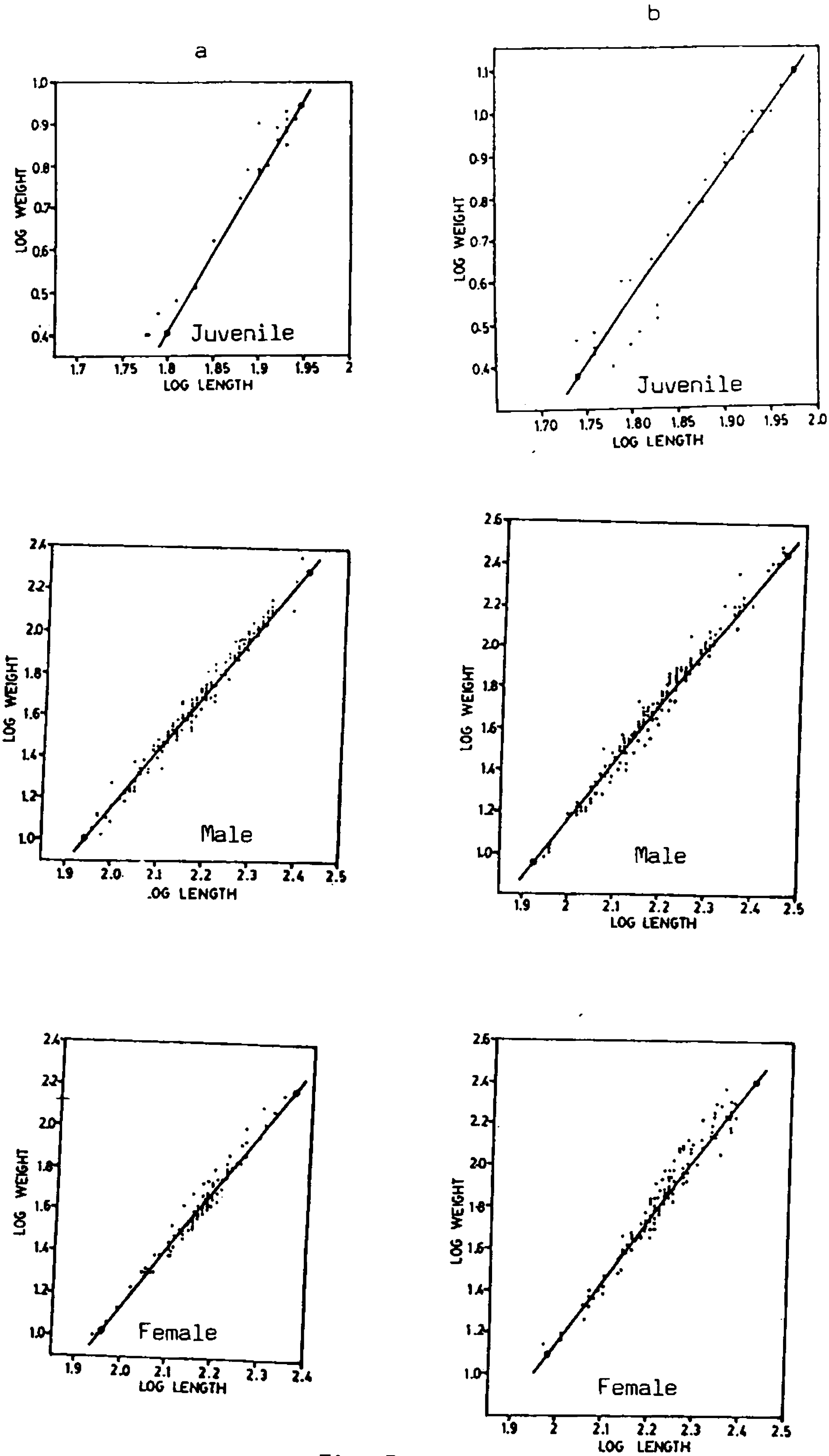


Fig. 7

CHAPTER 6

MATURATION AND SPAWNING

MATURATION AND SPAWNING

6.1 INTRODUCTION

Studies on the reproductive behaviour of a fish stock is quite useful for the proper management and exploitation of its fishery. An initial approach could be to elaborate the sequence of changes from the maturation of the gonad to the final release of the gametes. An understanding of the age and size at which the fish attains sexual maturity, the time and duration of spawning and the rate of regeneration of stocks are also important for the judicious management of the fishery resources at an optimum level. Information on sex ratio and the reproductive capacity of the stock, calculated from fecundity estimation coupled with the size and age at first maturity, are helpful to assess the age at which the fish are to be caught, since many species of fish are easily trapped during spawning congregation.

Information is available on maturation and spawning of *N. japonicus* from Mangalore (Kuthalingam, 1965), Andhra-Orissa (Krishnamoorthi, 1971 and Dan, 1977), Kakinada (Murthy, 1984), Portonovo (Krishnaveni, 1986) and South China Sea (Eggleston, 1972) and on *N. mesoprion* from Kakinada (Murthy, 1981). But not much is known about the maturation and spawning of these species from Cochin waters. So a detailed investigation was undertaken on *N. japonicus* and *N. mesoprion* from Cochin waters.

6.2 MATERIALS AND METHODS

Samples were obtained at fortnightly intervals from the catches of trawlers operated at Cochin coast for a period of two years (August, 1982 to July, 1984). The samples were brought to the laboratory, cleaned and surface moisture was removed by blotting. The total length of the fish was measured to the nearest mm and each sample was weighed to the accuracy of 0.1 gm. The sex, condition, colour and shape of the gonads were recorded. The maturity stages were classified based on the International Council for the Exploration of the Sea (ICES) scale (Lovern and Wood, 1937) with modifications. The ovaries were preserved in modified Gilson's fluid (Bagenal and Brawn, 1971) for the measurement of ova diameter and fecundity studies. Ova diameter study was carried out following the method by Clark (1934), Hickling and Rutenberg (1936), Prabhu (1956) and Marichamy (1970). The ova diameter was taken using the ocular micrometer. Samples of ova from anterior, middle and posterior regions of both the lobes of ovary were examined. Pooled ova samples were taken from ovaries of various maturity stages irrespective of the region.

The methods described by June (1953) and Yuen (1955) are used to calculate the gonado-somatic index (GSI), using the formula

$$GSI = \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100.$$

Male and female fishes were considered separately to calculate the index values from which monthly mean index values were derived.

The condition factor 'K' was calculated using the formula

$$K = \frac{W \times 10^5}{L^3}.$$

The sex ratio was calculated using the chi'square formula

$$x^2 = \frac{\Sigma (O - E)^2}{E},$$

to test the significance of difference in numbers between males and females.

6.3 CLASSIFICATION OF MATURITY STAGES

The classification of maturity stages is aimed to study the spawning period and the age at sexual maturity. The International Council for the Exploration of the Sea (ICES) scale (Lovern and Wood, 1937) was modified and employed to recognize the different stages of the gonads. In N. japonicus and N. mesoprion the ovaries were categorized into 7 stages and testes into 5 stages employing the usual features of the gonads in both the sexes.

a) Female:

Stage i - Immature: Ovary small and translucent, pinkish, covered with delicate membrane (yellow in N. japonicus, red in N. mesoprion), under microscope ova appeared small, transparent, yolkless and not easily separable.

Stage ii - Early maturing: Ovary translucent, pinkish, occupying 1/4 of the body cavity. Under magnification ova appeared round and transparent with prominent nuclei in the centre.

<u>Stage iii - Late maturing</u>: Ovary pinkish, subcylindrical, occupying 1/3 of the body cavity and blood cappillaries seen on the ovary. Under magnification ova appear golden yellow, but opaque with yolk granules around nucleus.

<u>Stage iv - Early matured</u> : Ovary dark yellow, occupying half the length of body cavity. Ovaries translucent with prominent blood cappillaries imparted in whole ovary.

<u>Stage v - Late matured</u> : Ovary orange in colour, occupying 2/3 of the body cavity. Ova large, spherical and translucent. Presence of an oil globule in the centre of ovum clearly visible.

<u>Stage vi - Ripe spawning</u>: Ovary reddish,occupying the entire body cavity. Ova extruded on slight pressure, transparent with oil globules under microscope.

<u>Stage vii - spent</u>: Ovary reddish, shrunken and flacid, occupying less than 1/2 the length of the body cavity. Few mature ova persist with maturing and immature eggs.

b) <u>Male</u>:

<u>Stage i - Immature</u>: Testes yellow, thread like and opaque.

<u>Stage ii - Maturing</u>: Testes orange, increased in size and translucent.

<u>Stage iii - Matured</u>: Testes pale yellow, subcyclindrical and increased in size, with clear margins, milt oozes out on pressure.

Stage iv - Spent: Testes dirty white, shrunken and translucent at its edges, no milt oozes on pressure.

6.4 RESULTS

6.4.1 Development of ova to maturity and frequency of spawning

Development of ova upto maturity was studied by recording the ova diameter from ovaries of all stages using an ocular micrometer. Each micrometer division (m.d) was equal to 0.014 mm. For the calculation of percentage frequencies, the size of the ova selected were above 3 m.d. The diameter frequencies have been categorized into groups of 3 micrometer division each and plotted as shown in fig. 9c and d.

In N. japonicus two distinct categories of oocytes were observed during most of its maturity stages. During stage I majority of the ova ranged between 4.6 micro division (0.056 - 0.084 mm). Few larger ova measuring 13-15 m.d. (0.182 - 0.210 mm) were also recorded. In stage II, apart from the immature stock, a stock of ova measuring 10-12 m.d. (0.14 - 0.168 mm) was also observed. After stage II the development of these ova were found to be rapid. The mode which made its appearance in stage II, 10-12 m.d. (0.14 - 0.168 mm), was shifted to 16-18 m.d. (0.224 - 0.252 mm) forming about 60% of the total number of ova and the rest measured 13-15 m.d. (0.182 - 0.210 mm) in stage III. At stage IV the maturing group increased further in its size with the mode at 22-24 m.d. (0.308 - 0.336 mm) and was seen separated from the immature stock. In stage V the ova were mature and measured 28-30 m.d. (0.392-0.420) and the immature stock measured 13-15 m.d. (0.182 - 0.194 mm). In stage VI ova were in fully mature condition with oil globules and measured 31-33 m.d. (0.434 - 0.448 mm), comprising 60% of the total ova and the rest measured 10-15 m.d. (0.14 - 0.21 mm). In the spent (stage VII) ovaries the immature ova measuring 4-6 m.d. and 10-12 m.d. were found along with a few ova in reabsorbing state.

It is indicated from the above that a single batch of ova always stood separated from the mature stock in this species.

In N. mesoprion, during stage I the majority of the ova were transparent with distinct nuclei measuring between 3-5 m.d. (0.042 - 0.070 mm) in diameter. Few large sized ova, 9-11 m.d. (0.126 - 0.124 mm) could also be noticed. At stage II large group of yolked eggs with a mode 9-11 m.d. (0.126 - 0.154 mm) could be seen along with the immature (0.042 - 0.07 mm) stock. At stage III the maturing group of ova shifted to 12-14 m.d. (0.168 - 0.196 mm). All the eggs of this mode continue to grow and at stage IV they measured 18-20 m.d. (0.252 - 0.294 mm) along with an immature stock measuring 6-8 m.d. (0.84 - 0.112 mm). At stage V the ova were mature and measured 24-26 m.d. (0.336 - 0.378 mm) and an immature group measuring 6-8 m.d. was also noticed along with it. At stage VI two matured stocks were seen, one measuring 27-29 m.d. (0.378 - 0.392 mm) and another at 30-32 m.d. (0.42 - 0.448 mm) along with the immature stock. At stage VII most of them were immature and reabsorbed, measuring 3-5 m.d.

The above analysis indicates that the spawning period in N. mesoprion is prolonged, which is evident from the presence of large number of intermediate oocytes. Various authors opined that the presence of yolked oocytes of different sizes in the mature ovary is a criteria for the existence of multiple spawning (Clark, 1934 and De Silva; 1937). However, there is a controversial opinion among fishery biologists as to whether the advanced group of yolked oocytes alone or all the yolked oocytes are spawned during the spawning season. It is generally believed that all the yolked oocytes are capable of development for eventual spawning (De Silva, 1937). The presence of two modes of eggs in stage VI suggested the prolonged spawning period of this species.

6.4.2 Seasonal occurrence of maturity stages

To determine the extent of the spawning period, the occurrence of various maturity stages of gonads during different months of the year are recorded. The percentage occurrence of various stages of maturity of gonads during different months have been plotted separately for N. japonicus (Fig. 8a) and N. mesoprion (Fig. 8b).

The highest percentage of *N. japonicus* with fully mature testes and ovaries occurred during August - January. The presence of mature specimens (stage V in female and III in male) for a prolonged period suggests the possible continuous spawning of this population. The spawning season of this species extends from August - January. This was further confirmed by the presence of spent specimens in October - December and 9 mm size group of fishes in November.

In *N. mesoprion* fully mature testes and ovaries (stage V and VI in females and III in male) were recorded between July - December with a peak during August - November. Ripe gonads were not observed between February and June. The spawning season was thus found to last for six months. The occurrence of large numbers of fish with ripe gonads during August - November indicated that this was the peak spawning period of these fishes. This observation was further confirmed by the presence of juveniles in October - December.

6.4.3 Relative condition factor

Changes in the condition factor (K) of a fish can be analysed using the equation,

$$K = \frac{W \times 10^5}{L^3} \quad \text{(Hile, 1936)},$$

where 'W' the weight and 'L' the length of the fish. The above formula holds good only when the weight is proportional to the cube of body length. The exponent value would be 3 for an ideal fish which maintains the same shape throughout, but this rarely occurs because body dimensions of fishes change as they grow (Le Cren, 1951).

The second formula for condition factor (K) is

$$K = \frac{W}{L^n}$$

derived from the empirical equation

$W = CL^n$. Theoretically condition factor decreases with increase in length of fish if 'n' is less than 3, and increases with increase in length if 'n' is greater than 3.

In the present study the value of 'n' was found empirically to be 2.7831 for male and 2.9881 for female N. japonicus. In N. mesoprion the values were 2.7983 for male and 2.8873 for female. 't' test also showed a slight deviation from Cube Law. The deviation from the Cube Law (vide Chapter V) necessitated the use of relative condition factor to obtain ponderal index. The effect of length on 'K' can be eliminated by computing the relative condition factor (Kn) based on the empirical length-weight relationship. The difference between 'K' and 'Kn' is that the former is measuring the deviation of an individual from a hypothetical 'ideal fish', while the latter is measuring the deviation of an individual from the average weight for length of the fish.

For N. japonicus and N. mesoprion the mean monthly values of 'Kn' was compiled for samples obtained from August 1982 to July 1984. Males and females were analysed separately. Values above 1 showed an increase in condition.

In N. japonicus generally the 'Kn' values (Fig.9b) showed similar trend in both males and females through out the year. A gradual increase in 'Kn' values could be noticed from July reaching its maximum in September and November and decreasing from January onwards. The examination of the gonads showed that the rise in the condition was due to the presence of mature and ripe gonads. The months of low condition factor indicated the post-spawning period and the fall in the condition was due to the cessation of breeding and the occurrence of spent gonads. Similar trend was observed in the 2nd year of study in both the sexes.

In N. mesoprion the 'Kn' values (Fig. 9a) showed similar trend in both males and females. It reached the maximum condition in August - September. A decrease could be noticed thereafter until spawning in December. The condition remained low during January - May. The same trend being repeated during the subsequent year. Studies on gonads showed that, occurrence of mature and ripe gonads in the samples coincided with maximum condition factor. The low condition observed from December - May may due to the cessation of breeding which is further indicated by the relative abundance of fishes with spent and immature gonads during these months.

Thus in both species, the rise in 'Kn' value synchronizes with the peak spawning months and agrees with the seasonal occurrence of maturity stages and GSI values.

6.4.4 Size at sexual maturity

A knowledge of minimum size at sexual maturity is helpful to ensure a sustained yield by regulating the mesh size of the net during fishing operation. The smaller sized fish may also get an opportunity to spawn at least once in their life time by regulating the mesh size. Size at first maturity was determined at the peak spawning season, when most of the adult fish with mature gonads could be collected.

To calculate the minimum size at sexual maturity (Lm) the fishes were classified into 10 mm intervals. Number of immature and mature fishes were enumerated in each size group for each month and the percentage of maturity was calculated for both males and females separately.

It can be seen from fig. 10c & d that in N. japonicus, the male and female below 115 mm (TL) were not mature. The percentage of mature males and females increased steadily to hundred percent maturity from 191-200 mm (TL) in males and 200-210 mm (TL) in females. L 50 was calculated as 160 mm (TL) for males and 171 mm (TL) for females. Thus the males seemed to have attained sexual maturity earlier than the females.

In N. mesoprion (Fig. 10a & b) it has been observed that a few fish mature at 91-100 mm (TL) (males) and 101-110 mm (TL) (females), after which the percentage of mature fish gradually increased. However, hundred percent maturity was found in 151-160 mm (TL) in males and 161-170 mm (TL) and above, in females. The value of L 50 calculated was 120 mm (TL) in males and 125 mm (TL) in females. Thus the males appeared to attain maturity earlier than the females in N. mesoprion.

6.4.5 Gonado-Somatic index

Gonado-somatic index (GSI) is used to find out the duration and intensity of breeding. The development of gonads and the general growth of the fish are closely associated. The index increased gradually during the development of the gonads and declined at the commencement of spawning. Therefore the GSI may be a useful criterion for determining the duration and intensity of spawning as shown in many other fishes (June, 1953; Yuen, 1955; Thomas, 1969; Ramanathan, 1977; Venkataramani, 1979; Passoupathy, 1980; Sivakumar, 1981; Krishnaveni, 1986).

For the present study the GSI was calculated for both male and female N. japonicus and N. mesoprion and monthly values are shown in Fig.11.

From Fig.11b it can be seen that in N. japonicus the mean GSI increased rapidly from July and gradually declined to a minimum in January. The appearance of individual with high index value in August and October suggested the high spawning activity during these months. The steep fall in January and February was due to the presence of spent gonads.

Similarly in <u>N. mesoprion</u> (Fig.11a) the GSI increased from June attaining peak in October - November and showed a decrease in December to January, indicating October - November as the spawning period. Gonadal development increased gradually from January onwards.

The mean GSI followed a similar trend in males and females of both species, except that, the changes in weight of testes are slight and gradual. The fluctuations in the index during spawning indicates a synchronous maturation of gonads, confirming an extended spawning season. The peak spawning as indicated by GSI is in general agreement with the percentage occurrence of maturity stages.

<u>6.4.6 Fecundity</u>

The reproductive potential of a fish population depends on the number of fertile female fishes and the number of eggs produced per female. The number of eggs produced (fecundity) is associated with the size and weight of the fish and the stage and condition of the ovary. In the present study the relationship between fecundity and body length, fecundity and body weight, fecundity and ovary weight were considered. Fecundity models are fitted after transforming the data to log base and regression lines were drawn by the method of least squares, expressing the relationship by the following equation

Log fecundity = Log a + b log x

where x is the length (L), or weight (W) or ovary weight (OW). By converting the data to common logarithmic form, the positive correlation of variance with size is eliminated.

Fecundity estimates varied in N. japonicus between 7,434 to 75, 358 for 40 females ranging from 120 to 240 mm total length, 23.8-160.2 gms body weight and 1.38 – 4.825 gms gonad weight.

In N. mesoprion the estimates of fecundity varied from 4, 868 to 68,409 for 50 females ranging from 110 to 200 mm total length, 20.8-128 gms body weight and 0.93 – 4.001 gms gonad weight. The number of mature ova increased corresponding to the increase in body weight and gonad weight of the specimen.

a) Relationship between fecundity and total length:

The logarithmic relationship between fecundity (F) and total length (L) are linear for N. japonicus (Fig.12a) and N. mesoprion (Fig.12b) and the calculated equations are as follows:

For N. japonicus

Log F = -1.1038 + 4.5586 log L

The correlation coefficient (r) between fecundity and total length was highly significant ($r = 0.897$; $P > 0.001$).

For N. *mesoprion*

$$\text{Log } F = -1.0196 + 4.3696 \log L$$

The correlation coefficient (r) computed for fecundity with total length was 0.9753 ($P < 0.01$) showing a highly significant relationship.

b) Relationship between fecundity and body weight:

Body weight of N. *japonicus* and N. *mesoprion* also showed a linear relationship (Fig.12c & d) with fecundity. The regression of fecundity (F) on body weight (W) can be expressed;

For N. *japonicus*

$$\text{Log } F = 1.9404 + 1.1843 \log W.$$

The correlation coefficient (r) value between fecundity and body weight, 0.8747 ($P < 0.001$) showed a high degree of correlation between the two variables.

For N. *mesoprion*

$$\text{Log } F = 1.8656 + 1.4667 \log W.$$

A high degree of correlation was found between fecundity and body weight ($r = 0.9668$; $P < 0.01$).

c) Relationship between fecundity and ovary weight:

The logarithmic relationship between fecundity (F) and ovary weight (OW) can be expressed;

For N. japonicus

Log F = 3.3367 + 1.98 log OW.

The correlation coefficient 'r' value 0.838 ($P < 0.001$), between these two variables is presented in Fig.12e

For N. mesoprion

Log F = 3.3864 + 2.0061 log OW and the straight line relationship was plotted in Fig.12f. The correlation coefficient (r) computed for fecundity with ovary weight was 0.9809 ($P < 0.01$) showing a highly significant relationship.

It has been widely acknowledged that fecundity is proportional to body weight and both are proportional to the cube of the body length (Simpson, 1951). Comparison of correlation coefficient values with length, weight and ovary weight indicated that ovary weight and body weight are closely related to fecundity.

6.4.7 Sex Ratio

Sexual dimorphism was absent in either of the Nemipterid species presently studied. From the commercial catches random samples of N. japonicus and N. mesoprion were collected and sex ratio was recorded after examining the gonad. Chi'square test was performed to test the homogeneity of male and female distribution. The observed results during the study period (August, 1982 to July, 1984) are given in table 17 & 18 and Fig. 13a & b.

In N. japonicus a balanced sex ratio (1:1) was found during most of the months except in November, 1982; October and November, 1983 and January, April and July, 1984. Males dominated during October, November, 1983 and January, April and July, 1984. But in November, 1982 the females were found to be more. Comparing the occurrence of fish in the two years, the males were found dominating during the spawning time.

In N. mesoprion the sex ratio was found to confirm the expected 1:1 ratio during most of the months of the year. However, deviation from the expected ratio was significant during September 1982, October and November, 1983; March and April, 1984. In all these months males were predominant.

Krishnamoorthi (1971) and Krishnaveni (1986) have reported that the sex ratio of N. japonicus varied in different seasons and in those cases males were prevailing. The present finding on sex ratio of Nemipterids is obtained by employing the technique of random sampling, though factors like courtship, behaviour and sexual segregation may operate during breeding season, resulting in variation of the sex ratio.

6.5 DISCUSSION

One of the objectives of the present investigation was to provide information on the breeding of N. japonicus and N. mesoprion in Cochin waters. The study provide details on various aspects of reproduction including the breeding season, gonado-somatic index, spawning frequency, length and age at 1st maturity, fecundity and sex ratio.

The egg development and spawning frequency were approximated from ova diameter frequency studies. In both the species the mature ovaries were characterised by translucent ova with a distinct oil globule along with yolkless oocytes. The two groups of yolked ova were observed during the later stages of maturation, which implies that the second group of yolked oocytes mature shortly after the first group and might be spawned subsequently. Such a fractional spawning was noticed in N. japonicus by Eggleston (1972) and Krishnaveni (1986). Murthy (1981) reported that in N. mesoprion the spawning lasts for about five months. The findings of the present study clearly indicate that both the species of Nemipterids in Cochin waters are fractional spawners and the spawning season lasts for four to five months.

The percentage frequency of stages VI and VII showed that in N. japonicus, spawning commences from August to January. Krishnamoorthi (1971) stated that N. japonicus spawns off Waltair during September - November and Dan (1977) observed that this species spawns twice a year during December - February and June - July at Waltair. Krishnaveni (1986) reported that N. japonicus spawns during August to November in Portonovo waters. In the South China Sea the spawning of N. japonicus takes place during May - October (Eggleston, 1972).

In Cochin waters it is observed that the spawning of N. mesoprion is from July - December. Whereas Murthy (1981) reported that this species spawns in the sea off Kakinada during December - April period with peak spawning during January. The seasonal changes in the spawning of the same species may be due to the racial differences of the species or may be due to environmental variations of the waters which they inhabit.

In N. japonicus and N. mesoprion the period of change in 'Kn' values coincided with the spawning period, seasonal variation in percentage composition of maturity stages and gonado-somatic index values. The rise in 'Kn' values at the time of peak spawning season were also observed by Krishnaveni (1986) in N. japonicus, Murthy (1981) in N. mesoprion, Sainsburg and Whitelaw (1985) in N. peronii, Venkataramani (1979) in Carangid fishes. Passoupathy (1980) in Sciaenid fishes and Sivakumar (1981) in Thryssa spp. have also observed the high 'Kn' values during the spawning period. However, the variations in spawning in different species have been attributed to different factors. The high and low conditions were observed before and after spawning in certain pleuronectiformes (Thompson, 1943). The low conditions before spawning and high conditions after spawning, in the cornish pilchards Sardina pilchardus, was due to sexual cycle and the availability of food respectively (Hickling, 1945). The increasing and decreasing condition in Blennius pholis were probably due to the general building up and losing of biochemical reserves respectively (Qasim, 1957).

The length at first maturity was 160 mm in male and 171 mm in female N. japonicus. Krishnamoorthi (1971) from Waltair coast and Krishnaveni (1986) from Portonovo waters have also obtained 165 mm long females at first maturity. However, Murthy (1981) reported that the first maturity was attained at 125 mm TL in N. japonicus from Kakinada coast. The data further indicated that in N. mesoprion, 50% of the fish mature at 120 mm (120 mm in male and 125 mm in female). Murthy (1981) reported that the first maturity was attained when N. mesoprion measures 100 mm in TL.

Both N. japonicus and N. mesoprion attained maturity at the end of the first year or at the beginning of the second year. Qasim (1973) stated that most of the tropical marine fishes mature fairly early and spawn at the age of first or second year of its life time. Fecundity is proportional to body weight and both are proportional to the cube of the body length (Simpson, 1951). In both N. japonicus and N. mesoprion the fecundity increased linearly as a function of length, body weight and ovary weight.

In the present investigation the sex ratio of N. japonicus and N. mesoprion was conformed to the expected 1:1 ratio during most of the months. During spawning, the number of males were observed to be more than the females. De Martine and Fountain (1981) suggested that the males dominated in places where spawning occurs. Magnuson and Prescott (1966) and Hunter and Goldberg (1980) have reported that during courtship a single female was followed by a group of males. During certain months, in both the species of Nemipterids a deviation from 1:1 ratio was observed. Reynolds (1974) opined that the deviation might be due to the partial segregation of mature forms through their habitat preference. Collingnon (1960) suggested that the sex ratio change might be due to migration. However, Baglin (1982) stated that the deviation might be due to the behavioural differences between sexes, thereby any one of the sex evolved have more accessibility than the other, during fishing operations.

Table 17 - Sex Ratio of *Nemipterus japonicus* during August 1982 to July 1984 with chisquare values.

Month	Male	Female	% of male	% of female	Chisquare value	Probability	M:F
August'82	59	46	56.19	43.81	1.6095	> 0.05	1:0.78
September	46	58	44.23	55.77	1.3846	> 0.05	1:1.26
October	44	37	54.32	45.68	0.6049	> 0.05	1:0.84
November	56	80	41.18	58.82	4.2353	< 0.05	1:1.43
December	45	37	54.88	45.12	0.7805	> 0.05	1:0.82
January'83	40	35	53.33	46.67	0.3333	> 0.05	1:0.88
February	38	35	52.05	47.95	0.1233	> 0.05	1:0.92
March	48	45	51.61	48.39	0.0968	> 0.05	1:0.94
April	38	32	54.29	45.71	0.5143	> 0.05	1:0.84
May	48	44	52.17	47.83	0.1739	> 0.05	1:0.92
June	32	32	50.0	50.0	0.0000	> 0.05	1:1
July	35	32	52.24	47.76	0.1343	> 0.05	1:0.91
August	39	31	55.71	44.29	0.9143	> 0.05	1:0.80
September	39	36	52.0	48.0	0.1200	> 0.05	1:0.92
October	49	10	83.05	16.95	25.7797	< 0.001	1:0.20
November	59	16	78.67	21.33	24.6533	< 0.001	1:0.27
December	26	26	50.0	50.0	0.0000	> 0.05	1:1
January'84	56	23	70.89	29.11	13.7848	< 0.001	1:0.41
February	23	32	41.82	58.18	1.4727	> 0.05	1:1.39
March	36	36	50.0	50.0	0.0000	> 0.05	1:1
April	48	21	69.57	30.43	10.5652	< 0.02	1:0.43
May	44	36	55.0	45.0	0.6000	> 0.05	1:0.82
June	-	-	-	-	-	-	-
July	36	18	66.67	33.33	6.0000	< 0.02	1:0.50

Table 18 - Sex Ratio of *Nemipterus mesoprion* during August 1982 to July 1984 with chisquare values

Month	Male	Female	% of male	% of female	Chisquare value	Probability	M:F
August'82	62	51	54.87	45.13	1.0708	> 0.05	1:0.82
September	56	35	61.54	38.46	4.8462	< 0.05	1:0.62
October	46	34	57.5	42.5	1.8000	> 0.05	1:0.74
November	36	50	41.86	51.14	2.2791	> 0.05	1:1.22
December	43	32	57.33	42.67	1.6133	> 0.05	1:0.74
January'83	44	34	56.41	43.59	1.2821	> 0.05	1:0.77
February	41	32	56.16	43.84	1.1096	> 0.05	1:0.78
March	51	42	54.84	45.16	0.8710	> 0.05	1:0.82
April	39	31	55.71	44.29	0.9143	> 0.05	1:0.79
May	37	32	53.62	46.38	0.3624	> 0.05	1:0.86
June	34	32	51.52	48.48	0.0606	> 0.05	1:0.94
July	44	39	53.01	46.99	0.3012	> 0.05	1:0.89
August	35	40	46.66	53.33	0.3333	> 0.05	1:1.14
September	35	31	53.03	46.97	0.2424	> 0.05	1:0.89
October	56	16	77.78	22.22	22.2222	< 0.001	1:0.28
November	49	12	80.33	19.67	22.4426	< 0.001	1:0.24
December	18	18	50.0	50.0	0.0000	> 0.05	1:1
January'84	34	34	50.0	50.0	0.0000	> 0.05	1:1
February	38	40	48.72	51.28	0.0513	> 0.05	1:1.05
March	33	18	80.49	19.51	4.4118	< 0.05	1:0.24
April	53	31	63.10	46.90	5.7619	< 0.02	1:0.74
May	49	52	48.51	51.49	0.0891	> 0.05	1:1.06
June	1	1	50.0	50.0	0.0000	> 0.05	1:1
July	12	6	66.67	33.33	2.0000	> 0.05	1:0.50

Fig. 8 a) Monthly percentage occurrence of different stages of maturity of *N. japonicus* during August 1982 - July 1984

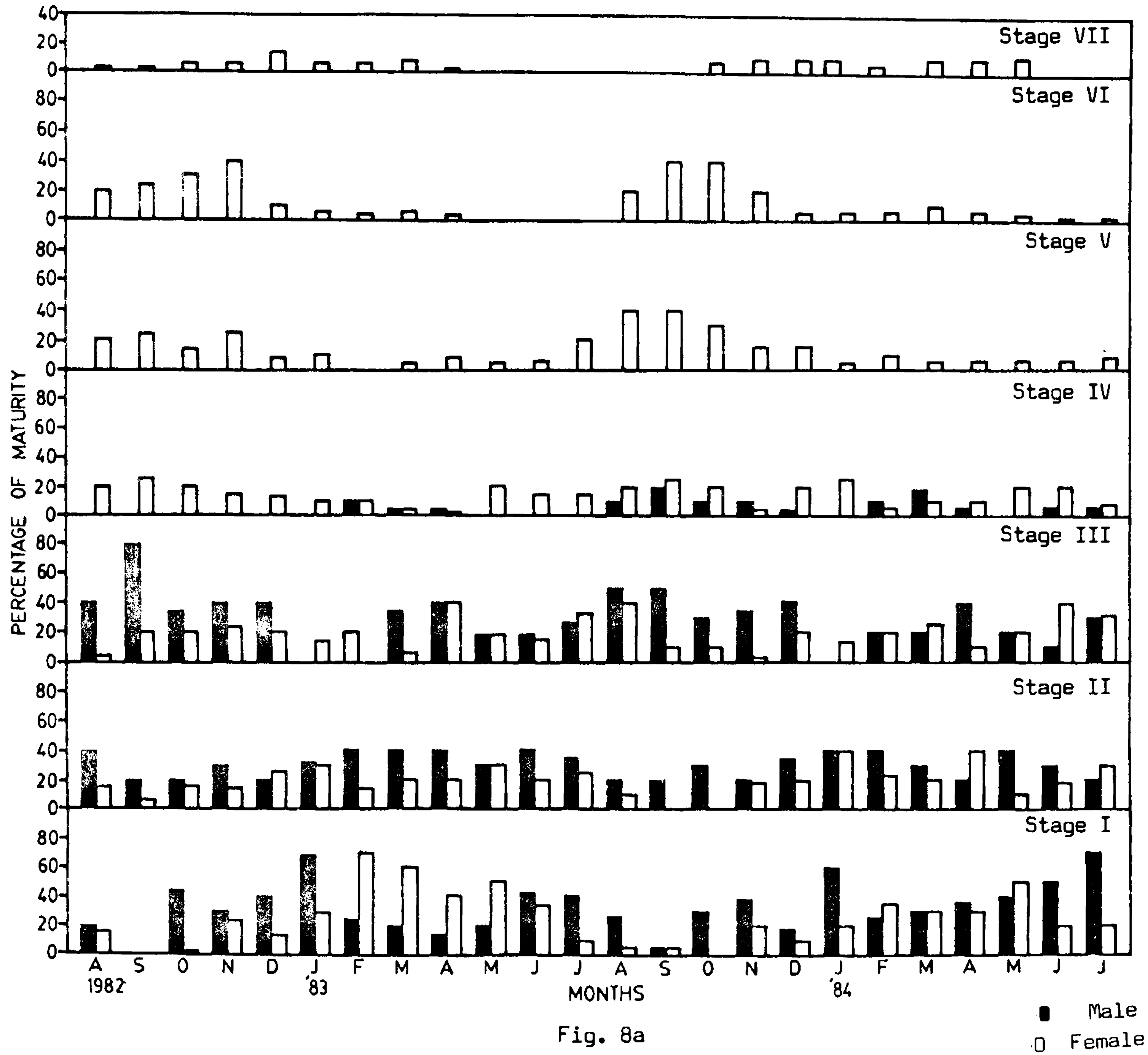

Stage VII
Stage VI
Stage V
Stage IV
Stage III
Stage II
Stage I
PERCENTAGE OF MATURITY
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
'84
MONTHS
Male
Female

Fig. 8a

Fig. 8 b) Monthly percentage occurrence of
different stages of maturity of
N. mesoprion during August 1982 - July 1984

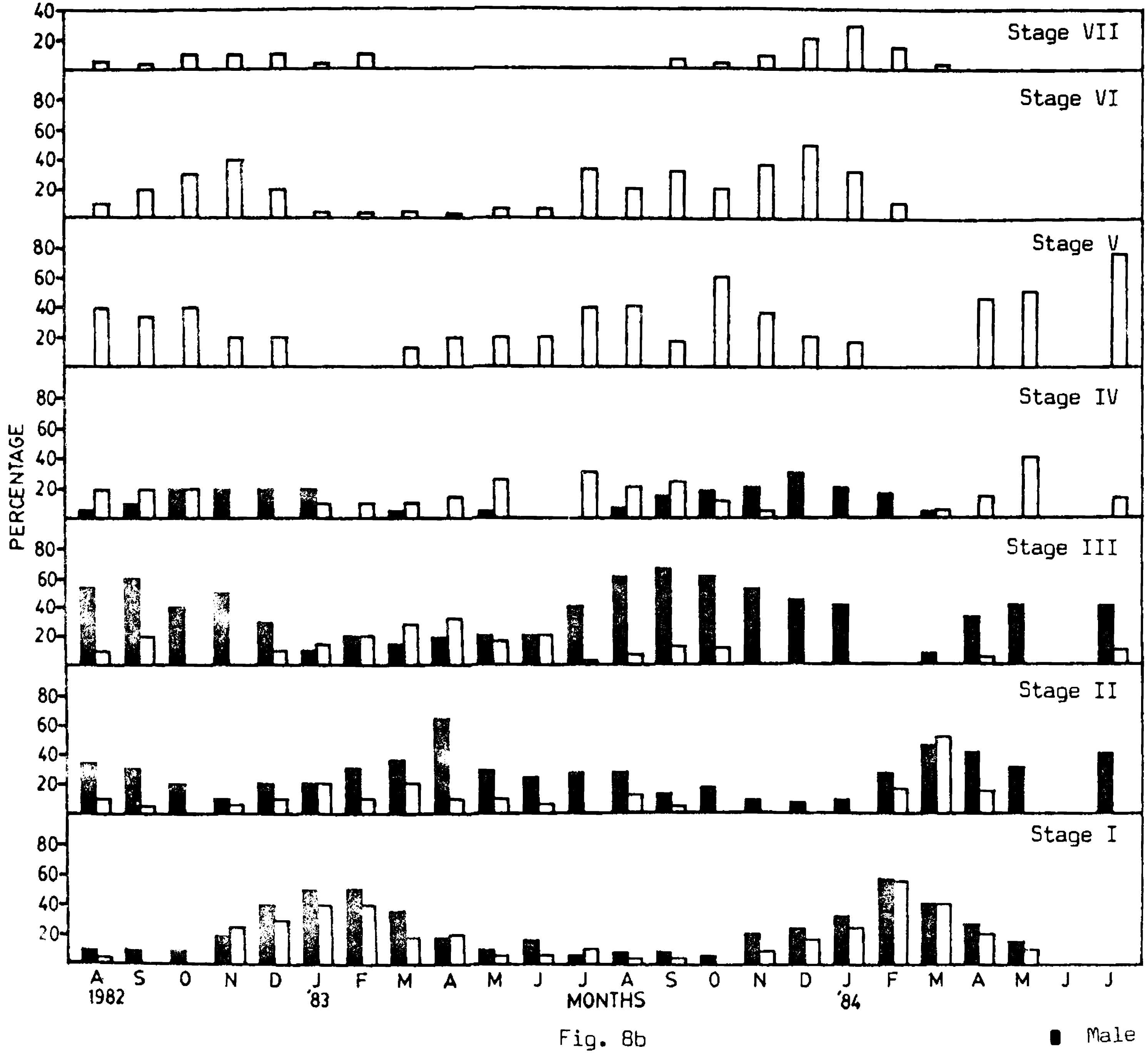

Stage VII
Stage VI
Stage V
Stage IV
Stage III
Stage II
Stage I
PERCENTAGE
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
'84
MONTHS
Male

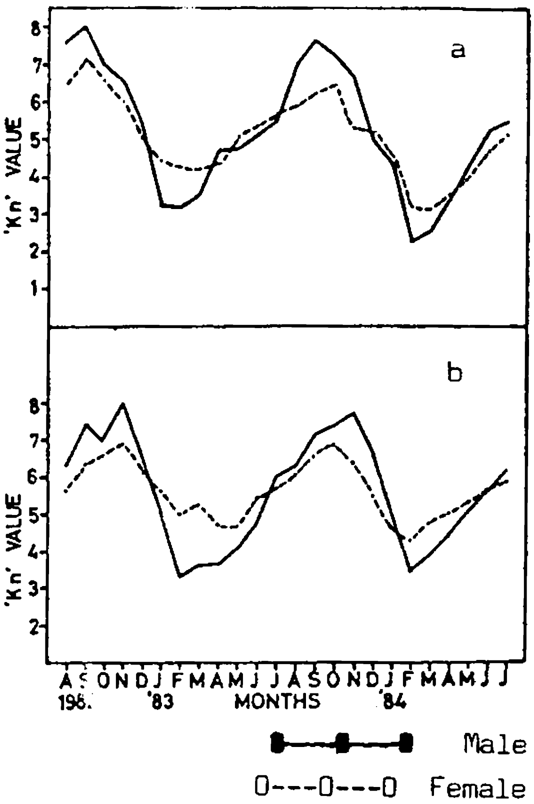
Fig. 8b

Fig.9 a) Monthly 'Kn' values of _N. mesoprion_
(August 1982 - July 1984)

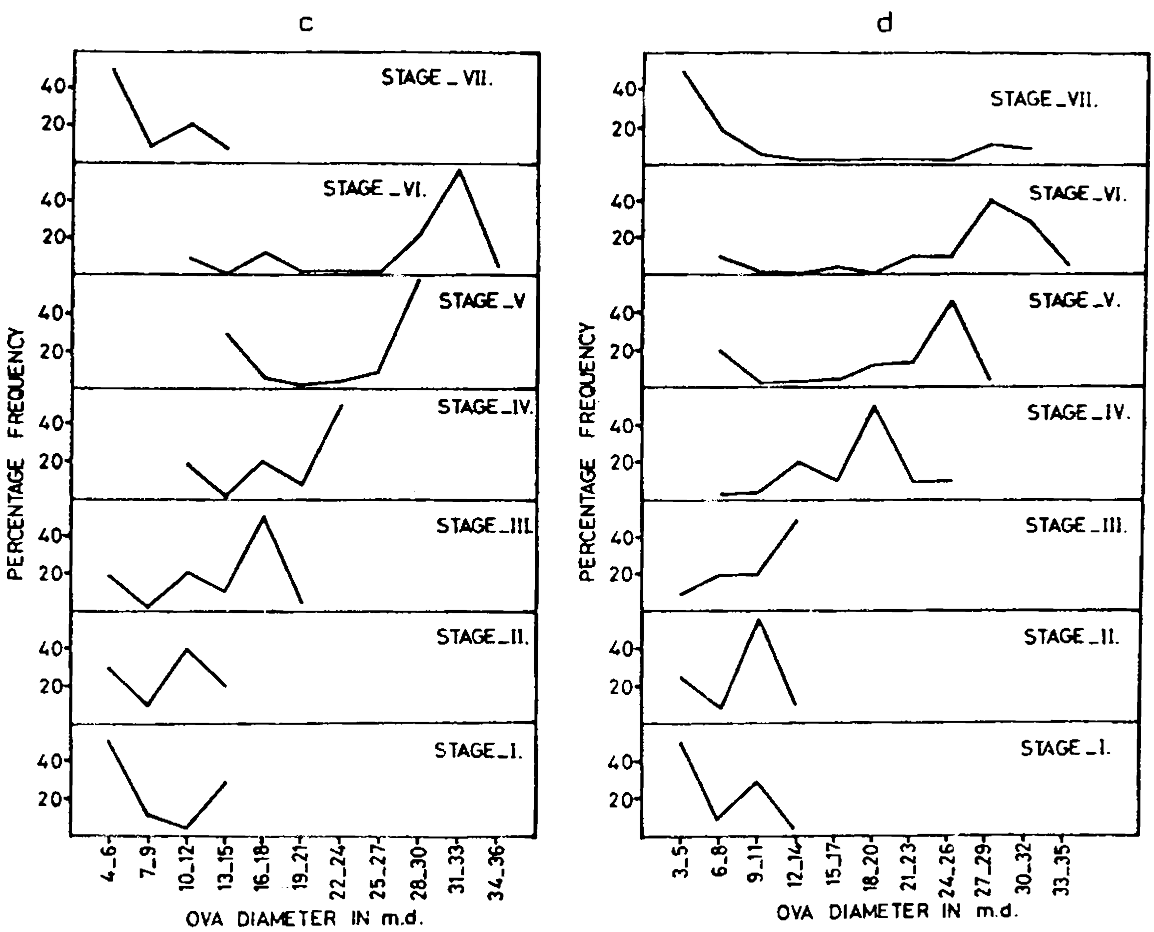
Fig.9 b) Monthly 'Kn' values of _N. japonicus_
(August 1982 - July 1984)

Fig.9 c) Percentage frequency of ova diameter in various maturity stages of _N. japonicus_

Fig.9 d) Percentage frequency of ova diameter in various maturity stages of _N. mesoprion_



a
b
'Kn' VALUE
A S O N D J F M A M J J A S O N D J F M A M J J
198.
'83
MONTHS
'84
Male
O---O---O Female



c
d
PERCENTAGE FREQUENCY
STAGE _ VII.
STAGE _ VI.
STAGE _ V
STAGE _ IV.
STAGE _ III.
STAGE _ II.
STAGE _ I.
4_6
7_9
10_12
13_15
16_18
19_21
22_24
25_27
28_30
31_33
34_36
3_5
6_8
9_11
12_14
15_17
18_20
21_23
24_26
27_29
30_32
33_35
OVA DIAMETER IN m.d.

Fig. 9

Fig.10 a) Size at first maturity in females of

N. mesoprion

Fig.10 b) Size at first maturity in males of

N. mesoprion

Fig.10 c) Size at first maturity in females of

N. japonicus

Fig.10 d) Size at first maturity of males of

N. japonicus

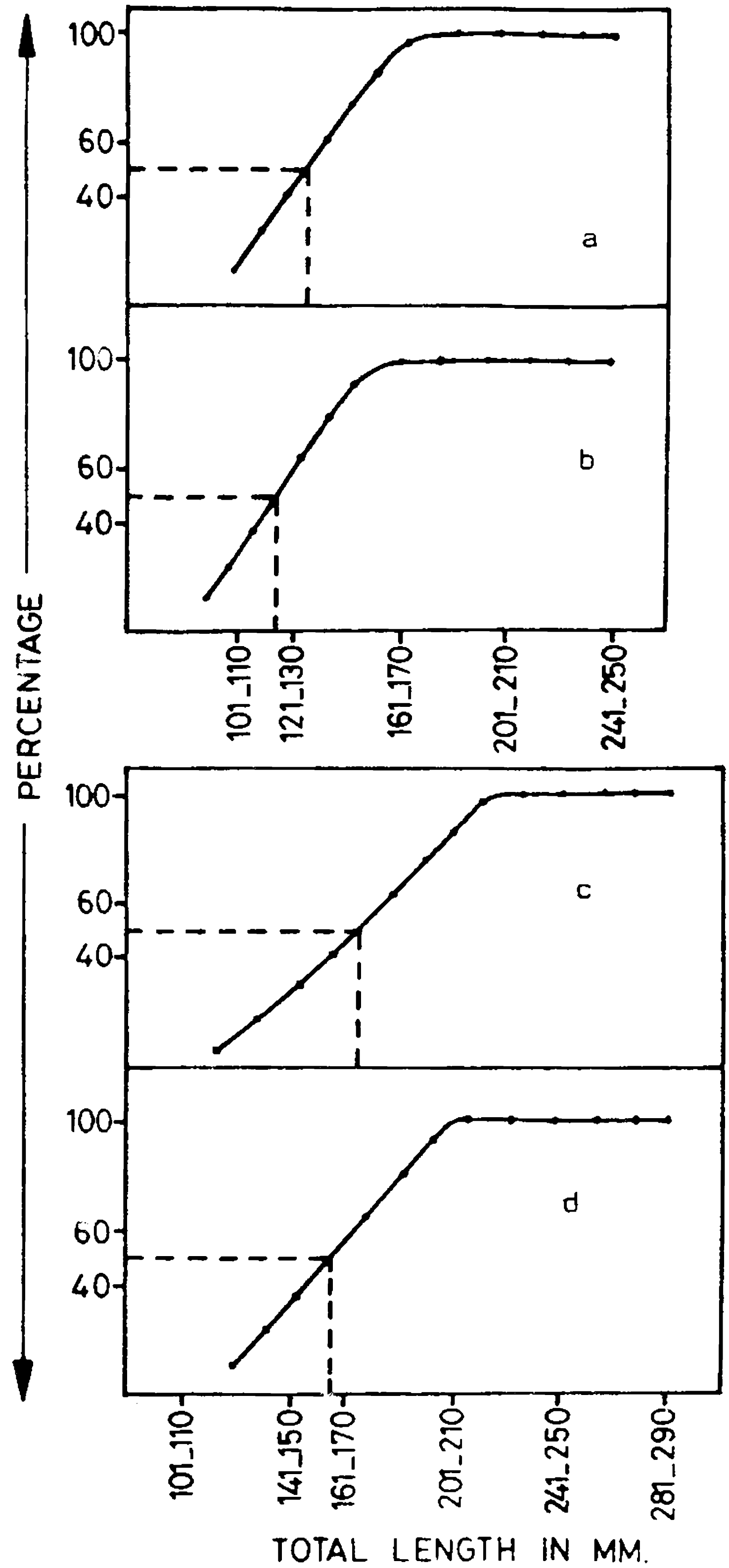

PERCENTAGE
100
60
40
a
b
c
d
101_110
121_130
161_170
201_210
241_250
141_150
281_290
TOTAL LENGTH IN MM.

Fig. 10

Fig.11 a) Monthly values of gonado-somatic index of *N. mesoprion* during August 1982 - July 1984

Fig.11 b) Monthly values of gonado-somatic index of *N. japonicus* during August 1982 - July 1984

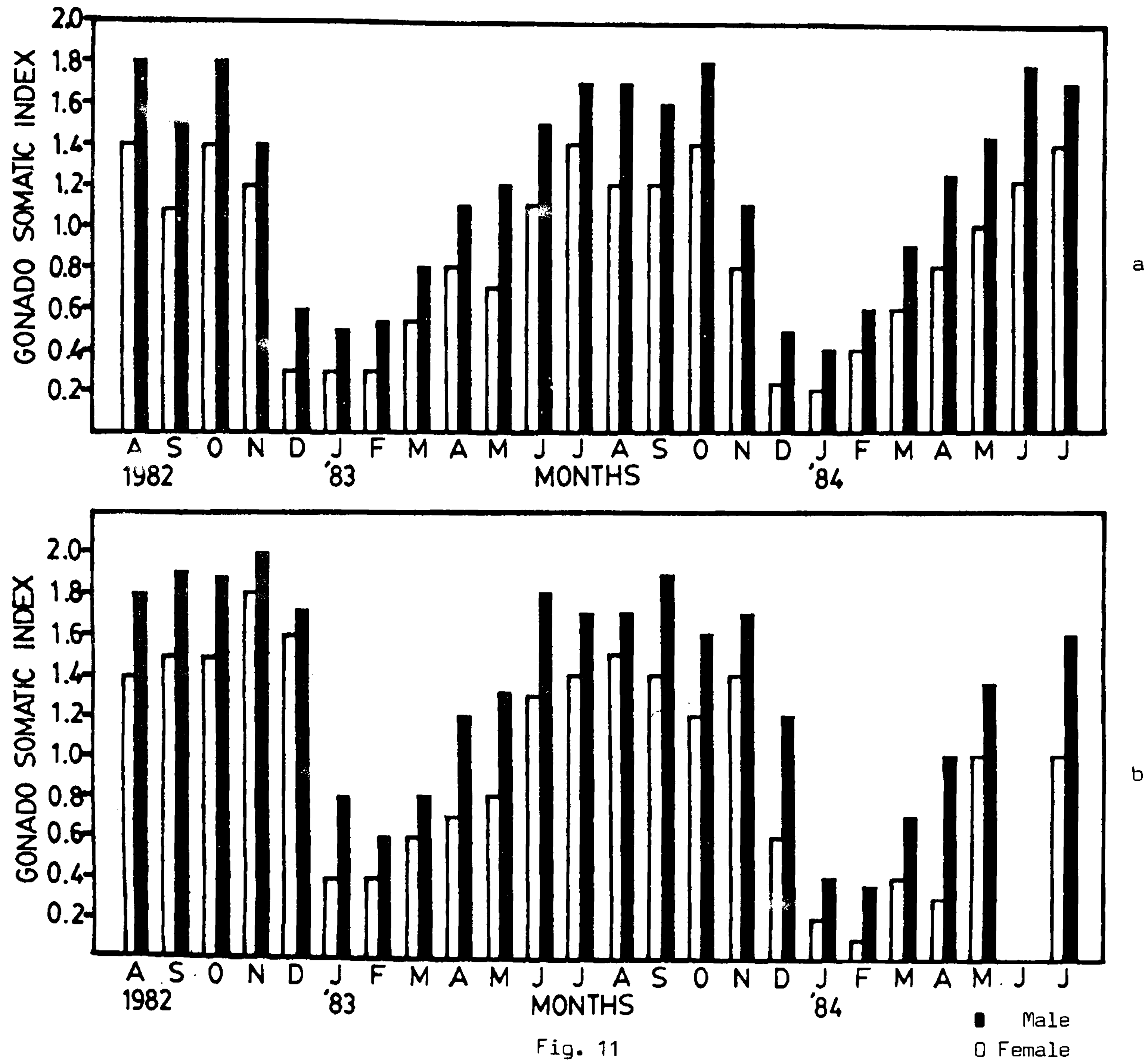

a
b
GONADO SOMATIC INDEX
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
'84
MONTHS
Male
0 Female

Fig. 11

Fig.12 a) Fecundity body length relationship in *N. japonicus*

Fig.12 b) Fecundity body length relationship in *N. mesoprion*

Fig.12 c) Fecundity body weight relationship in *N. japonicus*

Fig.12 d) Fecundity body weight relationship in *N. mesoprion*

Fig.12 e) Fecundity ovary weight relationship in *N. japonicus*

Fig.12 f) Fecundity ovary weight relationship in *N. mesoprion*

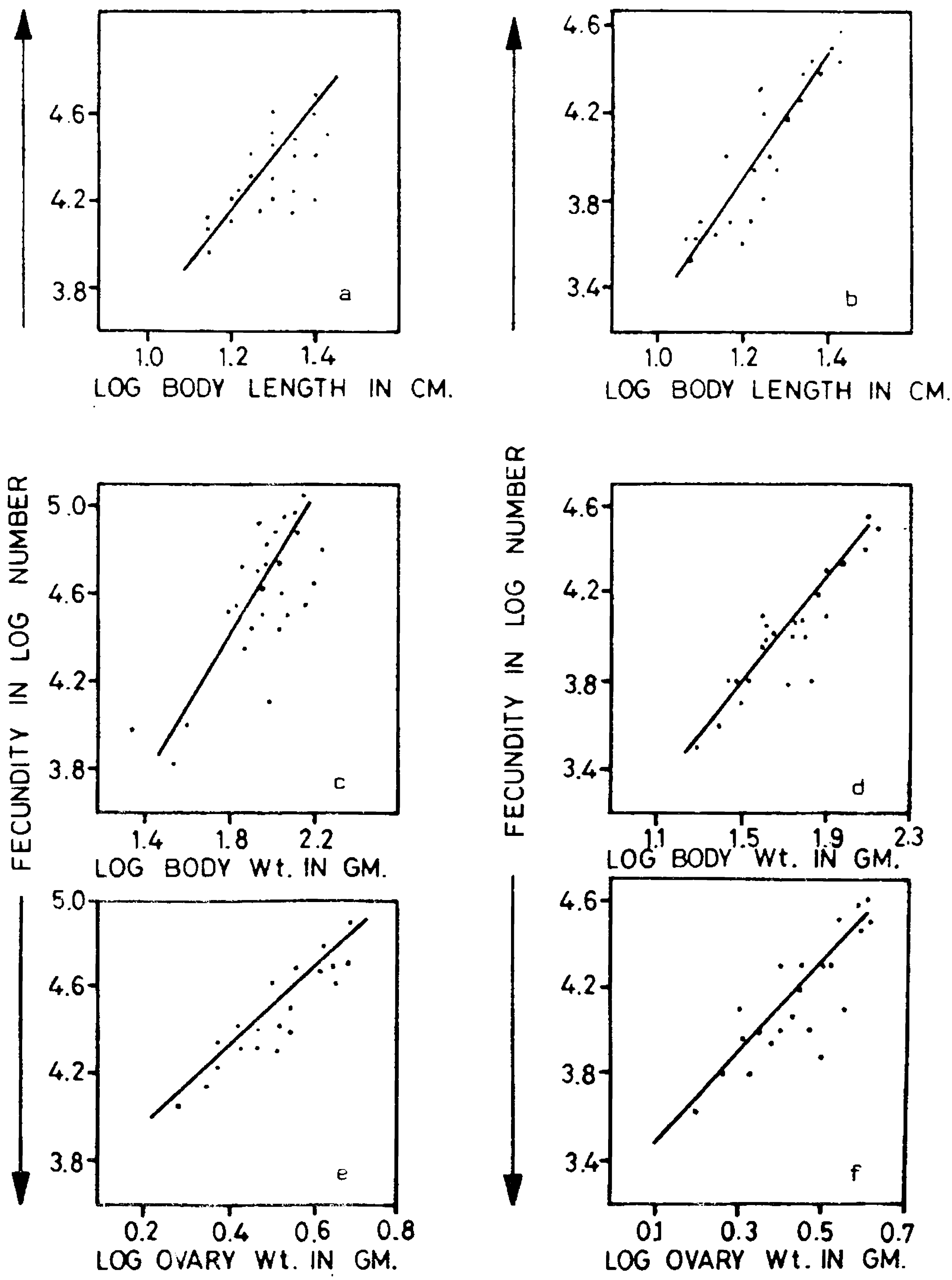

FECUNDITY IN LOG NUMBER
a
LOG BODY LENGTH IN CM.
b
LOG BODY LENGTH IN CM.
c
LOG BODY Wt. IN GM.
d
LOG BODY Wt. IN GM.
e
LOG OVARY Wt. IN GM.
f
LOG OVARY Wt. IN GM.

Fig. 12

Fig.13 a) Monthly sex ratio trends during August 1982 to July 1984 in N. *japonicus*.

Fig.13 b) Monthly sex ratio trends during August 1982 to July 1984 in N. *mesoprion*.

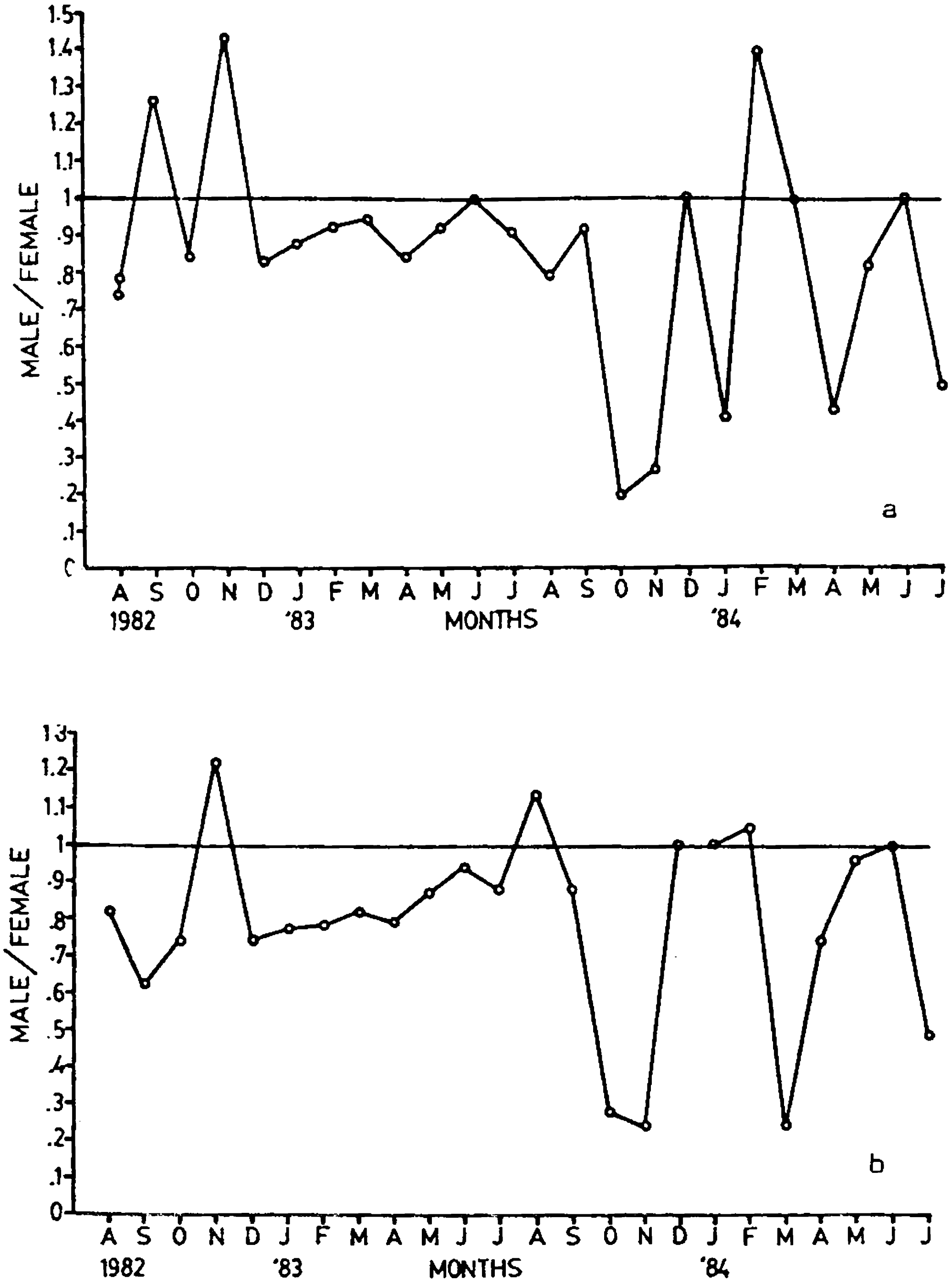

MALE/FEMALE
a
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84
MALE/FEMALE
b
A S O N D J F M A M J J A S O N D J F M A M J J
1982
'83
MONTHS
'84

Fig. 13

CHAPTER 7

BIOCHEMICAL COMPOSITION

BIOCHEMICAL COMPOSITION

7.1 INTRODUCTION

The geometrically increasing world population is in search of an alternative source of nutritive food. The easy accessibility, low cost and high nutritive value of marine fishes substitute it as another source of protein enriched food for the populous world. An understanding of their bodily biochemical composition will definitely help us to evaluate the nutritive value of these food fishes.

It is well established that most of the biochemical constituents of fishes are subjected to marked seasonal changes, which have been attributed to various physiological and other factors such as maturation, spawning, age, growth and feeding. Atwater (1888-1892) and Kostychev (1883, as quoted by Vinogradov, 1953) were the pioneers in this field.

The maturation of gonads is accompanied by profound changes in the biochemical composition of fishes. The main body constituents like proteins, carbohydrates, fats, etc. undergo variations during maturity cycle with the purpose of making the developing eggs self-sufficient. The accumulation of fat and protein in tissues and their subsequent transfer to gonads prior to spawning have been observed in many species of fishes both in foreign and Indian waters.

The water content changes with the stages of maturity in different tissues of the fish (Parker and Vanstone, 1966). After spawning the percentage of moisture was high in the liver and gonad of the fishes (Medford and Mc Kay, 1978). Ironside and Love (1958) and Greene (1921) opined that the muscle protein varies in maturing fishes and declined to a minimum level during spawning. The expenditure of liver protein for the purpose of germ building has been proved by Sorvachev and Shatunovski (1968). The fat accumulation in fishes is mostly in the muscle, liver and gonads which is utilised during the reproductive activity (Milroy, 1908 and Hoar, 1957). Depletion of fat during and before spawning has been observed in the tissues, especially in the flesh, of many species of fishes (Johnstone, 1918; Idler and Bitners, 1958). Greene (1926) and Black et al. (1961) have stated that the sexual maturation in fishes may have some relation with the muscle and liver glycogen. The changes occurring in the mineral constituents of the tissues during maturation are not only related with maturation, but also with other factors like depletion (Love, 1970).

Life becomes more of a strain with increasing age. The fish continues to grow throughout its life, but the growth rate declines with increasing age. The attainment of increased size can itself cause changes in the chemistry of the fish, but phenomena seen in larger specimens sometimes result from the onset of sexual maturity and it is not always possible to distinguish between the two factors. Several substances have been shown to change with the growth of the fish, but information on any one of them in most cases has been confined to a single species, so the general applicability of the result is not known. Orton (1929), Bruce (1924) and Paton (as quoted by Milroy, 1908) are the earliest workers who have initiated research in this field.

The proportion of extracellular fluid is greater in young fish at the stage when the cells are multiplying rather than increasing in size (Love, 1958). Parker and Vanstone (1966) observed a decline in water content with growth in small fishes. Munz and Morris (1968) confirmed the decrease in moisture content during growth in fishes. A negative correlation exists between water and fat content of the different tissues of the fish throughout the growth as suggested by Milroy (1908), Johnstone (1918), Iles and Wood (1965), Khawaja and Jafri (1967), Ramaiyan and Palpandian (1976) and Krishnaveni (1986).

The build up of gonads are often, perhaps always, accomplished at the expense of body proteins. Dietary proteins seem to be unequal to the huge demands made by the sex organs, while eggs and sperms are maturing (Love, 1970). But, Anon (1966) opined that the size has no significant influence on the nitrogen (Protein) content of the flesh, except during spawning season. The liver or muscle fat has been reported to increase during growth (Lovern, 1938 and Love, 1970). They concluded that in the light of Orton's suggestion of 'Over reproduction' with age, the increased lipid seems more likely to act as an extra energy reserve at the spawning time to assist recovery. By quantifying the amount of lactic acid accumulation after death, Patashnik (1966) and Kelly (1969) have observed that larger fishes carry great reserves of carbohydrates. No consistent relationship between the size of a fish and the mineral content of its musculature was found (Thurston, 1961). Despite the exhaustive information available regarding the chemical composition and nutritive values of many estuarine and marine fishes, the contributions towards the biochemical composition of Nemipterid fishes are very meagre. Hence the present investigation was undertaken to study the biochemical constituents like water content, lipid, total protein, carbohydrates and minerals in different bodily tissues like muscle, liver and gonads and their variations in relation to sex, maturity cycles and growth in N. japonicus and N. mesoprion for better understanding of their nutritive value and their dietary significance.

7.2 MATERIALS AND METHODS

Fresh specimens of N. japonicus and N. mesoprion were collected weekly, during the period of one year from August, 1982 to July, 1983 from the various fish landing centres in Cochin. The fishes after collection were packed in ice and immediately brought to the laboratory. In the laboratory they were washed thoroughly and the surface moisture was removed by blotting. Both the sexes were used for the study.

The biochemical changes in relation to maturity cycles were studied after classifying the five maturity stages based on the macroscopic appearance of the gonads and changes in the colour of the gonads during maturation. The five maturity stages were Stage-I (immature), Stage-II (maturing and recovering spent), Stage-III (mature), Stage-IV (ripe) and Stage-V (spent). For understanding the changes in the biochemical constituents in relation to growth, the total length of the fish was measured to its nearest mm and categorized into eight or nine different size groups with 25 mm interval, ranging from a minimum of 25-50 mm to a maximum of 225-250 mm.

The muscular, hepatic and gonadal tissues were dissected, weighed to the nearest mg, placed in separate vials and dried to constant weight in a hot air oven at 80°C. Dried samples were powdered and stored in a dessicator for further analyses. The water content in the tissues were expressed as percentage of wet weight while the other constituents were expressed as percentage of dry weight.

The weight difference between wet and dried tissues expressed as percentage of wet weight denoted the moisture percentage levels.

The method of Barnes and Blackstock (1973) was used to estimate the total lipid levels. Weighed tissue samples were extracted with chloroform - methanol mixture and the lipid extract was treated with sulphuric acid, phosphoric acid and vanillin. The optical density of the red coloured complex was estimated at 520 nm. The method was suggested by the authors as particularly suitable for determining seasonal changes in biochemical composition of marine animals.

Protein percentage in the tissues were determined by the method of Lowry et al. (1951). A weighed sample of the tissue was treated with alkali which was warmed in a water bath. The solution was treated first with an alkaline solution of copper sulphate and then with Folin's reagent. The intensity of the blue colour of the resulting solution measured spectrophotometrically at 750 nm was proportional to the protein concentration of the sample. Bovine serum albumin was used as the standard.

For the estimation of total carbohydrates the dried tissue samples were extracted with 5% trichloroacetic acid containing 0.1% silver sulphate. The extract was warmed with concentrated sulphuric acid and the rose coloured product formed was estimated photometrically at 520 nm. The method was proposed by Kemp and Kitz (1954) and considered suitable by Raymont and Krishnaswamy (1960) for the estimation of total sugars in aquatic organisms. The standard curve was prepared using glucose.

A known quantity of the dried sample was ignited in a silica crucible at 600°C in a muffle furnace till the organic matter was burnt out leaving no carbon residue. The content was weighed and the difference gave the ash content percentage.

7.3 RESULTS

7.3.1 Biochemical Composition of *N. japonicus* in relation to maturity cycle

a) Water content:

The percentages of water in muscle, liver and gonads were graphically shown in Fig.14a. In the females the water content in the muscle steadily increased from 72.0% in stage-I to 80.0% in stage-IV and decreased to 76.5% in stage-V. The percentage of moisture in the male muscle tissue also showed similar trend, but with a relatively low value of 70.5% in stage-I and 78.9% in stage-IV.

The liver tissue in both the sexes registered a relatively less moisture content than the muscle. The moisture value decreased from 72.8% in stage-I to 58.6% in stage-III and increased through stage-IV to 64.8% in stage-V in the females. The moisture content of the liver in the male closely followed the similar pattern but with a slightly higher percentage.

The water content in the ovary was higher when compared to the muscle and liver values. It decreased from 82.5% in stage-I to 72.0% in stage-III and increased to 76.8% in stage-IV and 77.0% in stage-V in the females. In the male the trend was similar but again with a higher value of 84.3% in stage-I, 77.0% in stage-III, 78.1% in stage-IV and 79% in stage-V, as in the liver.

b) Fat:

The mean percentages of fat in the muscle, liver and gonads during different stages of maturity in both male and female were plotted in Fig.14b.

The fat percentage in the muscle of both sexes decreased from 19.3% (females) and 14.8% (males) during stage-I to 4.3% and 3.4% in stage-IV, respectively. The maximum value was obtained in stage-III in the liver with 19.9% for females and 17.5% for males, whereas the minimum percentage was observed as 8.9% for females and 7.1% for males in stage-I. The ovarian lipid increased from 6.1% in stage-I to 21.8% in stage-IV and steadily decreased to 13.3% in stage-V. The testicular fat also showed a similar trend, but with more pronounced variation.

c) Protein:

The percentage of protein showed definite periods of high and low values in all tissues during different stages of maturity (Fig.14c).

The variation in trend was similar to that of fat in the flesh. The highest values were obtained during stage-I with 70.5% in females and 70.3% in males. It decreased to 53.0% in females and 54.3% in males during stage-IV and thereafter increased to 60% in females and 59.0% in males during stage-V.

The liver protein inversely followed the variation in the muscle with a lowest value of 60.0% for females and 55.0% for males in stage-I and a highest value of 73% for females and 65.0% for males in stage-IV, thereafter decreasing in stage-V.

However, the ovarian protein steadily increased from 60.0% in stage-I to 72.0% in stage-IV and steeply decreased to 63.3% in stage-V whereas the testicular value fluctuated with a minimum value of 59.0% in stage-I increasing to 71.0% in stage-III with a less evident fall during stage-V (66.8%).

d) Carbohydrate:

The carbohydrate content also showed a definite cycle in relation to maturity stages, almost parallel to that of the fat and protein cycles, in all the three tissues (Fig.14d).

In muscle, the carbohydrate content was comparatively lower than that of liver and gonads. There was no variation between sexes. The highest value in the muscle was observed during stage-I and stage-V (0.85%) and the lowest value (0.70%) during stage-III. The hepatic and gonadal values seemed to have an inverse relationship with the value in muscle, 3.1% in stage-II and 5.8% in stage-IV in the liver and 3.5% in stage-I and 5.1% in stage-III in the ovary.

e) Ash:

No distinct cyclical change in the ash content was observed in the three tissues during the maturity stages except that they closely followed the fat, protein and carbohydrate patterns (Fig.14e).

There was no significant difference in the ash content between the sexes, except that the values were little higher in the flesh of males.

The ash content was maximum in the liver tissue of the female during stage-III (1.63%) and minimum in the muscle tissue of female during stage-IV (1.30%). The variations between stages were more pronounced in the muscle than in the liver or gonads.

7.3.2 Biochemical composition of *N. mesoprion* in relation to maturity cycle

a) Water content:

The moisture curves in all the three tissues in both males and females were plotted in Fig.15a.

The moisture content in the body muscle of female increased from 71.9% in stage-I to 78.9% in stage-IV and decreased to 73.5% in stage-V. The water content of the muscle of male also showed the same trend. However, the lowest value was obtained in stage-V (72.4%) in the muscle tissue of male.

The variation in water content seemed to be less pronounced in the liver than in the muscle or gonad. The hepatic moisture percentage ranged from 72.9% in stage-V to 79.1% in stage-I in the females whereas the value was minimum in stage-III (71.6%) and maximum in stage-I (77.8%) in the males. The percentage of water in the gonadal tissues were not distinctly different in both the sexes. It seemed to decrease from stage-I (83.5% in females; 84.4% in males) to stage-III (76.9% in females and 79.5% in males) and thereafter increased to 82.9% in females and 83.8% in males in stage-V.

b) Fat:

The content of fat in the body muscle showed a decline towards stage-IV (2.6%) from stage-I (14.4%) and inclined to 5.8% in stage-V in the females. The trend was similar with a little lesser value in the males except in stage-V (6.1%).

The liver fat showed a steep rise from 8.3% in stage-I to 24.0% in stage-III in the females and thereafter a steady decline (15.0%) in stage-V. The male hepatic tissue did not show any variation from the value in the females.

The gonadal lipid seemed to be steadily increasing from stage-I (7.8% in females and 6.9% in males) to stage-IV (20.8% in females and 19.4% in males) and then slowly decreasing in stage-V (19.3% in females and 17.6% in males) as shown in Fig.15b.

c) Protein:

The concentration of protein was identical in both the sexes in the liver and gonad. However, the steady decline during maturation in the muscle content, in both the sexes was evident from Fig.15c.

The content of protein in the flesh was highest in stage-I and lowest in stage-IV, almost identical to that of the muscular fat value. The value ranged from 66.1% in females and 64.3% in males during stage-I to 57.9% in females and 58.2% in males during stage-IV.

The liver protein in the females increased from 70.1% in stage-I to 74.5% in stage-III and decreased to 73.1% in stage-V whereas the male hepatic protein increased from 71.3% in stage-I to 74.5% in stage-IV and decreased to 72.9% in stage-V.

The gonadal protein also showed a similar pattern as in the liver with a maximum value of 72.0% in stage-III (in females) and a minimum value of 60.9% in stage-I (in the males).

d) Carbohydrate:

The carbohydrate percentage alternate during different stages of maturity (Fig.15d).

The muscle carbohydrate content decreased from 0.83% in stage-I to 0.31% in stage-III and then increased to 0.46% in stage-V in the females. In male also muscle carbohydrate value showed the same trend, but with a lower value.

In the females the hepatic and gonadal percentage was higher than in the muscle and showed an increase from stage-I to stage-IV and stage-III respectively. The value was 3.4% during stage-I and 6.7% in stage-IV in the liver. The carbohydrate in the liver of male was higher than in the female of 4.9% in stage-I and 7.6% in stage-IV. The ovarian carbohydrate content increased from 4.8% in stage-I to 5.9% in stage-III and declined to 4.4% in stage-V whereas the testicular value showed a lower degree of variation from 4.2% in stage-I, 5.1% in stage-III and 4.1% in stage-V.

e) Ash:

The ash content analysis do not reveal any well defined pattern during maturity (Fig.15e).

The muscular ash in the female declined from stage-I (1.7%) to stage-IV (1.25%) and then slightly increased to stage-V (1.4%). The male muscular ash content also decreased from stage-I to stage-IV.

However, the hepatic ash value slighly increased from 1.6% in stage-I to 1.78% in stage-IV and decreased to the same value as in stage-I, during stage-V in the females. The male value was maximum during stage-IV (1.8%) and minimum during stage-V (1.5%).

The ovarian and testicular ash percentage increased from stage-I (1.3% in males and 1.4% in females) to stage-IV (1.63% in males and 1.56% in females) and then returned to the minimum value during stage-V.

The ash content showed higher values in the males than in the females in the gonads and liver, unlike in N. japonicus where the values were higher only in the muscle.

7.3.3 Biochemical composition of N. japonicus in relation to length groups

a) Water content:

The moisture percentage in muscle, liver and gonads in different length groups of N. japonicus were shown in Fig.16a.

In the flesh of the lowest size group females the water content was 78.3% and it declined to 74.9% in the highest size group, but with a higher value of 80.3% in the third size group. The males also showed a similar percentage trend for moisture, increasing from the lowest size group to the third size group and then gradually declining towards the highest size group. On an average, the males showed a slightly higher percentage of moisture in the muscle than the females.

The hepatic water content in both the sexes were also showing more or less the same pattern as in the muscle, which increases from the lowest size group to the third size group and then gradually declines in the highest size group. In the females it increased from 68.3% to 71.8% and then declined to 61.1%. In males, moisture content was slightly higher only in the lower three size groups as compared to the females.

In the ovary, the depletion range was from 70.3% in the lowest size group to 65.2% in the highest size group, having a small peak in the third size group of 73.1%. But the testicular moisture percentage steadily declined from the lowest size group to the highest size group. Generally, in the gonads also the initial three size groups exhibit a slightly higher value for the males.

b) Fat:

The fat content in the flesh, liver and gonads were calculated for various length groups of females and males and graphically plotted in Fig.16b.

The muscular fat percentage was observed to decrease from the lowest to the third size group and then increased gradually to the highest size group; showing an inverse relationship with the moisture content. The fat percentage varied from 4.2% (smallest size group) to 3.0% (third size group) and 8.5% (highest size group) in the females but a slightly lower value of 3.1%, 2.5% and 7.5% was noted in the males, respectively.

The inverse relationship with the moisture content was evident in the liver and gonadal tissues also. The hepatic value increased from 7.6% in females and 6.8% in males of the lowest size group to 18.0% in females and 17.4% in males of the highest size group. The females attained a higher range of lipid content in the liver, than the males. The lipid in the ovary was 7.9% in the smallest length group whereas it increased to 17.8% in the largest length group. However, the testicular value, which was greater than the ovarian fat percentage, ranged from 6.1% in the smallest length group to 18.3% in the largest length group.

c) Protein:

The mean percentage of protein in the muscle, liver and gonads in different length groups of males and females were represented in Fig.16c.

The variation in trend was more or less parallel to that of fat/water relationship in all the three tissues. The maximum percentage in the flesh was observed in the highest length group (61.7%) females which increased from the third size group (54.7%), whereas the lowest males value of 54.0% observed in the third size group increased to 62.0% in the highest size group showing a slightly higher average value for the females.

The protein in the liver of females steadily increased from 65.1% in the smallest size group to 76.1% in the highest size group. The male hepatic protein also increased from 63.3% to 76.8%, respectively. Generally, the females were having more protein in the liver. The gonadal protein steeply increased from the smallest size group (58.3% in females and 62.9% in males) to the highest size group (75.6% in females and 76.0% in males) in both the sexes, but with a slightly higher value for the male percentage.

d) Carbohydrate:

The carbohydrate percentage showed definite increase from lower to higher length groups in all the three tissues in both the sexes (Fig.16d). The carbohydrate content was generally low when compared to other constituents.

The carbohydrate percentage in the muscle of females ranged from 0.36% to 1.0% in the smaller to higher size groups. However, a low percentage for males in the flesh was observed in the smallest length group of 0.28% and in the highest length group of 0.91%.

The hepatic and gonadal carbohydrate values were also shown to be slightly higher in the females. In the liver the smallest size group females showed 0.84% and the highest but one size group (ie. VII group) showed an increase of 3.6% whereas the ~~smaller~~ males ~~carbohydrate percentage~~ increased from 0.96% to 3.5% in the highest group males.

The ovarian values for carbohydrate percentage ranged from the lowest value of 1.9% in the smallest length group with two peaks of 3.9% in the VIth and VIIIth (highest) length groups. The testes value increased from 1.5% in the IInd smaller group to 3.85% in the VII the and VIIIth (highest) length groups.

e) <u>Ash</u>:

The variation in the levels of organic constituent during growth in the three tissues viz. muscle, liver and gonads were plotted in Fig.16e.

The ash percentage in all the three tissues showed a similar declining trend from the smaller size group to the fifth or sixth group fishes in both the sexes. The female ash content was maximum in the muscle in the smallest size group (1.53%) and it declined to a minimum value of 1.1% in the sixth size group and then showed a slight increase to the largest size group. The male flesh ash percentage also exhibited a similar trend.

The hepatic mineral content of 1.68% (females) and 1.7% (males) in the smallest size group dropped to a minimum value of 1.1% (females) and 1.15% (males) in the sixth size group and then slowly increased to 1.35% (females) and 1.38% (males) in the highest size group.

The ovary and testes were also showing the same trend. They fell from 1.62% and 1.61% in the smallest size group to 1.0% and

1.1% in the sixth size group respectively, thereafter showing a slight increase of 1.39% for ovary and 1.34% for testes in the largest size group fishes.

7.3.4 Biochemical composition of *N. mesoprion* in relation to length groups

a) Water content:

The muscle, liver and gonad water percentage in different length groups were graphically shown in Fig.17a.

The moisture content increased from the lowest size group females and males to the third size group and declined gradually to the highest size group. The value for females ranged from 78.1% in the smallest length group, 80.5% in third size group and 76.1% in the highest size group whereas in the males it ranged from 77.65%, 79.6% and 76.4%, respectively. The female muscle registered a slightly higher value of moisture than in the males as against as in *N. japonicus*.

The hepatic moisture content was higher in the females in the smallest and highest size groups, but the trend was generally decreasing towards the highest size group in both the sexes. The ~~female liver~~ moisture content of liver in females was 74.0% in the smallest size group from where it decreased to 62.8% in the VIIth size group and the male value ranged from 73.8% in the lowest to 62.1% in the highest size group. The gonadial moisture content declined from 73.8% in the smallest to 68.0% in the highest group females. The testicular value decreased from 75.0% to 66.6% in the highest size group.

b) <u>Fat</u>:

The percentage of lipid was shown in Fig. 17b for the males and females of various length groups in all the three tissues.

The muscular fat decreased from 6.9% and 6.0% in smallest size group females and males to 4.4% and 4.2% in the third size groups respectively and then gradually increased to 8.6% and 8.4% in the highest size group females and males. The same trend was observed in the liver fat also. The female hepatic lipid decreased from the lowest size group (8.8%) to the third size group (6.1%) and then increased to 16.0% in the highest length group. The lipid content of male liver ranged from 8.1% (lowest size group) to 6.0% (third length group) and 16.2% (highest size group).

But the ovarian and testicular fat percentage gradually increased from the smallest to the highest length group. The ovarian fat was 6.8% in the lowest size group which increased to 25.3% in the highest size group. The testicular value increased from 6.4% in the lowest length group to 25.6% in the highest length group.

In all the three tissues the inverse relationship with moisture content was pronounced. The muscular and hepatic fat percentages were slightly higher in the females, but the gonadal percentage was generally higher in the males.

c) Protein:

The protein content in various length group of fishes, in both male and female, from the three tissues muscle, liver and gonads were drawn in Fig.17c.

In general, the protein percentage in all the three tissues were directly related to the increasing length and the females were showing a higher concentration throughout, irrespective of the increase in length.

The protein in the flesh of females showed a slight decline from smaller to third size group (69.0% - 63.4%) and then increased gradually (76.8%) in the largest length group. The males were also showing the same trend.

The hepatic protein steadily increased from 67.6% in the lowest size group females to 81.0% in the highest size group, whereas it increased from 69.8% to 80.9% in the respective males. The ovarian protein content increased from 63.2% in the smaller group fishes to 77.0% in the higher length group fishes. The testicular concentration also increased from 63.2% in the lowest size group to 76.1% in the highest size group.

d) Carbohydrate:

The carbohydrate values in all the three tissues for both male and female N. mesoprion are graphically represented in Fig.17d.

The definite increase in carbohydrate percentage in all the three tissues during the attainment of length was more pronounced than for protein and lipid, eventhough the values were very low. The values were clearly higher in the females than in the males, as in *N. japonicus*.

The carbohydrate content of body muscle increased from 0.41% in the smallest to 0.94% in the highest size group females. In males, the percentage increased from 0.28% to 0.93% towards larger size groups. The liver carbohydrate of females increased from 0.78% to 3.7% from smaller to higher size groups, and the liver content of males also showed an increase from the smallest (0.80%) to the highest size groups (3.6%). The carbohydrate content in smaller size group ovary was 2.0% whereas in the smaller size group testes it was 0.91%. Both the ovarian and testicular carbohydrate increased to 4.8% and 3.7% respectively in the highest size group fishes.

e) Ash:

The mineral percentage of *N. mesoprion* showed the same trend as that of *N. japonicus*, as evident from Fig.17e.

The ash percentage in the flesh of male and female were maximum in the smallest size group and minimum in the sixth size group. The initial ash value ranged from 1.48% to 1.08% and then slightly increased to 1.2% in the maximum size group females, whereas in male the value was 1.5% in the smallest size group, 1.01% in the sixth size group and 1.19% in the highest size group. The hepatic ash content in the female fishes were 1.68% (in the smallest size group), 1.18% (in the sixth size group) and 1.27% (in the largest size group). The ash percentage in the liver of males ranged from 1.7% to 1.14% and 1.28% in the respective size groups.

The ash content in the gonads were maximum in the smallest size group. The ovarian percentage was 1.58% and the testicular value was 1.6%. But the minimum value was obtained in the fifth size group fish. The fifth group females showed 1.13% and males showed 1.08%. Thereafter it showed a slight increase of 1.2% and 1.18% in the maximum size group females and males respectively.

7.4 DISCUSSION

7.4.1 Biochemical composition of *N. japonicus* and *N. mesoprion* in relation to maturity cycle

a) Moisture:

Water plays a decisive role in most of the biochemical functions in view of its ionic properties and due to its association with other constituents in their functions. Black et al. (1961) reported that water serves not only as a nutrient but also as a nutrient carrier in fish. Since water functions as the 'mileu' for all biochemical operations, the equilibrium state established between water and its component system must also vary with physiological activities such as maturation and spawning. The maturation of gonads of _N. japonicus_ and _N. mesoprion_ under study is accompanied by considerable changes in the moisture content in various tissues.

The moisture percentage of the muscle was minimum in immature (stage-I) and high in ripe (stage-IV) and spent (stage-V) stages. The ~~flesh~~ moisture content in the muscle tissue gradually increased from immature to the ripe fishes. Dambergs (1964) reported that the water level of the muscle tissue increases with maturation. In the liver, the highest water content was recorded in immature and spent fishes. The lowest moisture level in liver was noted in the mature fishes. The highest moisture values were recorded from the liver of spent fishes (Jafri and Khawaja, 1968). The gonadal water content decreased from a high value in the immature to the mature fishes and increased again in the spent fishes. The advancement towards maturity was associated with a very rapid fall of moisture in the ovaries and the lowest values coincided with peak ripeness as observed by Craig (1977).

It is found that in the Nemipterids, the water content in the liver and gonad generally showed a slightly higher value for the males whereas in the muscle the females were having a higher value. Interestingly, this can be correlated with the mineral content, which will be discussed later.

All those factors which affect the fat cycles may also influence the moisture cycles (Iles and Wood, 1965). The correlation between the varying moisture content of different tissues and maturation may be indirect, as the changes in moisture content variation may be more directly related to the altering fat, protein and carbohydrate content during maturation which are discussed under appropriate titles below.

b) Fat:

The maturation results in an extensive depletion of lipid reserves in the flesh. In both the Nemipterids, irrespective of the sex, the maximum level of muscle fat in immature fishes declined to a minimum level on the attainment of maturity. Depletion of fat from the immature to the ripe stage in the body muscle was observed by Lovern and Wood (1937) and Sathyashree (1981). The hepatic fat content gradually increased from immature to mature (stage-III) *N. japonicus*. However, the increase was more steady in *N. mesoprion*. But then it showed a decline during ripe and spent stages in both the sexes. Highest values of liver precede peak ripeness of gonads and with the onset of spawning a drain in the liver fat seemed to occur. Utilization of the stored lipid for the growth of sexual cells and energy metabolism results in the depletion of the storage of the lipid during spawning (Schehepkin, 1972). Earlier reports by Bull (1928) and Medford and McKay (1978) and recent observation on *N. japonicus* by Krishnaveni (1986) also state that the stored liver lipid is utilized during gonadal maturation and spawning and the metabolic demands of the developing gonads are met by the fatty reserves of the liver.

The fluctuation in gonadal lipid content and maturity stages were highly synchronized. The low values during maturing (stage II) stage may be due to the recovering spent phase, but the followed accumulation of fat in the gonad during mature phase results in its highest concentration during ripe stage. In post spawning fish due to spent phase the lipid was again depleted. The advancement of maturation is accompanied by an increase in the gonadal fat in the Nemipterids, as reported in several other fishes by Bruce (1924), Ramaswamy (1955) and Idler and Bitners (1958). Lipid from the liver, muscle or gut is transferred to the gonads to supply energy during maturation (Shatunovski et al. 1975). The decline in the high muscular fat from immature to ripe Nemipterids indicates that the building up of fat occurs first in the muscle and the corresponding increase in the gonadal fat may be due to its subsequent diversion from muscle to gonads. However, the muscle lipid decline from stage I to stage II do not show any corresponding increase in the gonad, possibly due to the utilization of fat for growth purposes. The drainage of liver fat from mature to spent fishes of _N. japonicus_ and _N. mesoprion_ suggests that the utilization of muscle fat alone does not fulfil the demands of gonadial maturation and so the liver fat is called upon to meet the demands at final stages of maturation. Translocation of lipid from muscle and liver to the gonad during maturation has been proved in other fishes by Rao (1967) and Plack et al., (1971). Correlating the seasonal variation in the gonadal growth and the level in the serum of gonadal steroids and serum total lipids, Dindo and Mac Gregor (1981) suggests that the lipid deposition and subsequent mobilization are associated with autumnal reproductive cycle.

The changes in the fat cycle in all the three tissues shows an inverse relationship with the moisture content in the Nemipterids. The relationship was noted in various other fishes as long ago as 1888 by Atwater to as latest as 1986 by Sivakami et al. and in Nemipterids itself by Krishnaveni (1986).

c) Protein:

Protein percentage in all the three tissues in both *N. japonicus* and *N. mesoprion* male and female follow a similar trend as that of fat, during the maturity cycle. The muscular protein gradually declined from immature to ripe fishes. The decline was more pronounced in the ripe females. But the value again increased when the fishes were spent. Building up of gonads is accomplished at the expense of body proteins. Mc Bride et al., (1960) and Masurekar and Pai (1979) have reported that much of the gonad tissue is built from proteins derived from the muscle. The pronounced decline of muscle protein in ripe females may be due to the high deposition of nucleoproteins in the ova during maturation. The increase in muscle protein in spent fishes suggests a possible stop in the withdrawal and utilization of protein for gonadal build up.

The hepatic protein level increases from immature to ripe fishes. An advancement towards maturation results in a greater accumulation of protein reserves in the liver indicating that liver probably meets the nitrogen demands of the body (Jafri and Khawaja, 1968). The enormous increase in liver protein towards ripeness in Nemipterids in comparison with the gonadal protein level could also possibly be due to the increased feeding during maturation of these fishes (Krishnaveni, 1986). The decline in liver protein from mature/ripe stage to spent stage is evident in male and female Nemipterids. Expenditure of liver protein for the purpose of germ building at later stages of maturation has been proved by Sorvachev and Shatunovski (1968).

The protein cycle in both testes and ovaries seems to be definitely influenced by the maturation of gonads. In both the sexes the highest gonadial protein is recorded in mature/ripe fishes. The steep rise of protein in the gonads of maturing to mature fishes indicates a peak period of synthesis and mobilisation of proteins as gonad build up advances. As reported by Jafri (1969) in Wallago attu, the accumulation and diminution of protein were more rapid in the Nemipterid ovaries also, than in the testes, may be because of a greater deposition of nucleoproteins in the ova.

An inverse relationship is discernible between moisture and protein in all the three tissues. The relationship between moisture and protein in the process of maturation is so glaring that the whole process may be observed by means of water determination. As protein is removed from the muscle, the water content increases steadily and hence can be used as a useful index of the state of depletion of the fish (Love, 1970).

d) Carbohydrates:

Physical exhaustion can profitably be studied by means of carbohydrate analysis in mammals, but not in fish. This is evident from the low value of carbohydrate in the flesh of Nemipterids also. Moreover, the intake of carbohydrate in the diet of Nemipterids seems to be very low (vide Chapter 3). Most of the energy needed for spawning migration in salmonids is derived from lipids or from glucose (Love, 1970). The muscle carbohydrate declined from immature to mature fishes, reaching as low as 0.30 mgm% (N. mesoprion male, Fig.15d). Thereafter it increased during ripe and spent stages. A decrease in muscle carbohydrates during spawning was noted by Bentley and Follet (1965). This may be possibly due to the conversion of the glycerol from muscle fat into carbohydrate through gluconeogenesis which leads to the maintenance of an adequate glucose level necessitated both by greater muscular activity and maturation of the gonads, as evidenced by the decrease of muscular fat during ripe stage.

The liver is generally considered to be the main store house of carbohydrate, chiefly in the form of glycogen, in the fishes (Fontaine and Hat ey, 1953). In Nemipterid liver the carbohydrate percentage increased from immature to ripe stage and declined during spent stage. The steady fall of hepatic carbohydrate from ripe to spent stages goes well with the findings of Chang and Idler (1960) that liver glycogen was preferentially depleted during spawning. In the early stages of maturation, the glycogen content of males is 50-100% greater than in the females, but the picture is reversed immediately before spawning (Bogoyablenskaya and Vel'tischcheva, 1972). In the present study, the Nemipterid liver carbohydrate content of males is greater than in the females. However, the earlier authors, Bogoyablenskaya and Vel'tischcheva (1972) concluded that, though much of the energy for fishes comes from gluconeogenesis, a greater vigour for this mechanism has been found in the males, but the onset of spawning causes expenditure of lipid from the body of females and glycogen from the males. Glycogen concentration in the liver of spawning Salmo salar was found to be only 0.5 mg/g in the females whereas it was 24.9 mg/g in the males (Fontaine and Hat ey, 1953) which also suggests the utilization of hepatic carbohydrate for gonadal development.

The gonadal carbohydrate content which increased from immature to mature fishes seems to have decreased during ripe and spent stages. A possible explanation at this juncture would be that when fat and protein have accumulated in the gonad, the role of carbohydrate becomes negligible. In fact, carbohydrate renders its services when there is a fall in lipid and protein levels. This is in agreement with the observation made by Kuo (as quoted by Nash and Shehadeh, 1980) that the carbohydrate level in the gonads decreased distinctly prior to spawning. However, Greene (1926) and Yanni (1961) opined that glycogen and glucose have both been found to accumulate in the ovary during maturation. But the changes in the carbohydrate reserves of the fish seem mostly to reflect the requirements of the developing ovaries.

The carbohydrate percentage does not exhibit any distinct relation to the moisture content in general, but for an inverse relationship in the gonads.

e) Minerals:

The inorganic ions in relation to maturation seems to show changes of a random nature (Love, 1970). In the Nemipterids studied, the ash content of the flesh decreased from immature to mature/ripe stage with a corresponding increase in the liver and gonad, respectively. The minerals required for gonad build-up in these fishes seem to have been evidently transferred from muscle through liver to ovary. The decrease in the liver ash during maturation seems to indicate the transfer of essential inorganic ions from liver to gonad; whereas the decrease from ripe to spent gonads suggests the withdrawal and utilization of phosphorus and other ions for egg build up. Another probable reason could be that the Nemipterids feed maximum during mature and ripe stages. However, the evidences are limited. The reason is most probably that, most of the works has been carried out on fish which ascend rivers to spawn, and the migration from salt water to fresh water, coupled with a loss of ability to osmoregulate after spawning, causes an overall loss of ions which masks the effects caused by maturation (Love et al. 1968). Even in non-migrating fishes, the variations in inorganic ions are not only related to maturation but also with other factors like depletion (Love, 1970).

However, the ash content seems to have an inverse relationship with the moisture percentage in the present study. The flesh mineral content has a strong negative correlation with the moisture. Maturation is seen to be accompanied by an increase in the water content of the muscle, and concurrently the predominantly extracellular ions sodium and chloride increase, while the intracellular potassium , magnesium and phosphorus decline (Sutton, 1968). Surprisingly, the low water content in the male muscle and high water percentage in the male liver and testes also seems to have a pronounced inverse relationship with the high ash content in the male muscle and low ash in the male liver and testes.

7.4.2 Biochemical Composition of *N. japonicus* and *N. mesoprion* in relation to length groups

a) Moisture:

In the young stage of fish, when the cells are dividing rather than increasing in size, a higher proportion of extracellular space results in more net water , sodium and chloride, all of which diminish as the fish grows. When the number of cells has reached a stable figure the water content becomes constant. The water content in the tissues like muscle, liver and gonads undergo a series of changes in the fishes under study, *N. japonicus* and *N. mesoprion*, when they grow in length.

The moisture percentage in the muscle attained a maximum value in the third size group fishes and declined to a minimum level in the highest size group, in both *N. japonicus* and *N. mesoprion*. The decrease in body water content associated with growth, as seen in this study, has also been reported in other species of fishes like herring (Balbontin et al., 1973) and Salmon (Parker and Vanstone, 1966). Corti (1950) opined that in the artificially reared Rainbow trout, the body moisture becomes progressively a smaller portion until at 300 days. The decreasing percentage of water with increasing length in herring appears to be a continuation of the phenomena from the larval stage, and is typical for cell division and growth (Houstan and Threadgold, 1963). The peak in moisture percentage seen in the medium (third size group) sized fish may perhaps be due to first spawning or starvation. The largest fish, all of which had spawned at least once already, showed the highest water content at the spawning time, when they were physically weak (Love, 1970).

The hepatic water content in N. japonicus increased from the smallest to the third size group and then decreased to a minimum value in the highest size group. But in N. mesoprion it steadily declined from the smallest to the highest size group. The gonadal water percentage also decreased from the smaller to the higher size group in both the Nemipterids. The variations observed in the constituents therefore seems to be related with the variations in the metabolism during growth and maturation (Bano, 1978).

However, it is interesting to note that the highest percentages of water in the tissues occurred when both fat and protein were at their minimum. Paton (as quoted by Idler and Bitners, 1958) while commenting upon the water changes in the muscle of migrating Salmo salar states: "It is this increase in the percentage of water of the flesh which maintains the weight of the fish per fish of standard length, although the solids as a whole have diminished". As discussed earlier, the variations in moisture are directly related to the variations in the solid constituents than to the physiological conditions which are further discussed below.

b) Fat:

The muscular fat in both sexes of the Nemipterids studied declined from the lowest to the third size group and then inclined to the highest size group. The increase in muscle oil during growth has been reported in many other species of fishes like Anguilla, Cyprinus carpio, Gadus morhua, Sardinella longiceps, etc. (Love, 1970). Hornel and Nayadu (1923) interpreted the relationship simply that older fishes are able to lay down reserves more readily because their growth rate is then slower. The hepatic and gonadial lipid also increased during growth, from the smallest to the largest length group, apart from a slight decline in the third size group liver content of N. mesoprion.

The reasons attributed to the change in lipid content in the muscle, liver and gonadial tissues during growth are numerous. The initial decline in the fat seems associated with the maturation of gonads and spawning as has been reported in many other species, or it may be due to the rapid utilization of fat in the early stages when the growth is fast. The subsequent increase in the larger fishes is rather difficult to interpret and may perhaps be entirely due to slowing down of growth (Khawaja and Jafri, 1967). The increase in the relative size of the liver of the Baltic herring increases as the fish grow, and as the size of the liver increases, so does the yield of oil per unit weight (Krivobock, 1964). Corti (1950) reported that from 37 days, the lipid decreased at 84 days, but then increased upto 300 days in reared Rainbow trout. Philips et al., (1957), Balbontin et al., (1973) and Perera and De Silva (1968) observed in various species of fishes that the correlation of increased lipid during growth does not exist in wild fish, suggesting that the lipid deposition is influenced partially by the quality of food and partially by the lack of activity in the confined space of the rearing area.

However, Parker and Vanstone (1966) suggested that the increase in total lipid content during growth is partly due to ontogenic increases in relative lipid. Some reason for this fluctuation can be attributed to diurnal variation in total body weight, resulting from fluctuation in body moisture. As shown by Steinberg (1963) and Needham (1964) the hormonal influence may also cause variation in the fat content during growth. Besides this, temperature of the external medium seems to influence the fat content of some fishes (Johnstone, 1917). Thus, various factors together contribute to the accumulation of fat during the growth of the fishes.

The proximate analyses of Nemipterids reveal a definite reciprocal relationship between moisture and fat content, as was reported by Bruce, as early as 1924 in herring and as late as in

1986, by Mukundan, in some fresh water fishes. Iles and Wood (1965) have classically shown in older herring that there is a general inverse relationship between fat and moisture content.

The changes in relative body composition obviously occurred in an orderly and progressive manner with growth, and it appears evident that the selective decrease in moisture accompanied by relative increase in lipid, protein and in combination, can be considered as a general ontogenesis (Parker and Vanstone, 1966).

c) Protein:

The muscular protein content in the Nemipterid fishes decline from the smallest to the medium (third) size group and then steadily increase towards the largest size group. The reduction in protein in the medium size group indicates that probably an active protein synthesis occurs in the muscle during this stage. A corresponding steady increase in the gonadal and hepatic protein also suggests that probably much of the muscular protein reserve is mobilized for the early phase of growth and maturation of the gonads. The steady increase in the gonadal and hepatic protein content may possibly be due to the active feeding habit of these fishes during spawning season also.

The increase in the hepatic and gonadial proteins right from the smallest size group to the largest size group of Nemipterids observed in the present study is further substantiated by Parker and Vanstone (1966) in Salmons. According to Bano (1978) the initial fall in protein may be due to reduction in the cell number with increasing size. Ironside and Love (1958) pointed out a decrease in the solubility of the muscle protein and a fall in the DNA content during growth. The haemoglobin content of the blood of several fishes increase as the fish grow (Das, 1965). The accumulation of protein in the larger size group fishes may also be due to lesser utilization in the senescence stage.

The protein and moisture contents in both the Nemipterid species are inversely related, like the fat/water relationship. The negative correlation is more pronounced in the flesh of these fishes. This has been earlier studied and established by many authors. Love (1962) opined that as protein is removed from the muscle, the water content rises steadily and so is a useful index of the state of depletion of the fish.

d) Carbohydrate:

The carbohydrate content exhibited a very low profile in all the three tissues of the Nemipterids, when compared to other constituents. But the variation was significant like in the other constituents. The carbohydrate percentage in the flesh, liver and gonads generally increased when the size of the fish increased, ie.

the carbohydrate percentage is positively correlated with the size of the fish. But there was a very slight steadiness in the gonadial carbohydrate percentage in the second and third size group fishes. The less carbohydrate in the smallest size group fishes and slackness in the smaller size group fish gonads may perhaps be due to rapid utilization of carbohydrate during growth and spawning. The increase in the higher size groups may be associated with the decreasing growth rate. Similar findings were observed by Krishnaveni (1986) in N. japonicus. Kelly (1969) noticed that the muscle of large Gadus morhua, sometimes after death, tends to reach a lower minimum pH, than that of small fish. Low pH results from the accumulation of lactic acid, derived in turn from carbohydrates, so it is possible that larger fishes hold larger reserves, as a buffer against depletion.

The variation in the carbohydrate percentage mostly depends on the physiological stage of the fish. Glycogen, the main carbohydrate in the muscle, was likely to be altered due to various reasons such as exercise, food constituents, starvation, etc. (Miller et al., 1959). Frazer et al. (1965) reported that the method of killing, degree of struggling and exercise prior to death as well as holding temperature after death might also effect the carbohydrate content in fishes.

e) Minerals:

The ash content, which gives an index of the total quantity of various inorganic elements in the body, generally decreases during growth in the muscular, hepatic and gonadial tissues of the Nemipterid fishes. The earlier reports, as reviewed by Love (1970) showed no consistent relationship between the size and the mineral content of the fish, but were rather confusing. The sodium and potassium content showed wide variations, but the mineral composition was seen to be relatively uniform, regardless of species, size, season or fishing ground (Thurston, 1961). But Mc Bride and Mac Leod (1956) found that the muscle sodium of small fishes were greater than in the large fishes. However, in general the larger fishes are more depleted than the smaller ones, and a greater demand for inorganic elements during early phase of growth seems valid (Khawaja and Jafri, 1967). Sathyashree (1981) and Jayalakshmi (1987) also supports these findings in various other species of fishes.

In short, certain conclusions can be arrived at for better understanding of the nutritive value of Nemipterid fishes and their dietary significance. The moisture and fat content showed an inverse relationship in all the tissues. The muscle protein and fat are at the maximum level in the early stages of maturation and also in the larger size groups. The inorganic ions were at the peak in the early stages of maturation. Hence, the larger fishes during the early stages of maturation seem to have high fat and protein content in the muscle, which possibly could be utilized as an alternative source of high protein food for human consumption.

Fig.14 Moisture (% wet weight), protein, fat, carbohydrate and ash (% dry weight) content in muscle, liver and gonad of N. japonicus in relation to maturity stages.

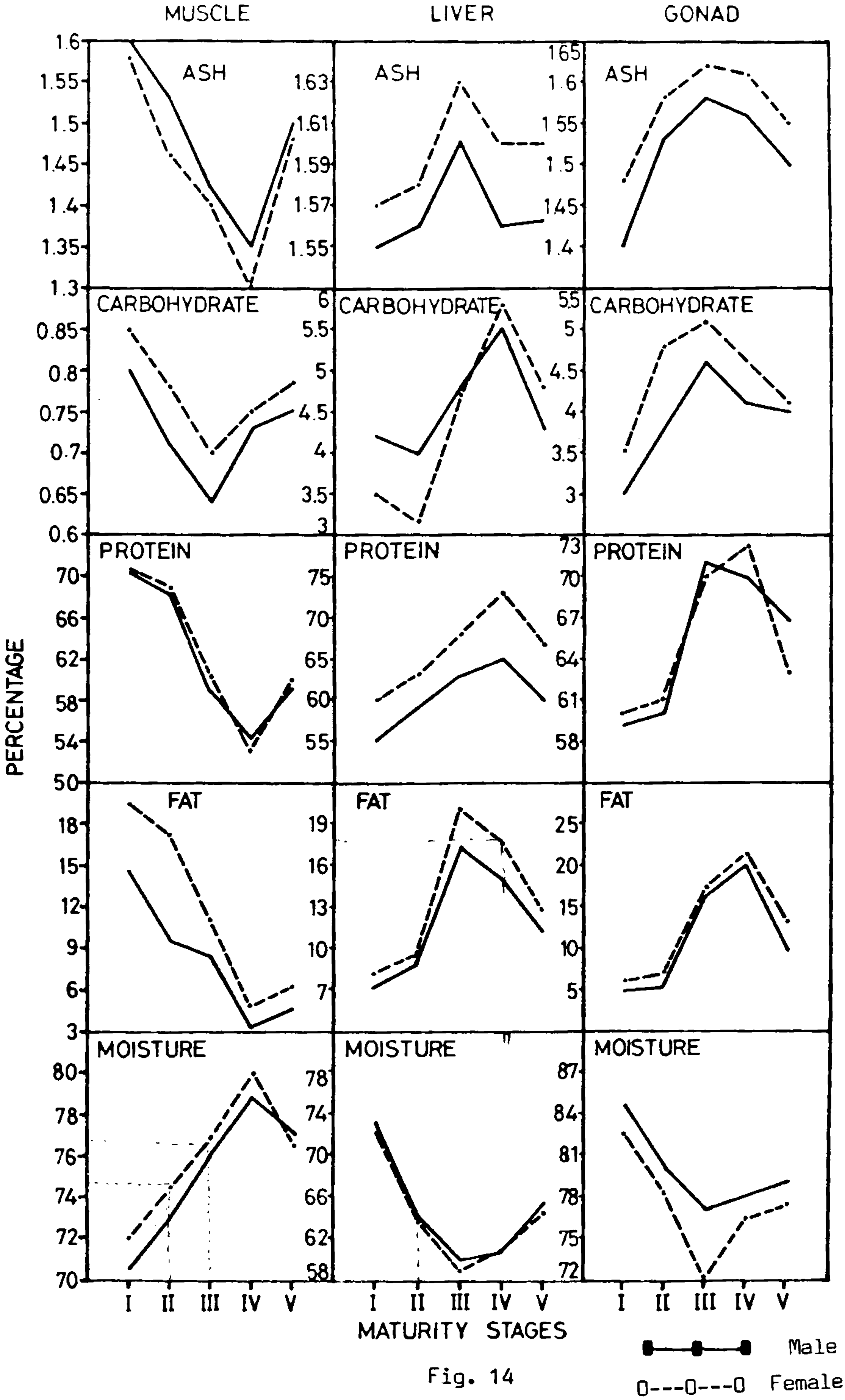
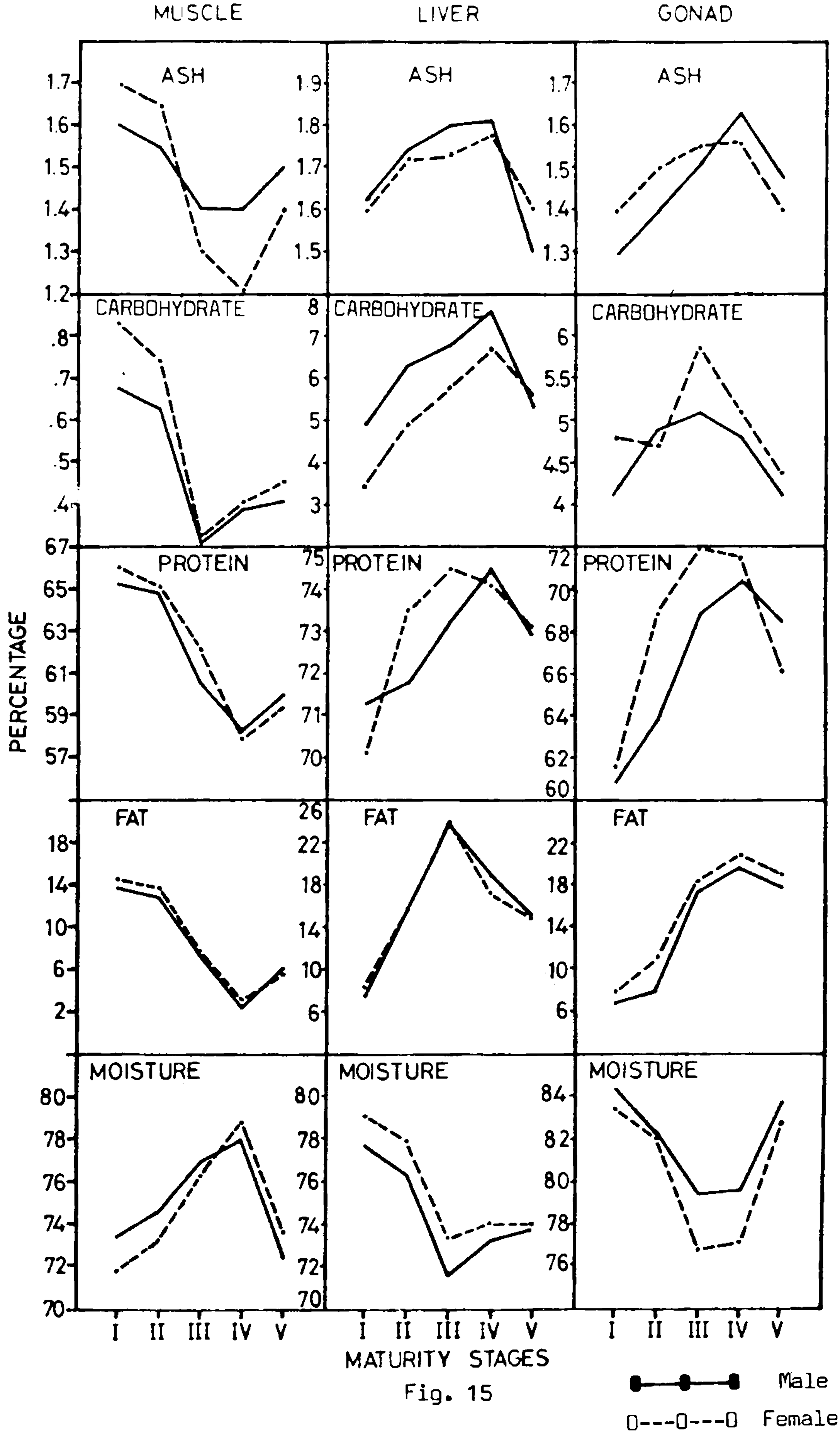

MUSCLE
LIVER
GONAD
ASH
CARBOHYDRATE
PROTEIN
FAT
MOISTURE
PERCENTAGE
e
d
c
b
a
I II III IV V
MATURITY STAGES
Male
Female

Fig. 14

Fig.15 Moisture (% wet weight), protein, fat, carbohydrate and ash (% dry weight) content in muscle, liver and gonad of N. mesoprion in relation to maturity stages.



MUSCLE
LIVER
GONAD
ASH
CARBOHYDRATE
PROTEIN
FAT
MOISTURE
PERCENTAGE
e
d
c
b
a
I II III IV V
MATURITY STAGES
Male
Female

Fig. 15

Fig. 16 Moisture (% of wet weight), protein, fat, carbohydrate and ash (% dry weight) content in muscle, liver and gonad of N. japonicus in relation to length groups.

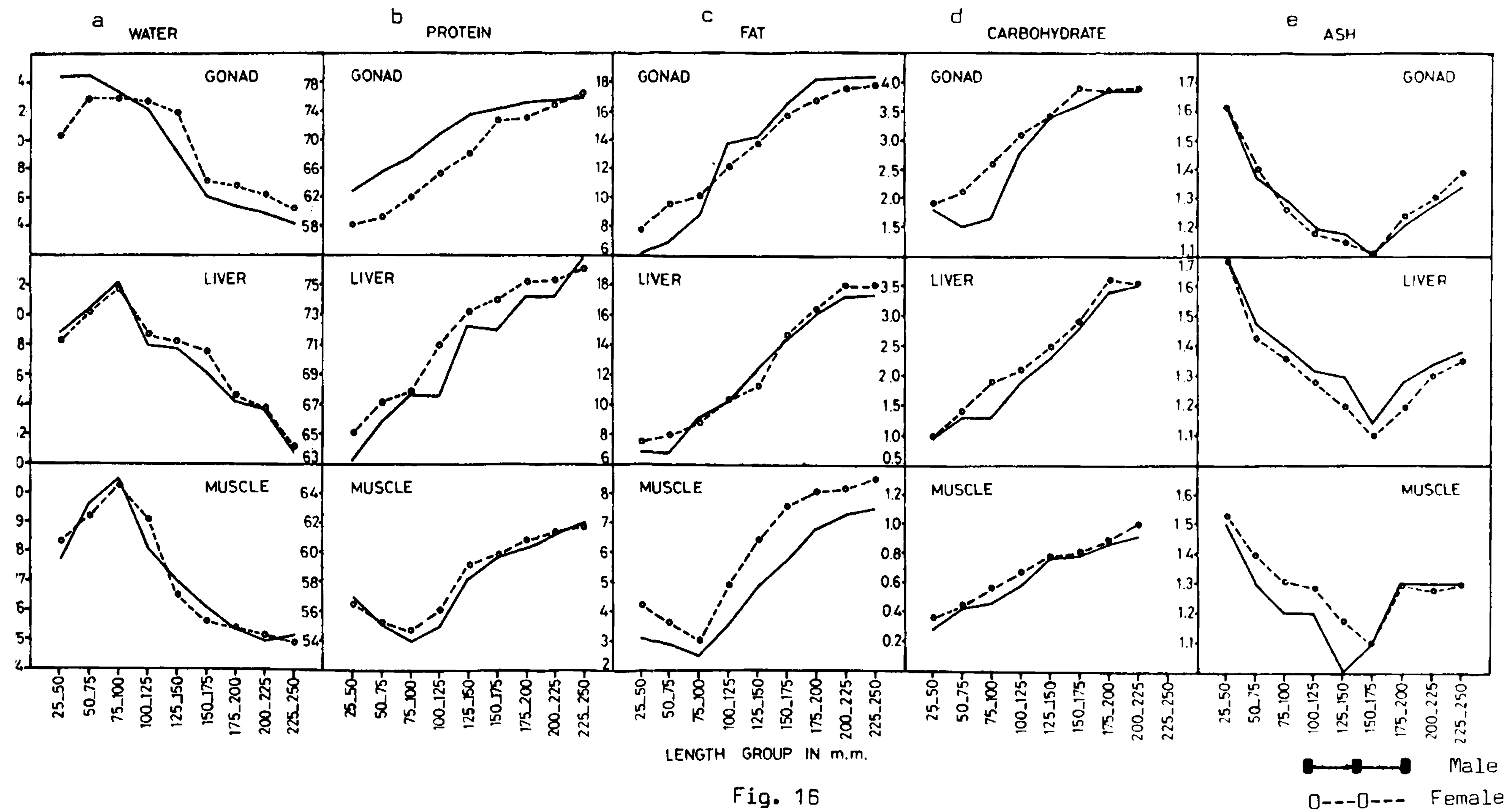

a WATER
b PROTEIN
c FAT
d CARBOHYDRATE
e ASH
GONAD
LIVER
MUSCLE
LENGTH GROUP IN m.m.
Male
Female

Fig. 16

Fig. 17 Moisture (% wet weight), protein, fat, carbohydrate and ash (% dry weight) content in muscle, liver and gonad of N. mesoprion in relation to length group.

RESUME

RESUME

The present work deals with the studies on the systematics, biology and biochemical aspects of Nemipterid fishes collected from Cochin coast from August 1982 to July 1984. Four species under the family Nemipteridae namely Nemipterus japonicus, N. mesoprion, N. tolu and N. delagoae were collected from Cochin waters, of which, N. japonicus and N. mesoprion are commercially important and forms a major fishery around the year. Bottom trawlers are employed to a large extent for the capture of these fishes and the peak landings are during July to November. These fishes, being comparatively cheaper, form a staple diet of the common people, and are consumed in fresh, salted or sun dried conditions.

Practically nothing is known about the biology and nutritive value of N. japonicus and N. mesoprion from Cochin waters. An attempt was, therefore, made to study the biology and biochemical aspects of these fishes from this area.

Food and feeding habits of these fishes show that they are actively predacious carnivores and bottom sight feeders. The large eyes, short snout and absence of tactile organs suggest that these fishes feed during day light. The position of their mouth and absence of sieve like straining mechanism in the gill basket are more suited for browsing and pecking off the animal preys from

the ground. The diet of both the species do not differ significantly and both of them share the same ground for their food. Prawns, polychaetes and small fishes are the major components of their food. Crabs, bivalves, gastropods, ostracods, mysids and foraminiferans form an occasional diet of their food. The food of males and females of both the species did not vary markedly but show certain food preferences during their maturation cycle. During breeding season N. japonicus and N. mesoprion consume polychaetes which are abundant in the inshore waters, and it may be due to their migrations closer to the shore during that time. Immature and spent fishes of both the species feed on polychaetes and prawns whereas mature fishes mainly feed upon small fishes. In both the species, breeding does not seem to affect feeding intensity and the percentage occurrence of gorged stomach was less.

The food analysis of Nemipterids reveal that the juveniles mainly feed on polychaetes and larval prawns, whereas the adults feed on prawns, small fishes, polychaetes and molluscs. The feeding intensity is directly proportional to the gastro-somatic index in both juveniles and adults. An inverse relationship is established between the gastro-somatic and gonado-somatic indices in N. japonicus whereas no relationship could be noted between gastro-somatic and gonado-somatic indices in N. mesoprion.

For assessing the growth, using the length frequency data, the growth equation for both the species were calculated by Elephan 1 method. In N. japonicus and N. mesoprion the L_∞ and K values vary slightly in both the sexes indicating that the growth pattern varies to some extent between the sexes. The length frequency distribution of these two species indicate that bulk of the catches comprised of fishes of late '0' year and 1 year size groups which suggests that this may adversely affect the fishery in the long run, if the catch is not regulated properly.

The length-weight relationship study in N. japonicus and N. mesoprion showed that the exponent values for male and female were less than three, indicating that per unit increase in length of the fish, the weight increase was less than three times. But in juveniles this value was more than three times. Significant differences could be noticed in the regression coefficient values of male, female and juvenile fishes of these species.

Studies on the ova diameter frequency, seasonal occurrence of maturity stages, gonado-somatic index and relative condition factor indicated that N. japonicus and N. mesoprion spawn in the same season and both are fractional spawners. The occurrence of high percentage of fully mature specimens and the rise in gonado-somatic index and K_n values revealed that the peak spawning extends from October to December. Fifty percent of males and females of N. japonicus mature at a mean total length of 160 mm and 171 mm respectively whereas in N. mesoprion fifty percent of the males mature at 120 mm and fifty percent of the females mature at 125 mm. However, both the species mature at the end of first or in the beginning of the second year.

A linear relationship could be seen between fecundity and total length, fecundity and body weight and fecundity and ovary weight. The sex ratio in both the species did not deviate largely/widely from the expected 1:1 ratio. No differential distribution of males and females could be observed in these species.

For understanding the nutritive value and the dietary significance of these fishes, the biochemical constituents like water, lipid, protein, carbohydrate and minerals in the different bodily tissues like muscles, liver and gonads were studied in relation to the maturity cycle and different length groups. The highest fat and protein contents in the muscle was observed during the early stages of maturation. In the different length groups studied the fat and protein composition was higher in the larger size groups whereas in the smaller groups the mineral content was showing a higher percentage. The flesh of the mature and smaller fishes have a low content of protein and fats. Hence, the larger fishes during the early stages of maturation seems to have high fat and protein content in the muscle which can be effectively utilized as a source of nutritive food.

Based on the results of the present study, the following points are suggested for the rational exploitation of these fishes at Cochin coast.

1. The mesh size may have to be regulated in order to avoid the exploitation of juveniles.

2. Fishing operations should be strictly restricted (based on unit stock study each year) during peak spawning months, in order to reduce the danger of diminution in the existing stock.

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