STUDIES ON SOME ASPECTS OF BIOLOGY AND UTILISATION OF THE MANTIS-SHRIMP, *Oratosquilla nepa* (LATREILLE) (CRUSTACEA STOMATOPODA)

THESIS

SUBMITTED TO

THE COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

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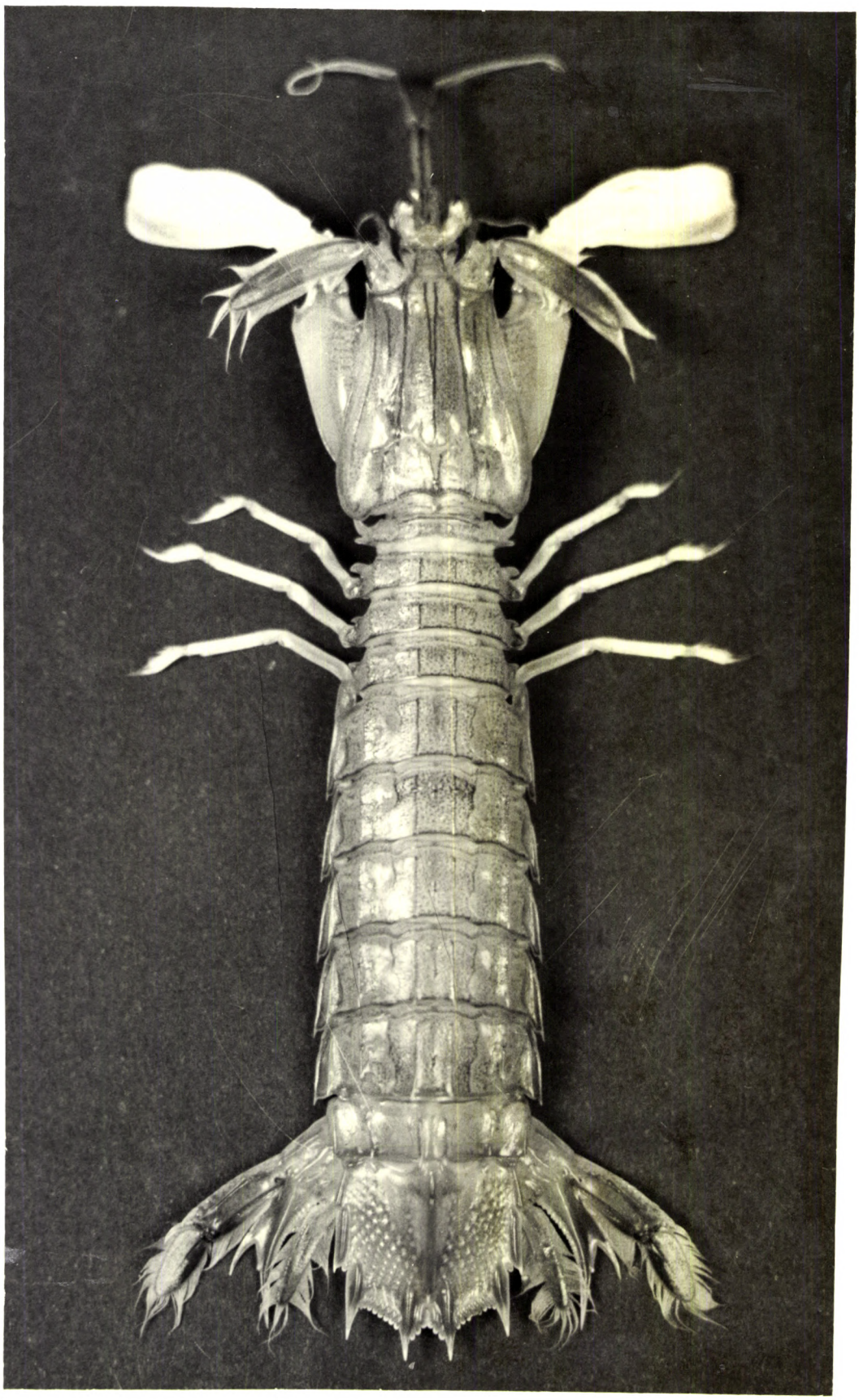
1996



Oratosquilla nepa

C E R T I F I C A T E

This is to certify that this thesis is an authentic record of research work carried out by Smt. Tanuja Rajeswary, M.Sc. under my supervision and guidance in the School 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.

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DECLARATION

The work presented in this thesis is the result of my own investigation and has neither been accepted, nor is being submitted for any other degree. All the sources of information have been duly acknowledged.

TANUJA RAJESWARY

ACKNOWLEDGEMENT

I Wish to place on record my sincere gratitude to my guide, Dr. M. Shahul Hameed, Professor and Director of the School of Industrial Fisheries, for his constant guidance, encouragement and support throughout the course of my research.

My sincere thanks are due to Dr. C. Suseelan, Senior Scientist, Central Marine Fisheries Research Institute, Cochin, Dr. B. Madhusoodhana Kurup, Reader, School of Industrial Fisheries, and Shri. H. Krishna Iyer, Principal Scientist, Central Institute of Fisheries Technology, Cochin, for the help rendered in the statistical analysis and their valuable suggestions.

Iam very much thankful to Dr. K.G. Ramachandran Nair, Principal Scientist and Dr. P.T. Lakshmanan, Senior Scientist, Central Institute of Fisheries Technology,for extending me necessary help and timely suggestions.

I thank all the members of the Faculty of Industrial Fisheries for the encouragement they have given during the course of my study. My deep sense of

appreciation and thanks are also due to Sri.Suresh Kumar, Sri.Harikrishnan, Sri.Ajit Thomas John, Smt.Leela Edwin, Kumari.Shassi, Full time research scholars of the School of Industrial Fisheries for their valuable encouragement and assistance.

I also take this opportunity to express my sincere thanks and gratitude to the Skippers and Crew of the fishing vessels of CIFT and IFP.

I place on record my deep sense of gratitude and thanks to Cochin University of Science and Technology for supporting this study by granting me Research Fellowship.

C O N T E N T S

CHAPTER 1

INTRODUCTION

India's fishing activities are concentrated on both around the East and the West Coast. The declaration of the 200 mile Exclusive Economic Zone in 1976, has enabled India to acquire full right to explore, exploit, manage and conserve the living and non living resources of nearly 2 million sq. km of seas around her. Currently, a major part of our fishing activities are confined to coastal waters up to 50 m depth. A large quantity of the fishes that are landed in our harbours are condemned as trash fish and sold at a very low price. There are yet some others which are thrown overboard as soon as they are caught and the stomatopods are one among them.

The stomatopods are landed in considerable quantities in almost all the maritime states of India. The total crustaceans landed in Kerala during the year 1993 was 72916 tonnes (Anon, 1995) and the stomatopods accounted for about 26.26 % During the previous year, they accounted for about 18.5 % of the total crustaceans landed. The stomatopod Oratosquilla nepa forms an important component of the bycatch of the shrimp trawlers. It comes under the family Squillidae characterised by the jack knife

claws like the garden mantis, relatively large and much flattened abdomen and small hinged rostrum. In addition, the eyes and the antennules are borne on movable rings or segments -a feature not common in Crustacea. Each pleopod is a featured respiratory organ and not necessary for egg carrying.

They are widely distributed in the Indo-Pacific region extending from Pakistan and Mozambique to Hong Kong to Australia. Throughout the west coast of India, this shellfish is available in plenty in the shrimp trawls. The highest landings of the Stomatopods have been observed from Karnataka where more than 50% of the crustacean landings are contributed by them. It is called by different names in different parts of India. In Kerala they are called as the "Peychemeen" or as the "Chelly".

1.1 Review of literature

A review of literature shows investigations on the monographs of Lanchester (1903). Kemp (1913) had reported 92 species of stomatopods from the Indo West Pacific region. Hansen (1926) had given an account of the stomatopods of Siboga Expedition. The stomatopoda of the Raffles Museum were reported by Tweedie (1934).

In this context, the works of Manning (1968), where a clear description of the family Squillidae given, is noteworthy. His studies on the stomatopods are mainly dealing with the taxonomical aspects in the Indo West Pacific region, North West Atlantic, the Mediterranean and the Red Sea.Tirmizi and Manning (1968) had reported 17 species of stomatopods from the West Pakistan waters.

Radda (1974) had confirmed the presence of O. nepa at depths between 8-20m bottom mud from the Gulf of Tonkin.Dingle & Caldwell (1978) described the ecology and morphology of feeding and agonistic behaviour in mud flat stomatopods with particular reference to the family Squillidae. In addition, he has made a comparison with that of other stomatopods. Manning (1978) conducted studies on Oratosquilla and described 2 genera and 9 species of Squillidae. The functional morphology of stomatopod crustacea with emphasis on the mouth parts has been described by Kunze (1981). In addition, a comparative study has been conducted on the families Gonodactylidae and Squillidae. A biological study of the Pakistani mantis shrimp Oratosquilla nepa was reported by Nazima and Qudusi(1984).

The food consumption of the Japanese mantis shrimp Oratosquilla oratoria was studied by Yamazake (1985) for a period of one year. The spawning ground of the shrimp was observed by Ohtomi and Shimizu (1991)from the Tokyo Bay. The distribution, abundance, sexual composition of the stomatopods from the Gulf of Nicoya were studied by Ana (1991). Roberto and Enrico (1993) had marked the different stages in the maturity cycle through different immunoelectrophoretic forms of the yolk proteins of the female Squilla mantis.

1.2 Review of literature of the stomatopods in Indian waters

The stomatopod fauna of the Indian Ocean is fairly well known mainly due to the monograph of Kemp (1913). Chopra (1939) had collected 16 species and varieties from the John Murray Expedition. Seventeen species are available in the Bombay waters according to Chhapgar and Sane (1967). Shanbhogue, (1973,1986) had done detailed studies on the stomatopod crustaceans from the seas around India. The embryology of 4 commercial species of Squilla was described by Nair (1941).

Alikunhi in (1965 &1967) studied the development, molt and growth of Stomatopods..A study of the stomatopod off

Mahanadi estuary was also undertaken by Alikunhi(1959). In 1975, he had studied the growth, maturity and spawning of Squilla nepa under laboratory conditions. A catalogue of the stomatopods in the reference collection of Central Marine Fisheries Research Institute were brought out in 1969 (Shanbhogue,1969). Malimath (1976) gave an account of O. nepa from Karwar waters. The distribution pattern and abundance of the stomatopod larvae in the Exclusive Economic Zone of India were presented by Reddy and Shanbhogue(1989). Sukumaran(1987, 1988) had dealt with the biological aspects of O nepa of South Kanara waters.

With reference to the literature pertaining to the processing aspects of stomatopods, very little studies have been conducted. Visweswariah et al. (1966) had developed a process for the utilisation of prawn head waste and squilla as poultry feed and the product has been claimed to be comparable to that of fish scrap meal. Madhavan and Nair (1975) have developed chitosan from Squilla and have claimed that though it is edible, as Tempura in Japan, the limited meat content adds as a disadvantage in its utilisation for human consumption.

Garg et al.(1977) had adopted simple procedures in the preparation of protein from jawala prawn and squilla without the

addition of chemicals. Moorjani et al. (1978) have projected the importance of chitosan having high viscosity and protein as a valuable by-product from Squilla in the Proceedings of the Conference on Chitin and chitosan. Ahamad and Mohammed (1985) compounded feeds for the culture of penaeid prawns from prawn waste and mantis shrimp. Stress has been laid on the importance of pelletized feeds and the inclusion of squilla, which is considered to be a low cost animal protein. Lekshmy et al. (1985) had conducted experiments on the nutritional quality of squilla with reference to the growth of experimental animals.

Reddy (1992) had pointed out the potential uses of squilla and emphasised the need for adopting low cost technology for the manufacture of cheap food products. In view of the availability of protein in a cheaper form, the present study was undertaken.

A thorough knowledge of the species composition, distribution and abundance, breeding and food and feeding are prerequisites for the proper exploitation of a fishery resource. This information is lacking in the stomatopods caught from Cochin waters. Also a study of the biological aspects will help in the effective utilisation of the resource. It will also help in

judicious fishing and an idea about when to utilise the resource will be known.

The literature pertaining to the various study conducted by the researcher are reported in the respective chapters for easy reference and to avoid repetition.

1.3. Objectives of the study

Mantis-shrimp Oratosquilla nepa constitute an important component of the bycatch of the shrimp trawlers in India. They form a major part of the stomatopod landings in our waters. Though these stomatopods are landed in large quantities no concerted attempt has so far been made to study the utilisation of this resource as a good source of protein for human consumption. Currently, those that are caught are either discarded in the sea or are landed in the harbour for converting it into manure or fish meal.

The present study aims to achieve the following objectives:

1. To understand the distribution pattern of O nepa in Cochin waters for better exploitation of the resource.

2. To learn the biological aspects of the animal which has a direct bearing on its utilisation for producing different products.
3. To have a thorough knowledge on the size groups available during different seasons for judicious exploitation and utilisation of the resource
4. To have a thorough understanding on the changes in the biochemical composition of O nepa during different seasons so as to utilise it properly for producing suitable products throughout the year.
5. To learn the keeping quality of the material in ice and frozen storage and to estimate the shelf-life of it in these two environments.
6. To test the suitability of the material for producing different products and to test the acceptability of the same for human consumption.

The above objectives will lead to the overall aim of utilising this underutilised protein rich material for human consumption.

CHAPTER 2.

DESCRIPTION OF THE SPECIES.

Introduction.

The correct identity of a species is an important prerequisite for any type of research on it.

A review of the works reveal that the morphological aspects of Oratosquilla nepa are studied by Tweedie(1934) who described the characters based on the collection from Singapore and Malacca. Shanbhogue (1986)studied the stomatopod crustacea from the seas around India. Kunze (1981) described the functional morphology of the stomatopod and delineated the differences exhibited by the families Squillidae and Gonodactylidae. Nazima and Quddusi (1984)gave an account of the species from Pakistani waters.

Systematic position.

The systematic position of Oratosquilla nepa can be given as follows:

Sub class	Malacostraca
Order	Stomatopoda
Super order	Hoplocarida
Sub order	Unipeltata
Family	Squillidae
Genus	Oratosquilla
species	nepa

Description of the species.

The body is narrow, dorso ventrally flattene depressed on the anterior as well as on the posterior en elongate almost cruciform (fig 1). It is made up of ninete segments (excluding the acron) and is divided into three regio cephalon or head,thorax and the abdomen. They have a shal carapace which covers only some of the cephalic and the thor somites. The last four thoracic somites are exposed. The are stalked. The first five thoracic legs are sub chelate the last three are biramous. The abdomen is large with five pair of limbs. The sixth abdomen joins with the forming a tail fan. Most salient features are the ge developed abdominal region and its appendages, the pec formed raptorial limbs and the triramous antennules.

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Description of the species.

The body is narrow, dorso ventrally flattened, depressed on the anterior as well as on the posterior end, elongate almost cruciform (fig 1). It is made up of nineteen segments (excluding the acron) and is divided into three regions: cephalon or head,thorax and the abdomen. They have a shallow carapace which covers only some of the cephalic and the thoracic somites. The last four thoracic somites are exposed. The eyes are stalked. The first five thoracic legs are sub chelate and the last three are biramous. The abdomen is large with first five pair of limbs. The sixth abdomen joins with the telson forming a tail fan. Most salient features are the generally developed abdominal region and its appendages, the peculiarly formed raptorial limbs and the triramous antennules.

General body surface.

When the surface dried specimen is observed it can be seen that the body surface is pitted.

Cephalon:

Eyes moderately wide; placed transversely on the stalk eyes tend to be relatively larger in small specimens. The antennular processes appear sharp in dorsal view. The ratio of the length /width of the rostral plate is nearly 1:1. It is trapezoidal in shape and rounded. The carapace is characterised by the presence of the distinct median carina throughout its length (Fig 2). The anterior bifurcation of the carina opens posterior to the dorsal pit. The relative length of the anterolateral spines is 0.13,and these over reach at the base of the rostral plate. The relationship of the anterolateral width to median length is 1.2 : 1.8. There are five pairs of appendages on the cephalic region (fig 3and 4).

The antennules are borne on the first cephalic somite Each antennule is deeply cleft and divided into two slender branches so that three flagella actually occur. The peduncular segments are slender and named as proximal, median and distal. There is a scaly plate a little way up and projecting laterally.

Its outer margin is finely serrated and bears plumose setae. The second peduncular segment is longest of all.

Antennae is found lateral to the antennuules. It consists of two segmented protopod, large two segmented exopod and a feeble three segmented endopod. The 1st antennal segment or the coxa is square shaped. The second antennal segment also called as the basis is made of irregularly shaped pieces. It consist of an exopod which is composed of two segments, a small basal segment and an elongated distal segment. The distal segment is called the antennal scale or the scaphocerite, which is flat and oval. The endopod is three segmented.

The mandibles are born by the third cephalic somites called as the mandible. The incisor bears pointed and sharp teeth. The molars are at right angles to the incisors, with double row of teeth ; each row bearing 7 to 8 teeth. These molar proceses terminate in the curved tooth. The mandibular palp consists of three slender setose segments of equal length.

The first maxillae also called as the maxillulae are thin, small and leaf like appendages carried by the fourth cephalic somite. They are leafy like, thin and small. It is

slightly curved and consists of a 2 segmented protopod ; proximal coxa and distal basis. The coxa is hatchet shaped and ends in a endite, which is flat plate.

The second maxillae are the appendages to the fifth cephalic somite. It consists of 4 segments. The second segment is the best developed and is provided with a bilobed endite ;the lower is small and club shaped while the upper one is truncate. The 4th segment has a triangular outline.

Thoracic region:

There are 8 pairs of thoracic appendages.(fig 5).

The first five thoracopods are sub- chelate, each of these consist of seven segments. The ischium and the merus form a single segment, the merus. The propodus and the dactylus form the prehensile subchela. The first 3 thoracopods are long and slender. The coxa is short bearing a heart shaped epipodite. The attachment of the ischium to the basis forms an inverted "V". The carpus is rectangular and the propodus is oval and its distal angle is produced into a dactylus. The dactylus has 6 teeth,the shape of the outer margin of the dactylus is sinuate. There is no spine or projection on the propodus. The carpal crest is

tuberculate. There is the presence of a spine at the inferodistal angle on the outer face of the merus.

The last three thoracopods (6th - 8th) are of a different shape. They are slender without chelae and subchelae. It consist of a protopod and two rami. The protopod is 3 segmented. the second longer than the rest. The 3rd segment is short with two rami and the exopod is stouter with 2 segments, the basal exopod. The outer ramus, or endopod consist of a smaller basal endopod with a long narrow styliform distal segment. In males, a tubular organ -protrudes from the inner side of the basal segment of the protopod of the eighth thoracopod. The lateral processes of the 5th, 6th and the 7th thoracic somites are bilobed. The relative sizes of the thoracic somites are given as follows:

6th thoracic somite-length upper 0.2/1.2 and lower 0.1/2 breadth 0.2/0.2

7th thoracic somite- length upper 0.1/1.4 lower 0.2/1.4
breadth 0.4/0.4

The anterior pleural lobe of the 6th thoracic somite is large, obliquely truncate. The presence of the thelycum or the

seminal receptacle of the sixth thoracic sternite is a distinguishing character of the females.(Plate 1)

Abdominal region.(fig 6):

The appendages of the first five abdominal somites are called the pleopods and those of the last form the uropod. Each pleopod is biramous and has two rami. The fifth pair differs from the others in having spiniform projections on the rear surface. The two rami representing the exopod and the endopod are flat and blade like. The exopod is unjointed. Endopod is triangular. At the middle of the inner margin, there is the appendix interna bearing several rows of coupling hooks. The appendages of the sixth abdominal segments are the uropods. The basal part consist of a short unsegmented protopod with a small spine. The exopod is strong and segmented. The basal segment is stout and armed with 8-9 spines. The ultimate spine is clawlike. The distal segment is oar shaped with plumose setae. The endopod is simple, long and narrow. The uropod and telson form the tail fan.

The fifth pair of abdominal appendage differs in pattern of spination, it has two spiniform projections on the

rear surface. The dorsal carina is absent on the telson. A strong median carina runs mid dorsally and it ends in a spine. The outer margin of the telson is cut into sharp teeth and large round denticles. The telson shows 6 large teeth along its margin,2 submedian,2 intermediate and two laterals. To each lateral tooth the margin shows a pre lateral tooth. All the marginal tooth are supported by carinae. There are 2- 6 teeth between the submedian,6-9 between the submedian and the intermediate and a single denticle between the intermediate and the lateral tooth. The presence of a tube like penis on the last thoracic limbs and petasma on the first pair of pleopods is a characteristic feature of the males.

Colouration.

General body colour is light brown. Thorax and abdomen with light greenish brown pigmentation. Median carina on carapace pinkish brown the same colour as that of the median carina is seen in the submedian and intermediate carina. .The last two segments of the antennular peduncle are light brown in colour. The lateral margins of the rostrum and the gastric grooves light greenish brown. Also, the bases of the marginal spines of the telson are light brown with a slight greenish tinge. The proximal portion of the basal segment of the uropod

is light blue whereas the distal part is yellowish. The basal prolongation of the spines are light blue and the carinae are pinkish brown. The distal part of the endopod of the uropod is bluish black.(Plate 2).

Remarks

The morphological characters of Oratosquilla nepa collected from Cochin waters shows agreement with that the features reported by Nazima and Quddusi(1984), Shanbhogue,(1986) and Manning(1978). Manning (1978) had given an useful account of the characters of the genus Oratosquilla. According to him, inspite of the number of characters, there is a rather remarkable uniformity in a series of specimens of any given species from one locality. With reference to the coloration of the specimen, there is total agreement with the description provided by Shanbhogue(1986). A slight variation in colour is noted in O.nepa collected from Cochin when compared to the same described by Nazima and Quddusi(1984). Hence it may be concluded that in general, the morphological characters of Oratosquilla nepa collected from Cochin waters well agree with that of the available descriptive account of the species not only from Indian waters but also elsewhere.

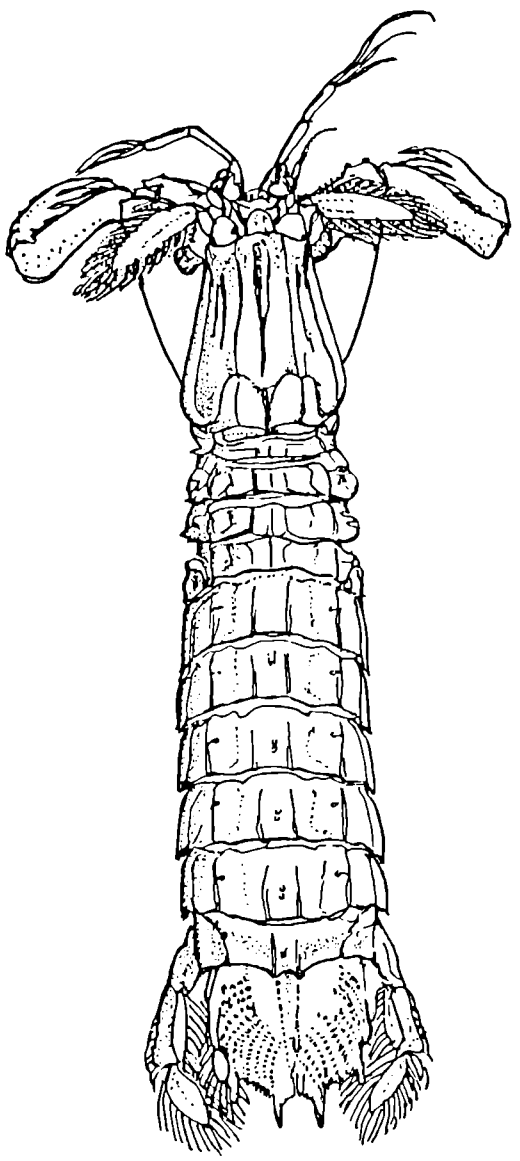
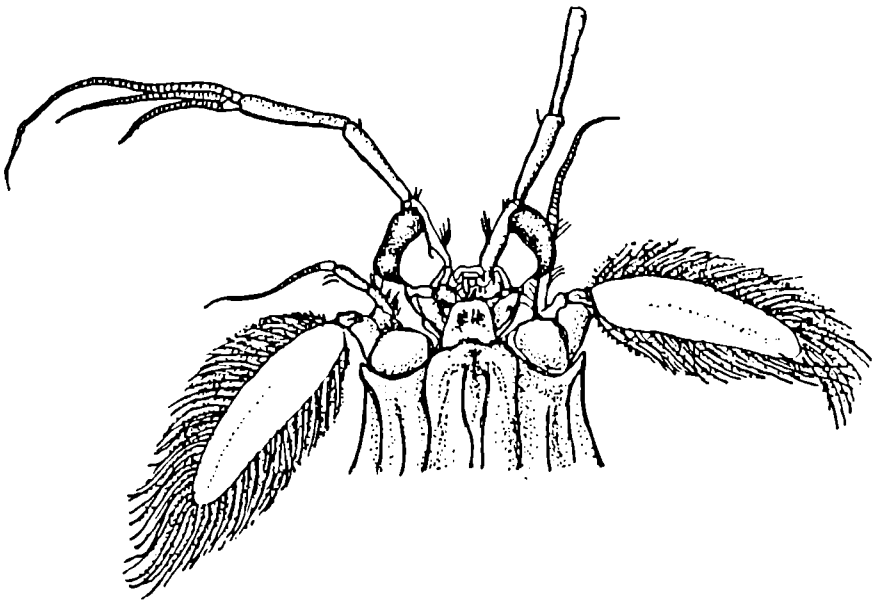
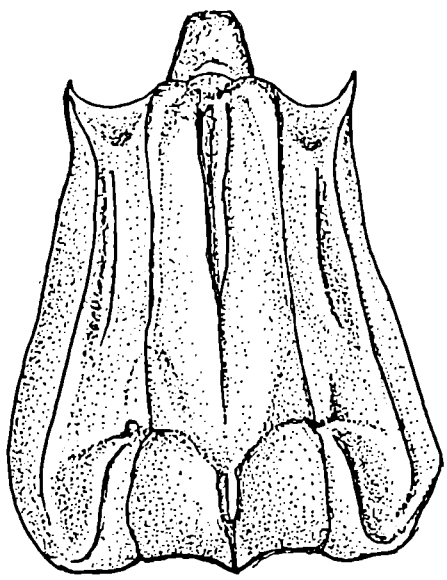


FIGURE 1 : Oratosquilla nepa - Dorsal View



(a)



(b)

FIGURE 2 .CEPHALIC REGION

(a)ANTERIOR PART - DORSAL VIEW

(b)CARAPACE - DORSAL VIEW

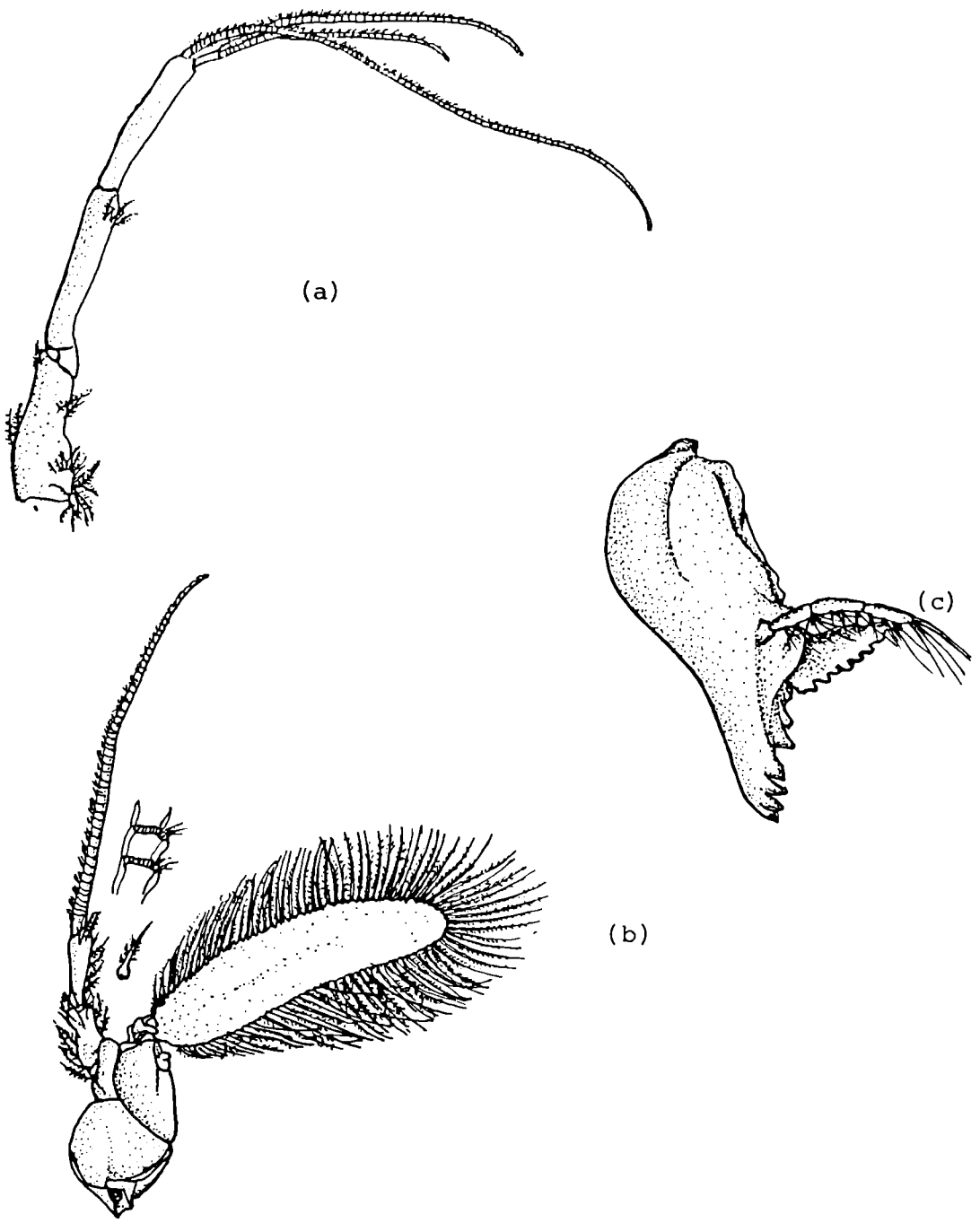


FIGURE 3 CEPHALIC APPENDAGES

(a) antennule

(b) antenna

(c) mandible

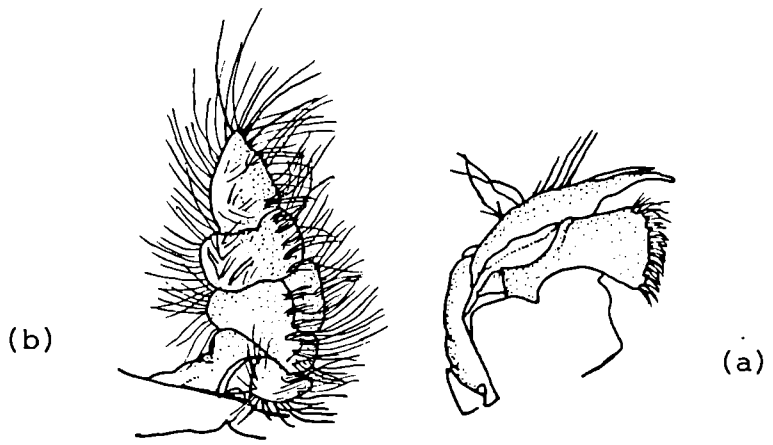


FIGURE 4: CEPHALIC APPENDAGES

(a) FIRST MAXILLA

(b) SECOND MAXILLA

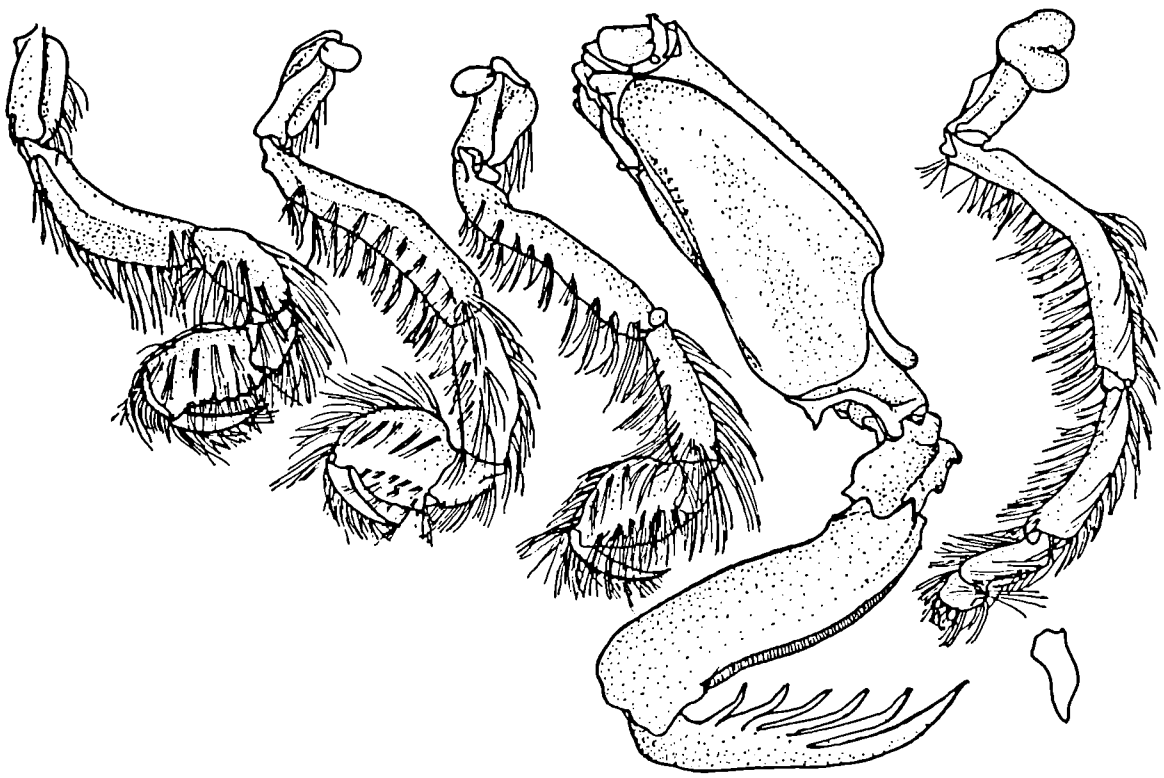
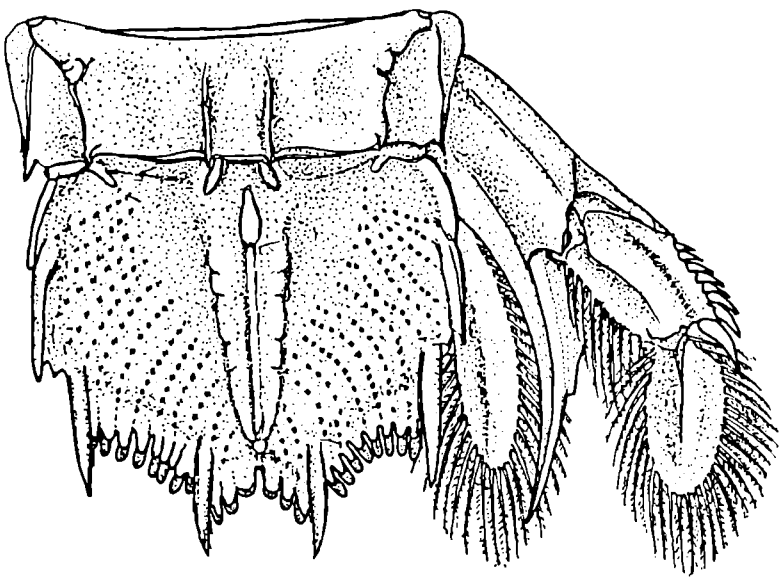
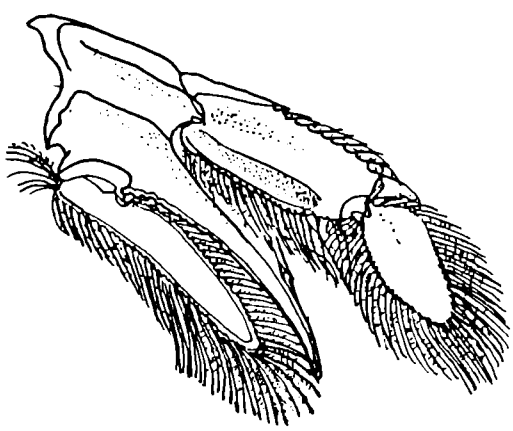


FIGURE 5: THORACIC APPENDAGES



(a)

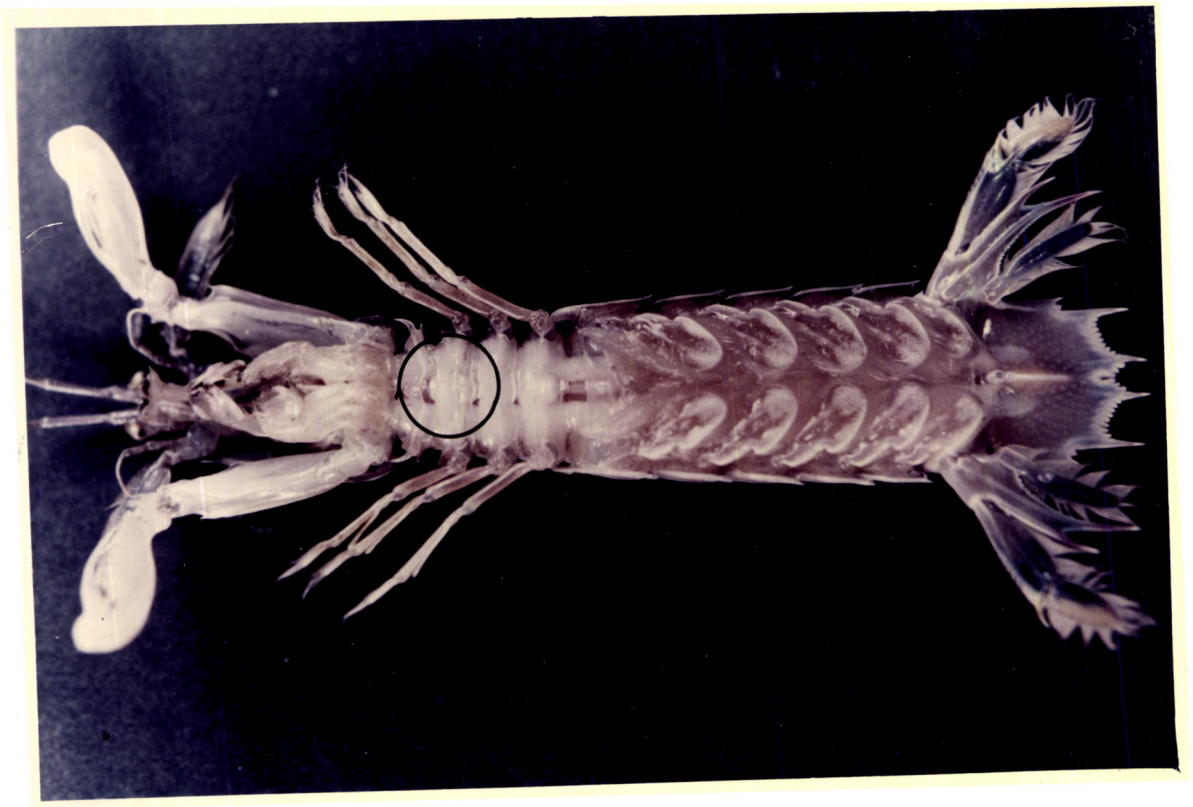


(b)

FIGURE 6: ABDOMINAL APPENDAGES

(a) Telson
(b) Right uropod

PLATE 1 MALE FEMALE



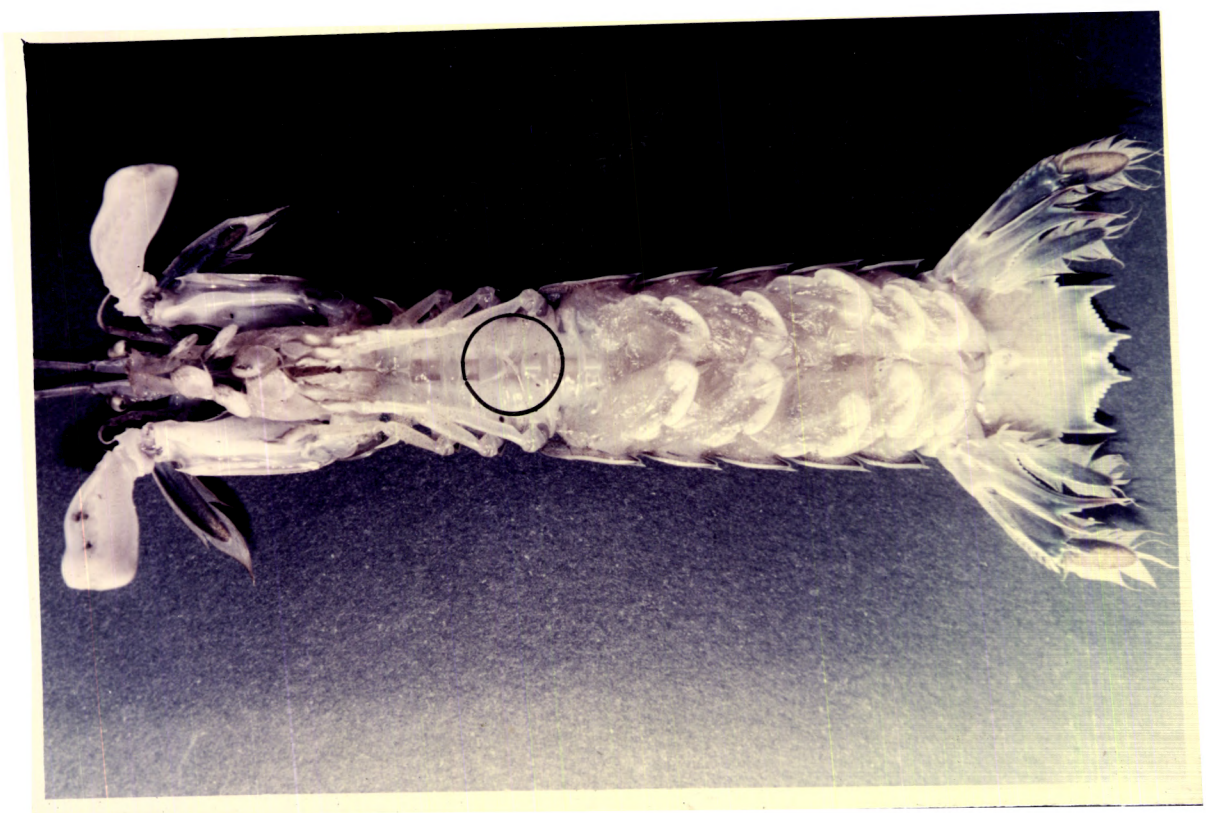
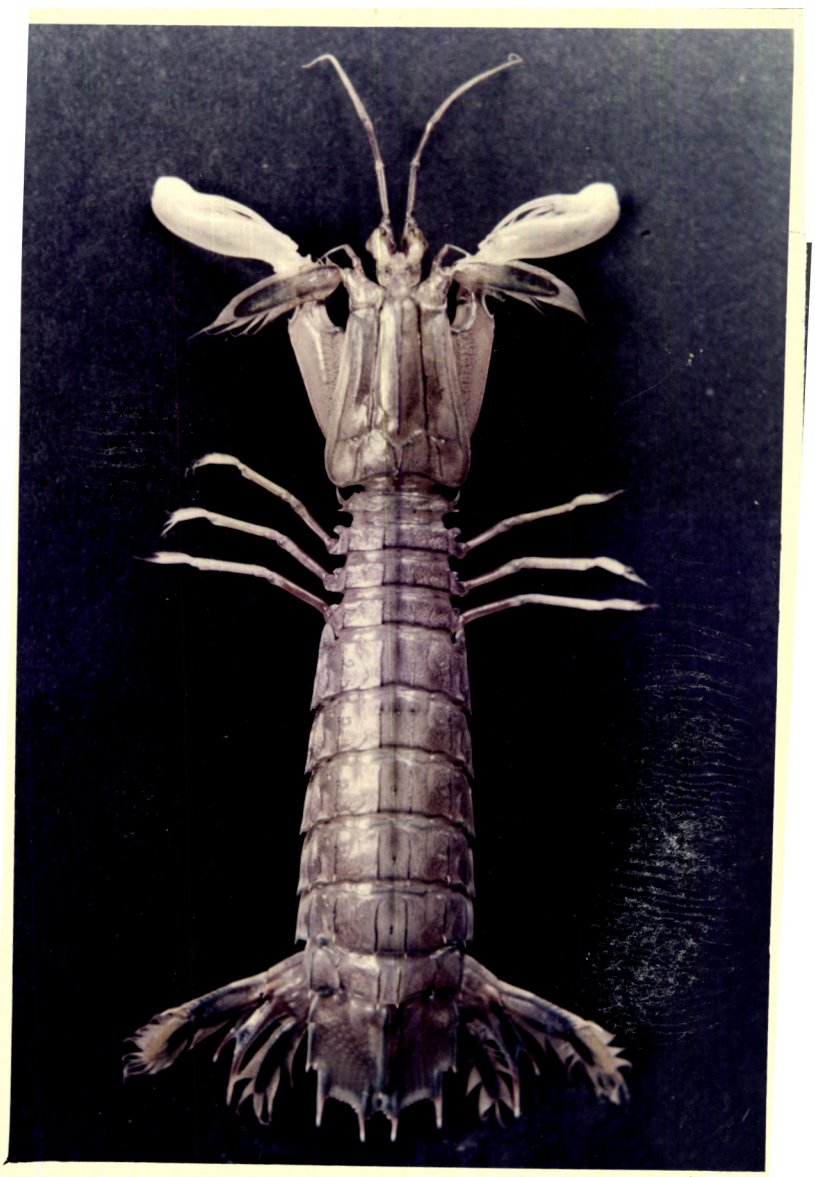


PLATE 2 *Oratosquilla nepa*



CHAPTER 3

SEASONAL DISTRIBUTION AND ABUNDANCE OF THE STOCK.

INTRODUCTION.

Data on distribution and abundance of stock are very essential to formulate strategies for the optimum exploitation of any resource. An account of the distribution of the stomatopods of the Indian Ocean are mainly that of Kemp (1913) who reported 97 species and varieties from the Indo-Pacific region of which 54 species belong to Indian waters. Other notable similar studies are those of Kemp and Chopra (1921), Gravely (1927) and Chopra (1934).

The geographical distribution of Eastern Pacific stomatopods is relatively well known Manning,1977;Manning and Reaka,1979;Reaka and Manning,1980. Morgan (1980) reported the seasonal occurrence of squilla empusa larva in Chesaspeake Bay while Reaka and Manning (1980) also gave an account of the distribution patterns of the stomatopods. Oratosquilla nepa also known to occur among some stomatopod of Sinai Peninsula and Red Sea (Manning and Levinsohn,1986). Griffiths and Blaine (1988),studied the distribution of Pterygosquilla armata

capensis off the West Coast of South Africa, whereas Ana (1991), reported the distribution, abundance and sexual composition in the Gulf of Nicoya, Costa Rica.

Shanbhogue (1973;1986) while describing stomatopods from the seas around India, also mentioned the pattern of distribution of Oratosquilla nepa in the seas. Nair et al (1990) estimated the landings and catches of squilla along the Kerala coast.

MATERIALS AND METHODS.

Study area

The area of operation extends approximately from $76^{0}05'$E to $76^{0}12$E longitude and $09^{0}45'$N to $10^{0}15'$N. This covers 8 to 15 nautical miles from the shore. Samples were collected from the experimental trawlers operating off Cochin waters during March 1992 to February 1994. Generally the trawl operations were carried for a period of one hour per haul. The collections were made between 10 am to 1 pm in the demersal trawl net of 32m (High opening trawl) and 26.4m with mesh size of 20mm at the cod end. . The length frequency distribution of the males and the females were analysed and the

magnitude of landings of O. nepa were estimated following (Nair et al, 1990). The total number of boats landed at the harbour was noted. The crew were interviewed to get information on the quantity of squilla discarded at sea. A preliminary survey was also conducted to get information on the quantity landed and discarded at sea. This was computed monthwise and the percentage of O nepa out of the total trawler landings were computed. Random sampling method was adopted during the survey.

RESULTS

The distribution of Oratosquilla nepa was recorded to be extending from $76^{0}05'E$ to $76^{0}12'E$ longitude and $09^{0}45'N$ to $10^{0}15'N$ (from the South of Cochin port to the North of Cochin) (Fig.1).

It could be seen that during the years 1992 to 1994 the length varied from 30-116 mm males and 31 to 116 mm in females. Their occurrence could be noticed during all the months however their availability cannot be ascertained during July 1992 and June 1993 due to the imposition of ban on trawling. Their occurrence in maximum numbers were observed during January and July which would suggest two peaks of abundance. During the months of September and October, they were poorly represented in

the catches. Also they were abundant in the pre-monsoon and the latter half of post-monsoon months.

Magnitude of exploitation of the stock.

The total estimated exploited stock during the period March 1992 to February 1993 and March 1993 to February 1994 were about 7,801 and 10,011 tonnes respectively. November appeared as the peak season during both the years and accounted for 39.9 % during 1992 and 44.7 % during 1993. The exploited stock of Oratosquilla nepa is given in Table 1. The total length and total weight of the specimens were recorded and analysed for determining the range, mean size, modal length and mean weight, of males and females are given in Table 2 and 3. The dominance of large sized Oratosquilla nepa in the catch during January and June in the males while in females it was obvious during March to August 92 and from January to August. 1993. Mean total length of the males during different months ranged from 34.5 mm to 89.02 mm in the males, whereas in the females, it ranged from 37.31 to 93.72 mm. The dominance of female could be discernible in the catches during all months except March April and June 1992 and January 1994.

DISCUSSION.

Shanbhogue (1973) stated that Oratosquilla nepa is a common species of Indian Ocean which is being caught in large quantities along the South West Coast of India by the mechanised boats from November to April. Its distribution is reported to be extending from Red Sea, Western Indian ocean and South Africa.

According to Manning (1991), the Oratosquilla nepa was caught by the Galathea expedition from Singapore at $1^{0}20'N, 103^{0}50'E$ and that of Malaysia at $4^{0}30'N, 103^{0}28'E$. The distribution of the species according him ranges from Indo West Pacific, from Western Indian Ocean to Hong Kong,Malaysia and Vietnam. The species was found to inhabit shallow and sub littoral waters (Manning,1991).

Shanbhogue (1973) reported that Oratosquilla nepa is having wide distribution starting from the Arabian Sea, Bay of Bengal, Singapore, Philippines and Hong Kong. The author also stated that during peak seasons the landings of the species in Cochin reaches upto nearly 2 tonnes and this statement is to be found to fully agree with the present study.

Griffith and Blaine (1988) observed the distribution and abundance of Pterygosquilla armata cappensis as

depth dependent. This statement fully complies with the present finding that the density of O. nepa is found to be depleting in the higher depths of Cochin waters. Size frequency analysis showed that the males of Squilla parva and Squilla aculeata were larger than the females. The smaller sizes of females is probably attributed to increased energy expenditure (Griffiths and Blaine,1988). On the contrary,in Oratosquilla nepa in the present study, it could be seen that the females were of larger mean sizes in most of the months when compared to the males.

The population of Squilla aculeata was dominated by larger individuals during April and May followed by a significant decrease during the rest of the year. In Oratosquilla nepa of Cochin waters, the larger sized individuals were found during March to August and December to February. The reason attributed to this phenomenon according to the above authors was due to the presence of small individuals (probably juveniles) in the range of 30-60 mm during most of the year. In Oratosquilla nepa the juveniles of 30-45mm were found during September and October in both years.

According to Reaka and Manning,(1987) although small individuals of 30-45 mm were present during most of the

year, their occurrence was in very low numbers. Similar observations were also found in Oratosquilla nepa of Cochin waters. The above authors stated that the stomatopoda are generally tropical shallow water organisms and O. nepais not an exception to this character.

According to Nair et al,(1990) only about 40 % of the total exploited stock are landed in the landing centres whereas 60 % is discarded to the sea at the fishing ground itself and therefore it appears that a major portion of it is being thrown back to sea to accommodate the commercially important fishes. Therefore it would be very difficult to quantify the exploited stock of O. nepa of Cochin waters. The peak season of abundance is from November to January/February when larger sized squilla are noticed in the catches.

During the monsoon high production has been substantiated in the phenomenon of upwelling noted at several places. These lead to the very explanation of a good fishery along the coast bordered by Indian Ocean waters. In the present findings too, there is agreement because high production of O. nepa was noticed during monsoon. (August/September) and (November/December). The Arabian sea has been found to be the richest part of the Indian Ocean in plankton content

(Subrahmanyan,1959a,& b; 1960). As a result, this goes to sustain the pelagic and the demersal fisheries chiefly prawns which feed on matter running down to the bottom. In this context, the availability of plankton can also be linked to the sustainability of O. nepa. This is also supported by the fact that the most important factor which leads to fish aggregation in the tropical environment is the availability of food and basic productivity which control the distribution of fish ultimately. According to (Kagwade,1967, Sudarsan,1965., Pruter,1964., Hida and King, 1955,) the trawl fisheries of Gujarat and Maharashtra could be attributed to the production during the North East monsoon and the concentration and sinking of plankton in these are higher during this time and this same phenomenon can be linked with O. nepa.

Sharma and Murthi (1973) linked the prawn fishery of West Coast of India to the hydrographical conditions. Hence it can be concluded that the distribution pattern of O. nepa is related to the hydrographical conditions prevailing in Cochin waters. The oxygen content is one among hydrographical factor which contributes to the maximum catch. According to them the maximum catch of prawns was obtained during monsoon when the oxygen content was low.

Table 1 Exploited stock of O.nepa from Cochin Waters

Month	Total Shrimp Trawler Landings	Exploited stock of O.nepa	Percentag O.nepa
March 92	1702.6	260.50	15.30
April	4623.0	1017.06	22.00
May	7092.0	1985.76	28.00
June	1138.0	148.17	13.02
July		TRAWLING BAN	
August	3617.2	1014.99	28.06
September	3151.0	632.72	20.08
October	1183.5	124.27	10.50
November	2175.8	868.14	39.90
December	2536.0	275.66	10.87
January 93	3410.0	917.63	26.91
February	1549.7	556.34	35.90
March	3536.0	939.16	26.56
April	3085.0	677.16	21.95
May	2078.4	470.97	22.66
June		TRAWLING BAN	
July	1305.8	351.39	26.91
August	4194.0	454.63	10.84
September	4455.0	449.96	10.10
October	3223.0	470.24	14.59
November	3216.0	1437.55	44.70
December	7897.1	3072.76	38.91
January 94	5508.7	1295.64	23.52
February	1482.8	391.60	26.41

Table 2 Population characteristics of exploited stock of O.nepa (Males)

Months	Range	Mean Size	Modal Length	Mean Weight
March 92	50-109	89.02	92.50	8.85
April	60-109	85.34	65.04	7.55
May	50-99	72.79	71.84	11.30
June	60-89	74.58	74.06	7.40
July			Trawling ban	
August	70-109	91.08	93.68	8.96
September	30-39	34.50	34.08	0.21
October	40-89	60.87	62.33	4.13
November	60-99	82.38	84.50	7.49
December	60-99	74.88	74.10	5.57
January 93	70-119	94.56	84.41	9.29
February	70-109	84.98	84.25	9.34
March	70-99	82.29	83.10	16.03
April	50-109	75.94	75.13	7.46
May	60-109	81.22	82.29	6.18
June			Trawling ban	
July	50-119	79.03	74.14	6.42
August	70-109	88.65	92.25	8.29
September	30-49	38.57	34.71	0.30
October	40-79	55.17	54.67	1.63
November	40-69	56.12	55.29	1.75
December	60-99	76.24	75.13	4.46
January 94	60-109	84.14	84.03	6.89
February	70-109	86.18	85.19	8.13

Table 3 Population characteristics of exploited stock of O.nepa (Females)

Months	Range	Mean size	Mean length	Mean weight
March 92	50-109	99.61	94.50	7.26
April	70-109	85.38	82.00	7.18
May	50-99	78.62	82.28	4.42
June	40-89	72.22	76.19	4.06
July			Trawling Ban	
August	70-119	93.71	96.42	8.02
September	30-49	37.41	35.79	0.39
October	40-89	63.36	64.36	4.17
November	50-89	80.00	82.37	4.99
December	50-119	92.01	79.41	4.52
January 93	60-119	88.60	96.17	9.32
February	70-119	86.37	83.36	7.89
March	70-99	34.41	84.45	6.37
April	60-109	85.48	84.45	6.88
May	70-109	84.74	84.14	6.75
June			Trawling Ban	
July	50-119	84.74	93.03	7.21
August	70-109	90.82	88.70	8.37
September	30-49	37.39	35.77	0.39
October	30-49	45.09	44.44	0.88
November	30-69	60.46	59.34	2.00
December	50-99	74.69	74.28	4.24
January 94	70-99	82.91	82.42	5.49
February	60-119	86.45	83.64	7.63

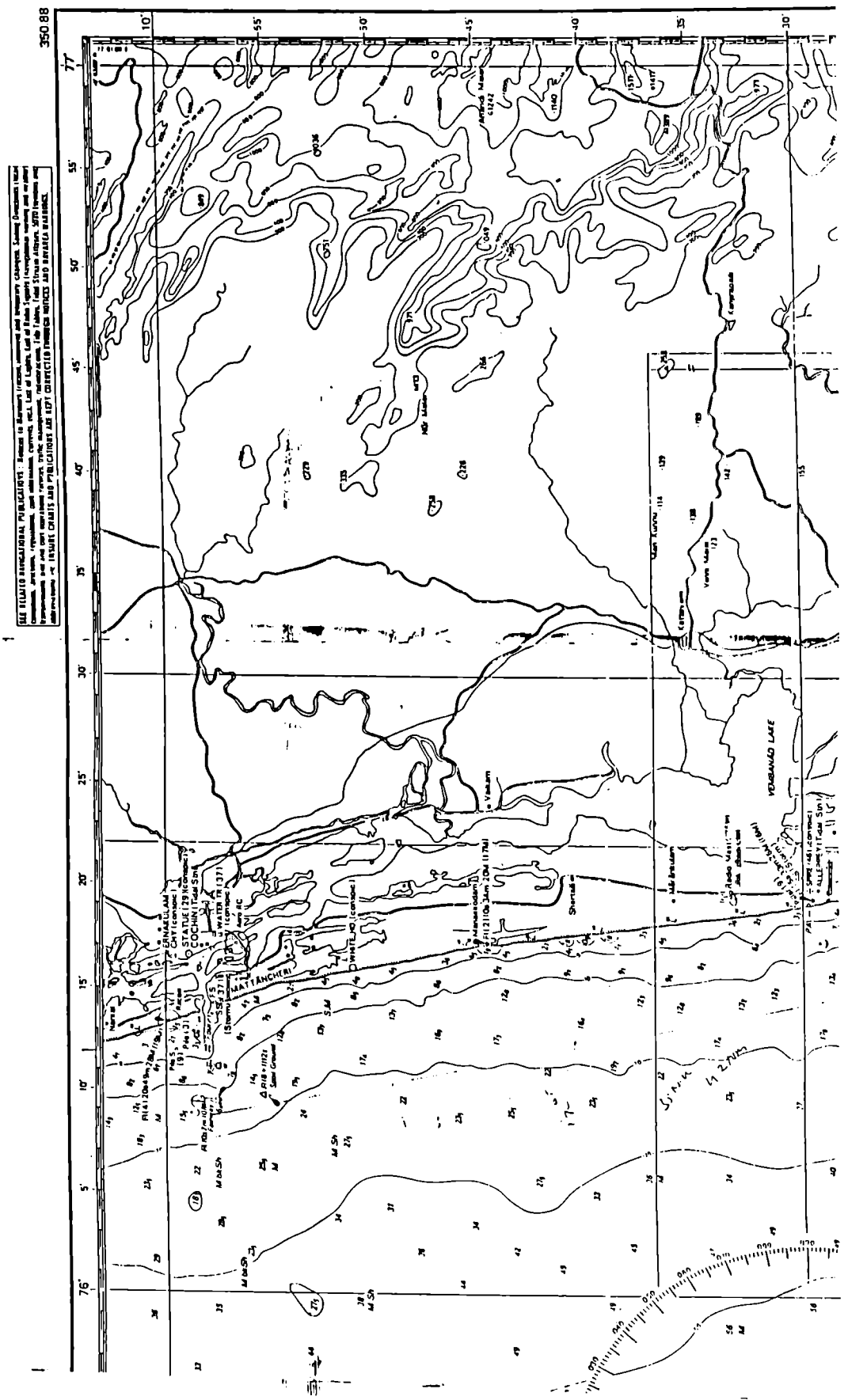


FIGURE 1: MAP SHOWING EXPLOITED AREA OF O.nepa IN COCHIN

CHAPTER 4

LENGTH WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

Introduction

The study of length weight relationship is an important tool in fishery biology with two objectives :(1) to establish a mathematical relationship between two variables namely the length and weight so that if one is known, the other could be computed and (2)to know whether the variations from the expected weight, for the known length groups which would indicate the fatness, general well being, gonad development and suitability of environment (LeCren,1951). The term length weight relationship is applied to the former, while the latter is termed as the relative condition factor.

The study of the relative condition factor(Kn) is useful in providing valuable inference on many interesting events in the life history of fish . They will be helpful to compare the plumpness of the fish and also the well being, fatness and gonadal development of the fish.

A study on the previous literature show that no attempt has so far been made to study the length weight

relationship of Oratosquilla nepa of Cochin waters. However, Sukumaran (1987) studied the length weight relationship of Oratosquilla nepa of South Kanara coast, while James and Thirumilu (1993), conducted his study from Madras waters . The length weight relationship of the edible Japanese mantis shrimp *Oratosquilla oratoria* was reported by Kubo et al.(1959). Among Crustaceans,the length weight studies are mostly carried out in shrimps and prawns, notably by Toro and Sukristijono (1980) in the former and Natarajan et al.(1988) in the latter.

MATERIALS AND METHODS.

Specimens of Oratosquilla nepa were collected from Cochin Fisheries Harbour for a period of two years during March 1992 to February 1994 . A total of 8179 specimens ranging in size from 30mm to 116mm were used for the study of length weight relationship. The total length was measured to the nearest millimeter from the tip of the rostrum to the apices of the submedian spines of the telson whereas the weight was taken to the nearest 0.01g. Specimens with damaged telson and rostrum were not used in the study. The data on the length weight relationship were analysed separately for each category as suggested by Le Cren (1951). The linear equation was also fitted separately for males, females and indeterminants. Specimens with

undifferentiated gonads were treated as indeterminants.

The length weight relationship can be expressed as

$$W=aL^{b}$$

and its logarithmic transformation can be expressed as

$$\text{Log } W = \text{Log } a + b \text{ Log } l.$$

where w = weight in g, "a" and "b" the constants and l =the total length in mm. The estimates of parameters "a" and "b" were estimated by the method of least squares. Significance of difference between regression coefficients of the sexes were tested by ANACOVA (Snedecor and Cochran,1967). To test whether the regression coefficients depart significantly from "3", "t" test was employed.

The relative condition factor "Kn" was calculated by the equation

$$Kn = W / \bar{w}$$

where W is the observed weight and $\bar{w}$ = calculated weight.
Kn was calculated month wise as well as for different length groups in males and females.

RESULTS

(1a) Length weight relationship

Statistical details regarding length weight relationship of O.nepa are shown in Table 1. The logarithmic relationship between length and weight of males, females and indeterminants are represented in Fig 1,2 and 3.The logarithmic regression equation obtained are as follows :

Female : Log W =-5.76398 + 3.370632 Log L (r =0.9748)

Male :Log W =-5.68780 + 3.428664 Log L (r = 0.9777)

Indeterminants : -4.25090 + 2.557412 Log L (r =0.8741)

The corresponding exponential formula can be represented as follows:

$$\text{Females } W = 0.000001722\ L^{3.370632} \text{ g/mm}$$

$$\text{Males } W = 0.000002052\ L^{3.428664} \text{ g/mm}$$

$$\text{Indeterminants } W = 0.00005612\ L^{2.557412} \text{ g/mm}$$

Where g/mm is the unit of measurement employed and the subscript of L is the length range used for the study following Mohan and Sankaran (1988).

The results of Analysis of Covariance on the length weight equation reveal that there is significant difference at 1% and 5% level (F=65.878504).Table 1.

In the "t" test used for determining the variation of "b" from "3", using the formula

t = b - 3 / Sb, the t values so obtained are

Males (t =31.0163,df =3614) P >0.05, P >0.001
Females (t =31.5834,df = 4317) P > 0.05, P > 0.001
Indeterminants (t =30.2801, df P > 0.05, P > 0.001

The above results reveal that "t" values in the males, females and the indeterminants were significantly deviating from "3". In the males and females the exponential values were found to be above "3" which would indicate stoutest pattern of growth. While in the indeterminants, the exponential values were less than "3" thus showing the reverse pattern of growth.

(1b) Relative Condition Factor.

The average "Kn" was computed monthly for the period 1992-1994 and is presented in Fig 4. The Kn values were found to be greater than 1 during March to June and October to

February in the males during 1992-1993 and 1993-1994 . In the case of females similar trend was observed. A fall in the Kn values was observed during September, which was then followed by a rise. In general both in males and females much variation was not observed. The Kn values calculated in respect of different length groups showed high values (above 1) in the length group 80-89 in the females while in the males, Kn values were found greater than 1 in the size groups 50-59, 70-79, 90-99 and 100-109. In Indeterminant group, Kn values were more than 1 in various months in all groups. Also there was not much variation in the Kn values during different months.

The values of Kn were found to be invariably high in the bigger size groups in both males and females. In males, Kn was low in the size group upto 40-49 and thereafter, increased up to the size group 70-79 An inflexion was then observed in the 90-99 group followed by an increase in the 100-109 group. In the case of the females, the Kn values were found as low up to 50-59 size group and thereafter it showed an increasing trend. A slump in the Kn values was noticed in the size group 100-109, however an increasing trend could be seen in the Kn values in the subsequent size groups. On the contrary, in indeterminants, the Kn values did not show any significant variation

DISCUSSION

An appraisal of the length weight relationship of Oratosquilla nepa collected from Cochin waters showed that there exist significant difference between the males, females and the indeterminants. The significant difference of b values between the sexes proved statistically of Oratosquilla nepa caught from Cochin waters is noteworthy. According to James and Thirumilu (1993), b values of males and females were not significantly different in the the specimens caught from Madras waters, which is found totally at variance with the present findings.

According to Kubo(1959), in the Japanese mantis-shrimp Oratosquilla oratoria, reported b value was near to 3. It would thus appear that the cube law may be applied to this animal also as in the case with most fishes. This is in full agreement with present results in Oratosquilla nepa of Cochin waters where the b value is found to be 3 in males, females and indeterminants. However Sukumaran, (1987), James and Thirumilu (1993), and Kubo (1959), have worked out a common equation irrespective of sexes since no difference could be seen difference in the regression values arrived at in the case if females. On the contrary, in the present study, frequent difference could be seen in the the regression value of males,

females and indeterminants therefore separate equations were established in respect of each sex.

Besides, there was no categorisation as indeterminants in the previous studies, however in the present study,the above group was created to accommodate the specimens with distinguishing sex through external morphological manifestations. The b value of this group arrived at in the present study cannot be compared with any of the previous findings due to want of similar information.

According to Natarajan et al.(1988),in Macrobrachium idae,the exponent value is more than three. However Sriraman (1989), observed significant difference in b values between males and females. In the Penaeus monodon it follows the cube law as the values of "b" were recorded to be always less than 3 . An increase in "Kn" value was observed during June-July and Nov-Dec in both males and females. This could be due to the high rainfall as observed by Natarajan et al.(1988) in Macrobrachium idae. According to Natarajan et al.(1988), the decline in the "kn" values followed by a rise in the afterwards was observed in Macrobrachium idae.This agrees with the present study in Oratosquilla nepa as the occurrence of ripe

individuals were found to be high during June-July and Nov-Dec and a correspondingly high "Kn" values were noticed during these periods. In Oratosquilla oratoria, ponderel index is reported to be subjected to considerable variation Since the ponderel index is also studied to assess the "well being" of the animal, it can be compared with the relative condition factor. Therefore, a comparison of the present finding with that of Kubo(1959) was attempted. Ponderel index values were more or less the same in both the sexes of Oratosquilla oratoria (Kubo,1959) and this conforms with the present findings that Kn in males and females of Oratosquilla nepa from Cochin waters also showed more or less similar values.

Table 1 Comparision of regression of Length-Weight relationship of Males,Females and Indeterminants of O.nepa

Sex	df	X	Y	XY	RC	SS	MS
Males	3614	-577.589	1200.783	-104.593	0.181	1219.723	0.338
Females	4317	-1191.500	682.622	200.295	-0.168	716.292	0.166
Indeterminant	242	-99.588	31.261	1.893	-0.019	31.297	0.129
Pooled	8177	-1868.677	1914.667	97.594	-0.006	1967.313	0.633

(f1= 8177, f2= 2) F= 65.878 *

* Significant at 1% and 5% levels

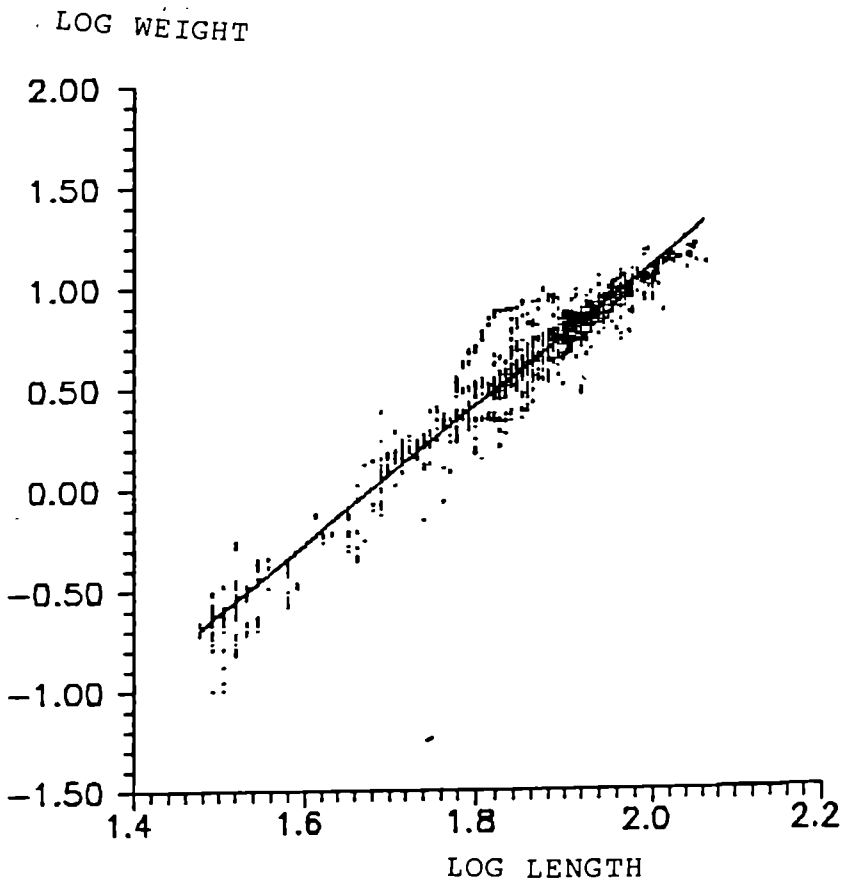


FIG.1: Male - LENGTH WEIGHT RELATION

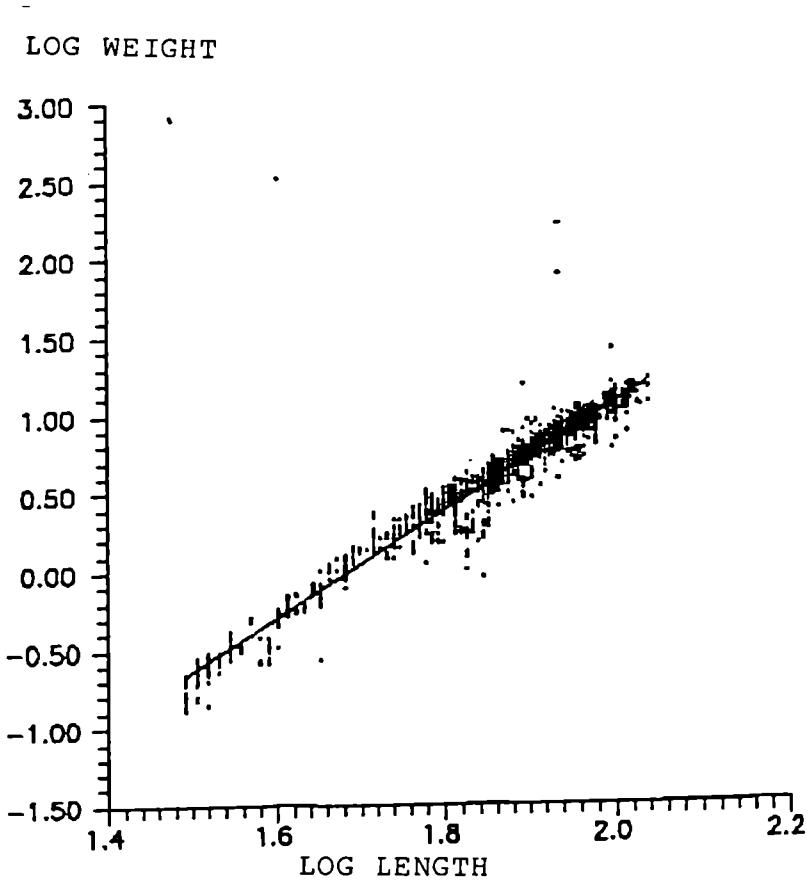


FIG.2: LENGTH WEIGHT RELATIONSHIP(female)

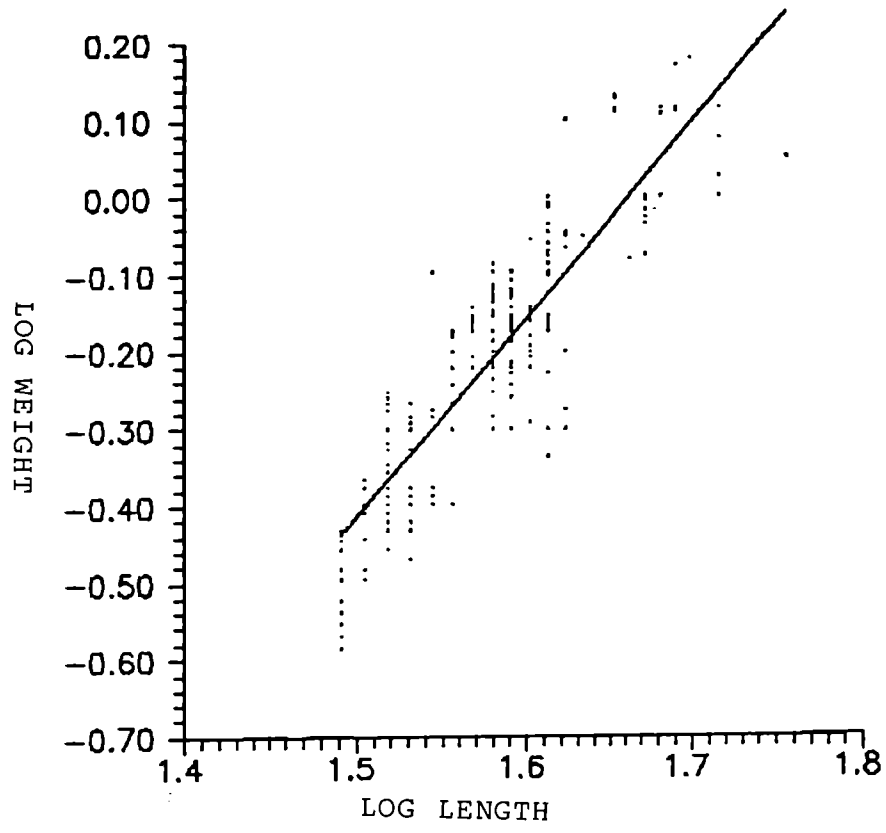


FIG. 3: LENGTH WEIGHT RELATIONSHIP IN INDETERMINANTS

CHAPTER 5

FOOD AND FEEDING HABITS

Introduction

Feeding is one of the important activities of an organism since it forms the only source of energy needed for the other activities of the animal. The distribution, growth, migration rate and behaviour of fish are largely dependent on the availability of preferred organisms and so the stomach content analysis are of inestimable value in the studies of fishery biology. These studies help to gain information on the main prey organisms and the preference or dietary overlap between year classes of different species living in the same or comparable habitats They also help to determine seasonal and geographical variations in dietary composition (Lear,1972,Vinogradov,1972 ; Frost,1977)and to identify the existence of separate groups of the same species with different feeding habits based on food availability. In addition, the quantity and quality of food is of utmost importance in influencing the timing of reproduction, fecundity, age at first maturity and survival.

A knowledge of the relationship between the animal and their food items is essential for the prediction of abundance and the exploitation of the stocks.

The food and feeding habits of the stomatopods have been studied by a number of workers. Kubo et al.(1959) has studied the feeding habits of the Japanese mantis shrimp Oratosquilla oratoria. Similar studies were also carried out by Senta etal.(1969),Yorita (1972),Dingle and Caldwell (1978). Nasima and Qudusi(1984) observed the stomach contents of the Pakistani mantis shrimp of the genus Oratosquilla and subsequently by Hamano and Matsuura (1986). In India,Reddy and Shanbhogue (1994) studied the feeding biology of Oratosquilla nepa along Mangalore coast. However virtually, there is no information on the food and feeding habits of Oratosquilla nepa inhabiting along the Cochin waters.

ii.Materials and methods.

O.nepa for the present study were collected from of Cochin Fisheries Harbour and a total of 1039 specimens ranging in the size 31-115mm,(520-females and 519 males) were examined for this purpose. Immediately after collection,the total length wet weight, sex were noted. Each individual was cut open and the nature of their fullness of their stomachs were examined. They were then preserved in 5% neutral formalin. The stomach

contents were categorised into broad groups such as detritus, crustaceans, molluscs, animal matter,worms, ostracod, fish larvae, digestive matter, algae,diatom and unidentified matter. The occurrence of many of the food types in stomach contents could be established only from the appearance of fragments. The occurrence method of (Hynes, 1950) was adopted to indicate the presence or absence, of a particular type of food. In view of the fact that the occurrence method alone does not give a clear picture of the importance of individual food items,the points method (Pillay,1952) was also employed in the present study.

The intensity of feeding was judged by the degree of the distension of the stomach. This was judged visually and classified as gorged, full, 3/4 full, 1/2 full,1/4full, trace and empty. For the sake of convenience, specimens with gorged and full stomachs were considered as actively fed,3/4 as moderately fed while stomachs with traces were treated as poorly fed. Monthwise percentage occurrence of stomachs with different intensities of feeding were computed.

The Gastrosomatic index (GSI) was calculated for each specimen to determine the feeding intensity by applying the formula

$$GSI = \frac{\text{weight of the gut}}{\text{weight of the fish}} * 100$$

and the average was calculated for each month.

Results

The percentage occurrence of stomachs in various degrees of fullness is presented in Fig 1

a. Feeding intensity

In general, the percentage of gorged and full stomachs were less when compared to the other categories. Specimens with gorged stomachs were not present in all the months except in May,June and December during the period 1992-1993 and May,August and October during 1993-1994. Highest percentage of gorged stomachs were observed in December 92 (27.5%) during the first year while in May 1993 (15%) during the second year. On the contrary,the occurrence of lowest percentage of gorged stomachs were observed in May 1992(1.39%) and in October during 1993. With regard to the specimens with "full stomachs", their occurrence was noticed during during six months in 1992-93 against eight months in 1993-94. Likewise,the highest percentage of occurrence of full stomachs were observed in May92(13.89%) while lowest was

noticed in June 1992-93, however in 1993-94 period, the percentage of "full" stomachs were highest in May 93(32.5%)and lowest December 93 (5.13%).

3/4 full,half full,1/4 full stomachs were encountered almost round the year 1992-93 and 1993-94. The percentage of specimens with full stomachs were 2.5% (Feb 93) to 37.75% (Sept 92) during 1992-93 and 2.04% (Nov93) to 20% (August 93) during 1993-94. The presence of half full stomachs were observed throughout the year. In both the years,highest was in 47.22% and lowest (2.27%) in Oct92 during 92-93 while in1993-94,the highest percentage was encountered in Sept 1993 (29.41% and lowest in May 1993 (2.5 %).

Stomachs with "trace" amounts of food items were also found in all the months during the period of investigation,highest occurrence was observed to be in Jan 93 (83.35%) during1992-93 and the lowest August 92(7.5%)whereas in 1993-94,the highest was observed in Nov 93 (4.89%) and the lowest in May93(7.5%). Specimens with Empty stomachs were also noticed in all the months. The highest percentage was encountered in August 92 (70.59%) and lowest in December 92. In 1993-94,the highest occurrence of the same was observed in Oct 93 (4.62%)

while it was lowest in July 93.

Feeding intensity in relation to sex.

The percentage of full and gorged stomachs were taken together to find out the highest percentage of active feeders among the males and the females. It was observed that highest feeding activity was during Dec 92 (60%) in the males, while in the females, the percentage of active feeders were highest during June 92 (6.89%).

The highest percentage of empty stomachs varied from 4.44% (April 92)to 75 % (Aug 92)in the males, while in the females the variation was from 2.22% to 67.74% During 1993-94, the percentage occurrence of empty stomachs varied between 5% (Jul93) to 90%(Sept 93) in males and 0.59%(Jul 93) and 55% (apri193) in the females.

In regard to the percentage occurrence of specimens with 3/4 stomachs,during 1992-93, the minimum percentage was 6.52and maximum 15% were recorded in March and September 92.

Food composition in relation to sex and size groups.

Table 1 & 2 show the food composition in the males and the females. There was not much variation in the occurrence

of crustaceans in the stomach contents of both sexes except for the males in 1993--94. The molluscs, were more in the females in both the periods of study, when compared to the males. The males fed more on detritus when compared to the females and the females were found to feed more on animal matter. Diatoms were totally absent in the females during the 1993-94,while during 1992-93,about 2.63% of the females had diatoms in their gut. Diatoms were totally absent in the males for two years. The same trend was noticed in the echinoderms,ostracods and sagitta. Worms were present in the females during1992-93 but absent in the other half. In the males,they were present in both the years

Sand was present in considerable amounts for both sexes; but in the females,it dominated. Mud was also present in both sexes. Fish larvae mainly represented by anchovies were present in the diet of females in both the years. There was no incidence of fish larvae in the males. Algae was also present in both males and females,but in the females it was totally absent during the second half of the year. There were incidences of unidentified matter,about 17.28% in both sexes.

An observation of the food preference of the different size groups revealed that the most important item of the diet

preferred by all size groups of O. nepa was detritus. This was followed by Crustacean (appendages and shell bits), Molluscs,fish remains(bones and scales),algae, animal matter,unidentified matter, worms,ostracods,fish larvae and diatoms.

During 1992-93, 2.07 % of the males in the sizegroup of less than 50mm had crustaceans in their stomach. At the same time,their counterpart did not have crustaceans in their stomachs. Likewise in size group 50-75mm,the crustaceans were found in 15.75% of the males and 21.55% of females. In the size group 76-100,14.1% of the males and 19.96% of the females had the above item in their gut. In the largest size group of more than 100 mm,it was found that crustaceans were totally absent in the males but present to the extent of 2.1% in the females. During the second year,crustaceans were found in both sexes and in almost all size groups.

The smaller individuals had lesser percentage of molluscs (0.9%) in the males during the period 1993-94 while in the females,molluscs were present in considerable quantities. In the larger size groups of greater than 100mm, molluscs were totally absent.

The monthly fluctuation of GSI in O.nepa during

1992-94 are shown in Fig 2.In males, GSI was very high during Sept 92 and Dec 92 during 1992-93. In the females, the GSI was considerably high during May 92 and Sept92 in 1992-93 and in 1993-94, no definite trend could be discernible. The values were lower in August 92,Nov 92 and Feb 92 during 1992- 93 in males. Likewise similar trend could be seen during 1993-94. in Nov 93 and Dec 93. In females,lower values of GSI were evident during the months of August92,Oct92 and Feb 92.,;whereas in 1993-94,the same trend could be noticed in April, July and October.

Discussion.

In Oratosquilla nepa collected from Cochin Fisheries Harbour, the percentage of occurrence of empty stomachs were invariably high, when compared to the other categories of stomachs. This was followed by 1/4 full stomachs. Besides an appraisal of the feeding behaviour shows that Oratosquilla nepa exhibits the characteristics of a bottom feeder. The stomach contents were constituted by crustaceans,molluscs,diatoms,worms, fish remains which included scales and bones. This was followed by algae, animal matter, fish larvae,echinoderm, ostracod, unidentified matter,etc. It is also persistent to note that the food items were found mostly in churned form. Food in the form of pulpy mass could also be observed. As far as the detritus are

concerned,it is most likely that it could have been ingested as an incidental food while feeding on other targeted benthic organisms.

The stomach contents of the male and female mantis shrimps show similarity during both years of study. except for the slight variation noticed in some minor items of the diet. A comparison of the diets of the males and females showed that during the period 1992-93,detritus was found more in the case of the females (84.96%) when compared to the males. Likewise, the females had a higher percentage of sand, when compared to the males. With regard to the crustaceans, molluscs and not much variation could be drawn between males and females. The variation in the presence of minor items of diet like diatoms, echinoderms, ostracod and sagitta,are worth noticing. In females, during 1993,the above items were totally absent in the males and the females and an exception to this is in the case of diatom. There was not much variation in the detritus contents of in both sexes.

In females, there was the predominance of crustaceans, molluscs, digestive matter,sand, mud and algae.A comparison of the diets of Oratosquilla nepa during 1992-93 and 1993-94

revealed that crustaceans, molluscs, digestive matter and sand dominated during 1992-93. Echinoderms, ostracods, sagitta and miscellaneous items were totally absent during 1993-94. During 1993 -94,detritus and mud were found in significant quantities when compared to the previous year.

Shanbhogue(1994) observed in O. nepa of the Mangalore coast that detritus formed the chief constituent of its diet. This is also true in the case of O.nepa caught off Cochin waters. The above author also revealed that that the gut contents of both males and females of this species is similar. Yamazake(1985), in Oratosquilla oratoria(de Haan) of Matsu Bay, North Japan,noted that crustaceans often appeared in the stomachs ofwild shrimp. Hamano and Matsuura(1986), while studying the food habits of Oratosquilla oratoria, confirmed that it is a predator, which consumes mainly crustacea and mollusca in the Hakata Bay. The other items in the diet included fragments of appendages of crustacea, shells of mollusca,scales, rays and otoliths of Pisces, setae of Polychaeta and their bodies. In the present study,the items of the diet were classified as crustacea,mollusc,.etc. Crustacea were found in the form of bits and pieces like antennule, antenna. Also in addition to this, the shell bits of molluscs and crustaceans were seen. The

molluscan were mainly constituted by the gastropoda in the whole form. Likewise, the crustaceans were mainly constituted by the prawns and their parts.

Nazima and Qudusi (1984) while studying the gut contents of Oratosquilla of Pakistani waters had observed orange coloured pieces of stick like material, packed in longitudinal bundles. In addition, the other items in its diet were fish scales, fin rays, shell fragments, portions of crusts of some invertebrates and body parts of crustaceans. In the present study, fish scales and bones were classified under the category fish remains. Also fish larvae represented mainly by anchovies formed a portion of their stomach contents. In addition, flesh which was classified as animal matter was also present. Dingle and Caldwell (1978) suggested that the diet of Oratosquilla of Thailand consistedof gastropods, pelecypods, crabs and hermit crabs. However, Kubo (1959) indicated that Oratosquilla oratoria of Tokyo Bay predates more on crustacea and pisces than mollusca. Dingle and Caldwell (1978) divided stomatopoda into two groups by their prey capturing behaviour. First spearers having raptorial claws aimed with spines and they spear and then hold soft bodied prey such as fish and shrimps. Second, smashers; generally having few spines on their raptorial claw and smash the hard

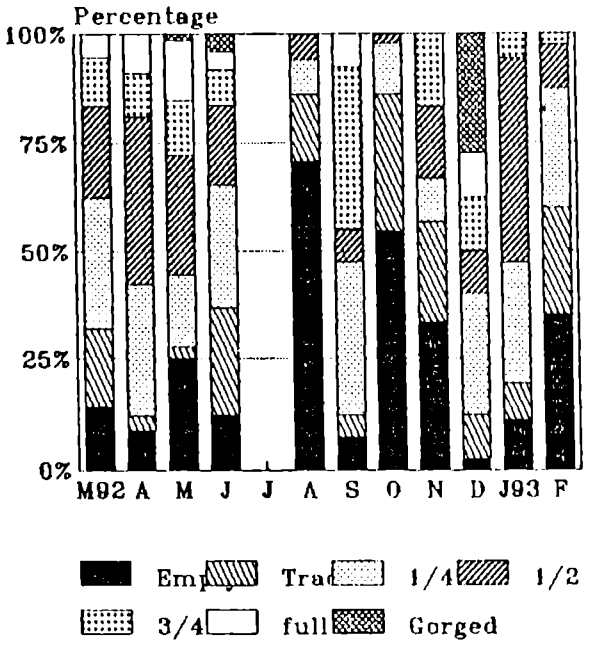
shell of the gastropods, pelecypods and hermit crab shells with the heel of the raptorial claw. Hence species of Oratosquilla were regarded as spearers though they indicated that the diets of some of this genus resemble those of smashers. The GSI values were high in the males and the females during May and Sept, 92. This could be due to active feeding. The absence of gorged and full stomachs in certain months could also be an indication of the breeding period. The increase in demand for the maturing gonads for space could be the probable reason for avoiding gorged and full stomachs. Empty stomachs were absent in some months of the year:the time when the spent ones recover after spawning.

Table 1 Frequency of occurence of major food items in stomach of male O.nepa

Month	No	Samples with stomach	Crustaceans	Mollusc	Detritus	Fish-remains	Digested matter	Animal Matter	Diatom	Echinoderms	Ostracod	Worm	Sagitta	Sand	Mud	Larvae	Algae	Misc.
MAR 92	46	40	22.5	70	92.5	67.5	45	--	--	--	--	--	--	10	--	--	--	--
Apr	45	43	44.2	18.6	60.47	20.93	43.9	58.1	--	--	--	--	--	9.3	--	--	--	--
May	42	27	85.2	9.4	100	7.41	--	7.41	--	--	--	2.3	--	3.7	--	--	30	--
Jun	20	20	40	--	100	--	90	--	--	--	--	--	--	40	--	--	--	--
Jul	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug	20	15	100	--	100	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep	20	18	66.7	22.2	88.89	15	100	--	--	--	--	--	--	--	50	--	--	--
Oct	20	6	66.7	--	100	--	--	--	--	--	--	--	--	55.6	--	--	100	--
Nov	10	6	100	16.67	100	--	--	--	--	--	--	--	--	--	--	--	--	--
Dec	20	20	75	25	60	--	95	--	--	--	--	--	--	100	20	--	--	--
Jan 93	16	15	86.7	--	100	--	--	80	--	--	--	--	--	--	--	--	--	--
Feb	20	11	--	18.2	100	63.64	--	--	--	--	--	--	--	18.2	--	--	18.2	--
Mar	20	14	14.29	71.4	85.71	64.3	45.5	--	--	--	--	--	--	--	--	--	--	--
Apr	20	17	58.8	--	100	41.18	71.4	94.12	--	--	--	--	--	--	52.9	--	--	--
May	20	16	81.3	--	87.5	--	--	--	12.5	2	--	--	--	--	--	--	--	--
Jun	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul	20	19	84.21	5.26	5.26	94.74	33.3	--	--	--	--	--	--	--	36.8	--	10.52	--
Aug	20	16	81.3	6.25	100	18.75	18.75	56.3	--	--	--	6.25	--	--	--	--	--	--
Sep	20	18	100	22.2	77.78	44.4	--	31.9	--	--	--	--	--	--	--	--	--	--
Oct	29	19	89.5	31.5	31.58	31.58	10.5	10.53	--	--	--	--	--	--	--	--	--	--
Nov	29	18	--	--	61.11	61.11	22.3	16.7	--	--	--	--	--	--	--	--	--	--
Dec	20	18	50	50	83.33	--	11.1	22.2	--	--	--	--	--	22.2	--	--	--	--
Jan 94	20	14	64.3	--	85.71	--	100	--	--	--	--	--	--	--	--	--	--	--
Feb	20	14	35.7	--	28.5	--	--	--	--	--	--	--	--	35.7	45.9	--	--	--

Table 2 Frequency of occurence of major food items in the stomachs of O.nepa female

Months	No.	Samples with stomachs	Crustac-ans	Mollusc	Detritus	Fish-remains	Digested matter	Animal Matter	Diatom	Echino-derms	Ostracod	Worm	Sagitta	Sand	Mud	Larvae	Algae	Misc.
Mar92	45	38	84.21	13.16	23.68	73.68	52.63	--	2.63	2.63	2.63	15.79	2.63	31.58	--	10.53	--	--
Apr	45	39	74.36	28.21	71.79	12.82	--	7.69	--	--	--		--	23.5	5.13	--	2.56	--
May	30	27	77.78	74.07	25.93	70.37	18.52	--	--	--	--	37.04	--	70.37	3.7	--	11.1	6.3
Jun	29	23	65.22	52.17	69.56	34.78	30.93	4.35	--	--	--	--	--	39.13	--	--	21.74	--
Aug	31	10	10	--	70	--	20	--	--	--	10	--	--	70	--	--	20	--
Sept	20	19	63.2	10.53	8.42	--	--	--	--	--	--	--	--	68.42	23.08	--	--	--
Oct	24	14	71.43	--	100	--	28.57	7.14	--	--	--	--	--	--	--	--	50	--
Nov	20	14	85.71	--	100	50	--	--	--	--	--	--	--	--	--	--	--	--
Dec	20	19	89.47	36.84	100	--	36.84	15.79	--	--	--	--	--	--	--	--	--	--
Jan93	20	17	99.11	--	100	47.06	--	--	--	--	--	--	--	47.06	--	--	--	--
Feb	20	15	53.33	20	100	13.33	--	--	--	--	--	--	--	53.33	--	--	13.33	--
Mar	19	12	50	58.33	66.67	33.33	83.33	--	--	--	--	--	--	58.33	--	--	--	--
AApr	21	10	30	30	80	70	--	20	--	--	--	--	--	--	--	--	10	--
May	20	11	27.3	--	63.64	--	--	--	--	--	--	--	--	--	36.36	--	9.09	--
Jul	13	12	83.3	--	25	75	66.67	--	--	--	--	--	--	58.33	--	--	--	41.67
Aug	20	17	88.24	58.82	100	41.18	23.53	52.94	--	--	--	--	--	5.85	--	--	--	--
Sep	14	13	92.31	--	92.31	46.15	--	38.46	--	--	--	30.77	--	--	--	--	--	--
Oct	20	13	100	--	92.31	61.54	--	--	--	--	--	--	--	38.46	30.77	--	--	--
Nov	23	15	4.67	33.33	66.67	33.33	13.33	26.67	--	--	--	--	--	6.67	26.67	6.67	--	--
Dec	19	15	20	66.67	86.67	33.33	15.26	--	--	--	--	--	--	60	53.3	--	--	--
Jan94	20	19	68.4	57.89	57.8	31.58	78.9	--	--	--	--	--	--	57.89	--	--	--	10.53
Feb	20	15	40	6.67	13.33	--	--	--	--	--	--	--	--	66.47	73.3	6.6	--	--



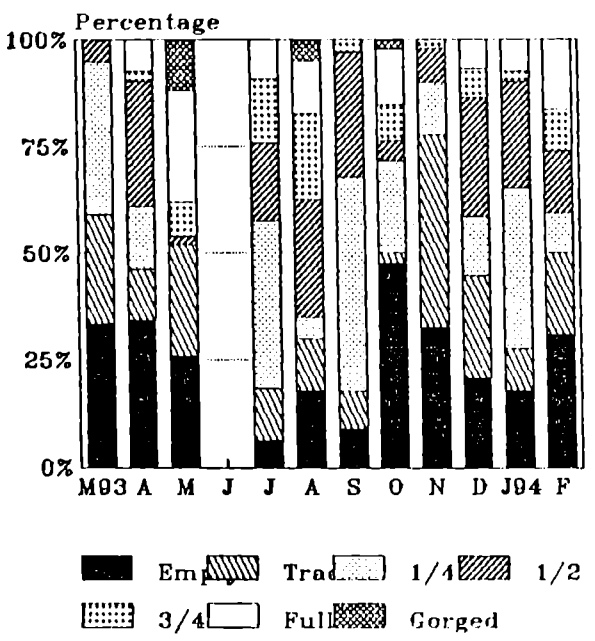
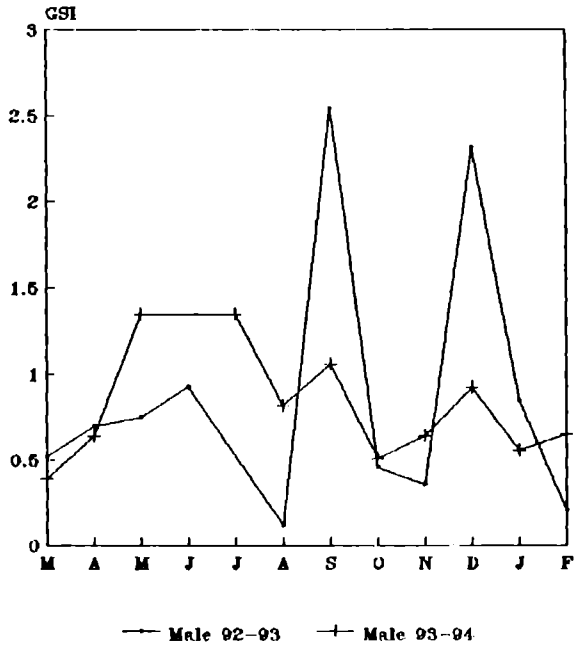


FIGURE: 1: PERCENTAGE OCCURENCE OF STOMACHS IN VARIOUS DEGREES OF FULLNESS



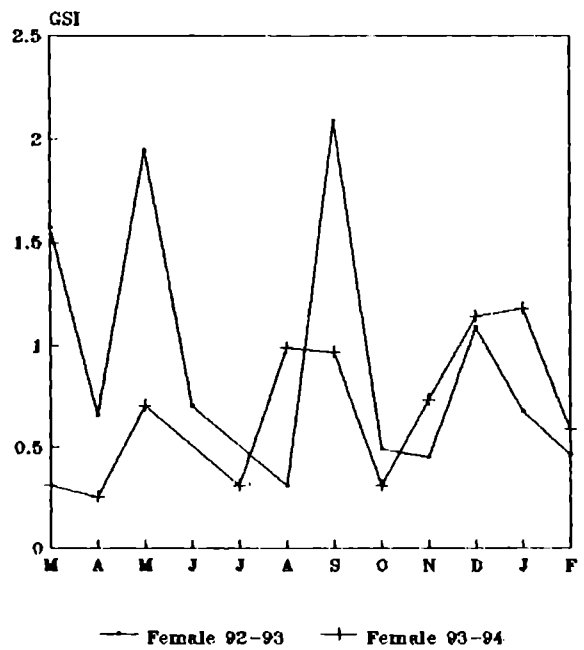


FIGURE 2: MONTHLY VARIATION IN GASTRO-SOMATIC INDEX (G S I)

CHAPTER 6

AGE AND GROWTH

INTRODUCTION.

Information on the age and growth of an organism is important in understanding the nature of stock and the role played by various year classes in the fishery constituted by the animal, the conditions under which optimum growth is possible and the influence of various environmental factors on growth. Knowledge of age data, in conjunction with length and weight can give valuable information on the stock composition, age and maturity, longevity, mortality, growth and yield. Information on growth is essential for stock assessment in the context of successful resource management where simultaneous additions and losses by weight that take place in the population are decisive factors determining the stock size.

Age and growth studies in stomatopods are that of Kubo (1959), who dealt with growth of the Japanese mantis shrimp Oratosquilla oratoria in Tokyo waters while Hamano (1990) observed growth of Oratosquilla oratoria of Hakata bay.

Studies on the age and growth of Oratosquilla nepa of

Indian waters are scanty. Alikunhi (1975),James & Thirumilu (1993) reported the age and growth of the species from Madras, while Sukumaran (1987) studied similar aspects of this species from South Kanara Coast. Alikunhi (1965) also observed growth of Oratosquilla nepa under laboratory conditions.

It would thus appear that practically no information is hitherto available on the age and growth of Oratosquilla nepa inhabiting Cochin waters.

MATERIALS AND METHODS.

The von Bertalanffy growth function (VBGF) was used to describe the growth. The simplest version being in the form of

$$Lt = L_{\infty} \left[1-e^{-k\ (t-to)}\right]$$

for growth in length. Where "$L\infty$ " are the asymptotic length attained by the fish if it were to grow infinitely ;K is the growth coefficient and "to" is the age the fish would have at length 0 if they had grown according to the equation. Lt is the predicted length at age t.

Length data of 7935 specimens (3616 males and 4319 females) were collected from Cochin Fisheries Harbour and were used for estimating growth parameters of Oratosquilla nepa. The length data of both sexes were treated separately. The analysis was carried out in the following stages.

1. Modal class progression analysis by integrated method (Pauly,1982,1983)
2. Estimation of $L\infty$ and K by Ford - Walford Plot (Ford,1933 ;Walford 1946).
3. Estimation of 'to' by von Bertalanffy plot
4. Fitting of von Bertalanffy growth equation

Modal class progression analysis

The length frequency data for males and females for the period March 1992 to February 1994 are given in Fig 1 and 2. The length data grouped at 10 mm class intervals pooled for each month were sequentially arranged over time scale. The modes for each month were marked against the mid value of the respective classes. A smooth growth curve connecting a majority of the modes was traced with the help of a curved ruler. Subsequently, similar curves connecting other modes were also made.

The lengths corresponding to various ages starting from an arbitrary age were read from the selected curves at regular time intervals (quarters) and an average was arrived at. The mean lengths at different time intervals so obtained were subjected to further analysis using the Ford Walford plot for estimating the growth parameters.

Ford- Walford plot.

The Ford - Walford plot is essentially a rewritten version of the VBGF having the linear form

$$L_t = a + b\, L_t$$

the above equation can be written as

$$L_{t+1} = L_\infty (1-e^{-k}) + e^{k}\, L_t$$

Or

$$L_{t+1} = a + b\, L_t$$

The lengths at age derived from the modal progression analysis were subjected to linear regression (Snedecor and Cochran,1967). The results obtained from regression were used to calculate the growth parameters L_∞ and K as per the following formula

$$L\alpha = \frac{a}{(1-b)}$$

$$K = -\log_e b.$$

The time interval used was 3 months and hence the K value obtained was multiplied by 4 to get the annual growth increment (k).

Estimation of "to"

Estimation of "to" was also made using von Bertalanffy (1934) plot in which the results of the regression of -ln (1-Lt/L) against "t" was used to calculate "to" as

$$t_o = -a / b$$

Fitting of von Bertalanffy growth equation

The growth parameters thus derived from the above methods were fitted in the VBGF to obtain growth model for males and females of O.nepa.

RESULTS

(1) AGE :Months mode curve-

The months mode curve identified in the length

frequency analysis are plotted in the frequency polygons of both the males and the females (Fig 1 and 2) The trend lines progressing through the modes of the successive months, representing the various broods are also given .

The results of the plot of -ln (1-L t/L) against t and the corresponding values of "to" are given below.

	a	b	r	t0 (years)
males-	0.037	1.23084	0.9629	-0.0301
females-	0.077	1.5869	0.9842	-0.0485

Thus von Bertalanffy growth equation for the different sets of parameters can be written as

$$117.6120\ (1-e^{-1.2832\ (t\ +\ 0.0301)})$$ for the males

$$112.5497\ (1-e^{-1.8516\ (t\ +\ 0.0485)})$$ for the females

(2) GROWTH :von Bertalanffy's equation-

By applying the least square method, the values of "b" and "a" could be estimated as follows:

b = -0.0301

a = 1.230842 for the males and

b = -0.0485

a = 1.586928 for the females

The value of "K" is determined by using the formula

$$K = -\log e$$

$$b = \log \frac{1}{e^{-k}}$$

"-to" for different ages was calculated

K = 1.8516 for females

1.2832 males

Using the values of $L\infty$, K and to as estimated above, the growth equation for Oratosquilla nepa male and female are given as follows. By the end of the first year,

L_t =86.2566 mm in the case of the males

L_t =97.1416 mm in the females.

The results are in agreement with that of the growth arrived at from modal progression method in the case of the males which attain 85.5 mm by the end of the first year against the

calculated value of 88.2566 mm. In females, the growth arrived from modal progression was 89 mm and the same by Von Bertalanffy method was 97.1416. Though the values found closer, it is not comparable with that of the male counterpart.

The theoretical growth curve traced by the end of twenty first month was 104 mm in the males and 111.5 mm in females The calculated value in males was 105.6272 mm and this in comparison with the value arrived at from modal progression shows full agreement. However, in females, the length was 108.7342mm and though it is almost closer to value traced from modal progression analysis, there exists some difference unlike in males.

Ford walford plot.

L_∞ was calculated by the Ford walford method and the values were 117.6120 mm and 112.5497 mm in the males and females respectively.

DISCUSSION

Ageing based on the hard parts is unsuccessful among the crustaceans because during moulting, these hard parts get shed completely and therefore modal progression analysis by the

integrated method (Pauly, 1982 1983) was widely employed due to its simplicity, fully utilizing the facility of subjective manipulation in connecting the modes and arriving at the most probable curve.

Accordingly, the von Bertalanffy model has been chosen adequately for a variety of marine fish because it is also amenable to statistical analysis.

The results obtained by the analysis of the data from 1992 to 1994 employing the modal progression analysis revealed that by the end of 6 months, the males and females reached a length of 60 mm and 65mm respectively and by the end of the first year, the males and females reached a length of 85.5 89 mm respectively. By the end of the 21 st month, the males attained a length of 104 mm against 111.5 attained by the females.

The empirical lengths at different ages as calculated by von Bertalanffy equation showed a high degree of agreement of growth estimated in the males. However, in the females, some difference in the values could be discernible. The asymptotic length ($L\infty$) computed for the males and the females showed a difference of 5.0623

On the basis of length frequency analysis Sukumaran (1987) reported that Oratosquilla nepa of the South Kanara coast attained a length of 108 mm by the end of the first year. James & Thirumilu (1993) observed that males of Oratosquilla nepa from Madras waters reached a length of 92.33 mm, 95.99 and 113.59 mm at the end of the 1st, 2nd and 3rd years respectively, whereas in the females, the values were 95.81, 107.82 and 113.97 mm respectively. This is in agreement with present findings in Oratosquilla nepa from Cochin waters.

The $L\alpha$ values according to James (1993) was 96 mm in the males and 114 mm in the females,while in O.nepa from Cochin waters, in the present study,it is computed as 117.612 for the males and 112.5497 in the females. It would thus appear that in the females, $L\alpha$ value conforms with previous estimates while in males the values show some difference with the available reports. The difference noticed may be due to the difference in maximum length attained in the specimens encountered in the catches from the South East and the South West Coast of India. On the contrary, the $L\alpha$ values of Oratosquilla nepa arrived at in the present study are comparable with similar values reported by Sukumaran (1987). It may, therefore, be inferred that there

exists similarity in the specimens inhabiting the same coast. Sukumaran (1987)reported the L_∞ value in O.nepa as 143 mm.

Alikunhi (1965) reported that Oratosquilla nepa grows upto 27.5 -30 mm in 15-30 days,41-53 mm in 34-61 days and 93- 96 mm in 129 to 176 days in the laboratory conditions. This, in comparison with the growth rate encountered from the wild stock is indeed fast. This may be due to better environmental and food conditions provided in the aquarium, whereby the growth might have become faster. It would also suggest the possibility of the difference in growth rates between laboratory reared and the wildstock of Oratosquilla nepa.

According to Kubo et al. (1958) in Japanese mantis shrimp Oratosquilla oratoria, the mean body lengths of each age group were 5 to 7.2 cm, 7.5 to 11.3 cm and 9.4 to 14.4 in the 0, 1 and 2 age groups respectively irrespective of sex. The largest average body length of the 3rd age group was 15.06 cm in the females and 14.35 in the males. The length at the end of the 1st year ranges between 75 to 113 cm. Hamano(1990) while rearing the stomatopod crustacean Oratosquilla oratoria of Hakata bay under laboratory conditions, observed that it can grow upto 15 cm (150mm). The males of this species were reported to be larger

than the females in the same age as shown in the difference in carapace length of the male against 31.9mm in females at the end of 36 months. So far no attempt has been made to establish the sex wise difference in growth rates in O.nepa of Indian waters,however, in the present study, sex wise difference in growth rate could be established in this species inhabiting Cochin waters.

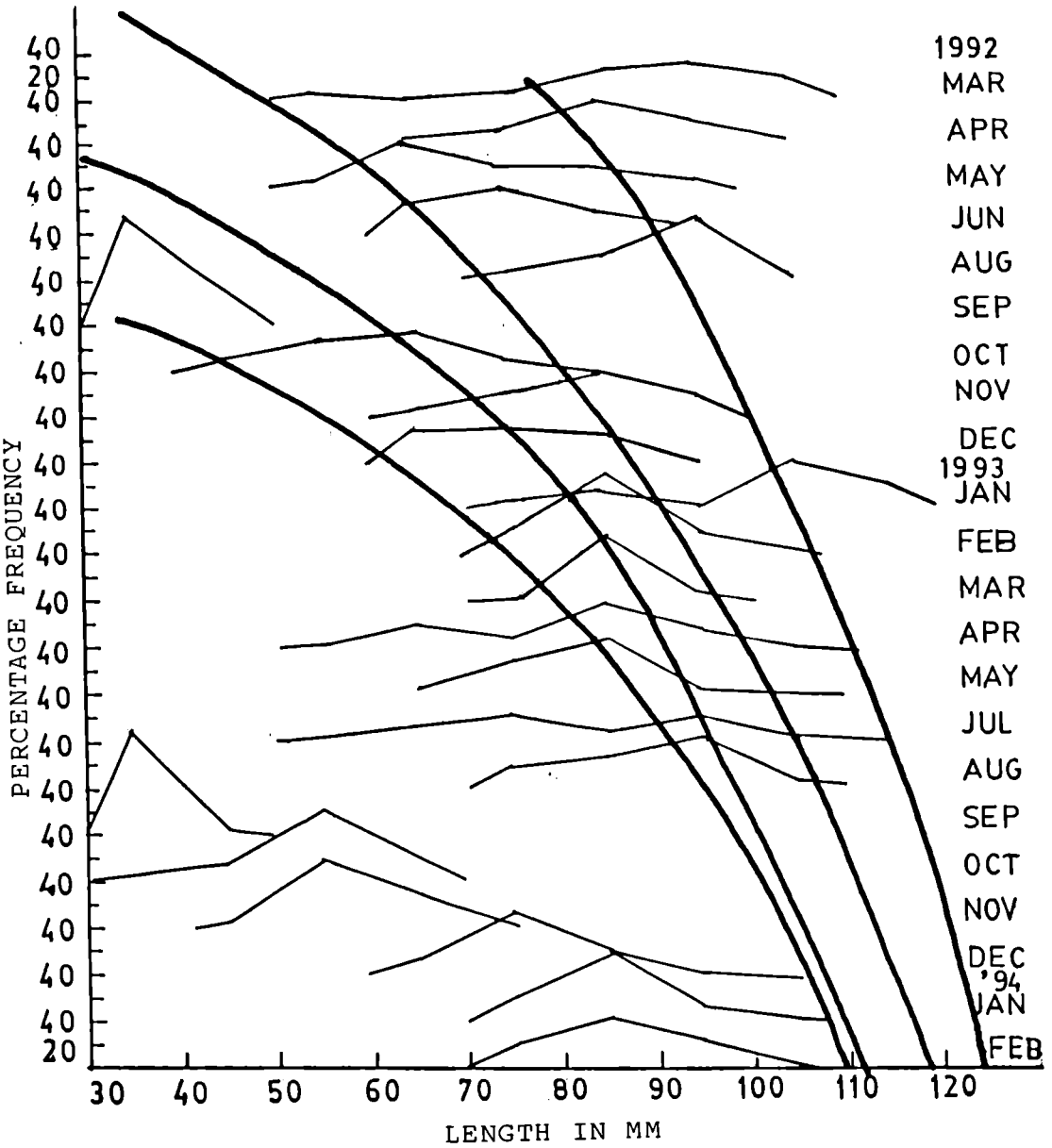


FIG:1: GROWTH CURVES CONNECTING THE MONTHLY MODES OF MALE O. nepa FOR MODAL PROGRESSION ANALYSIS

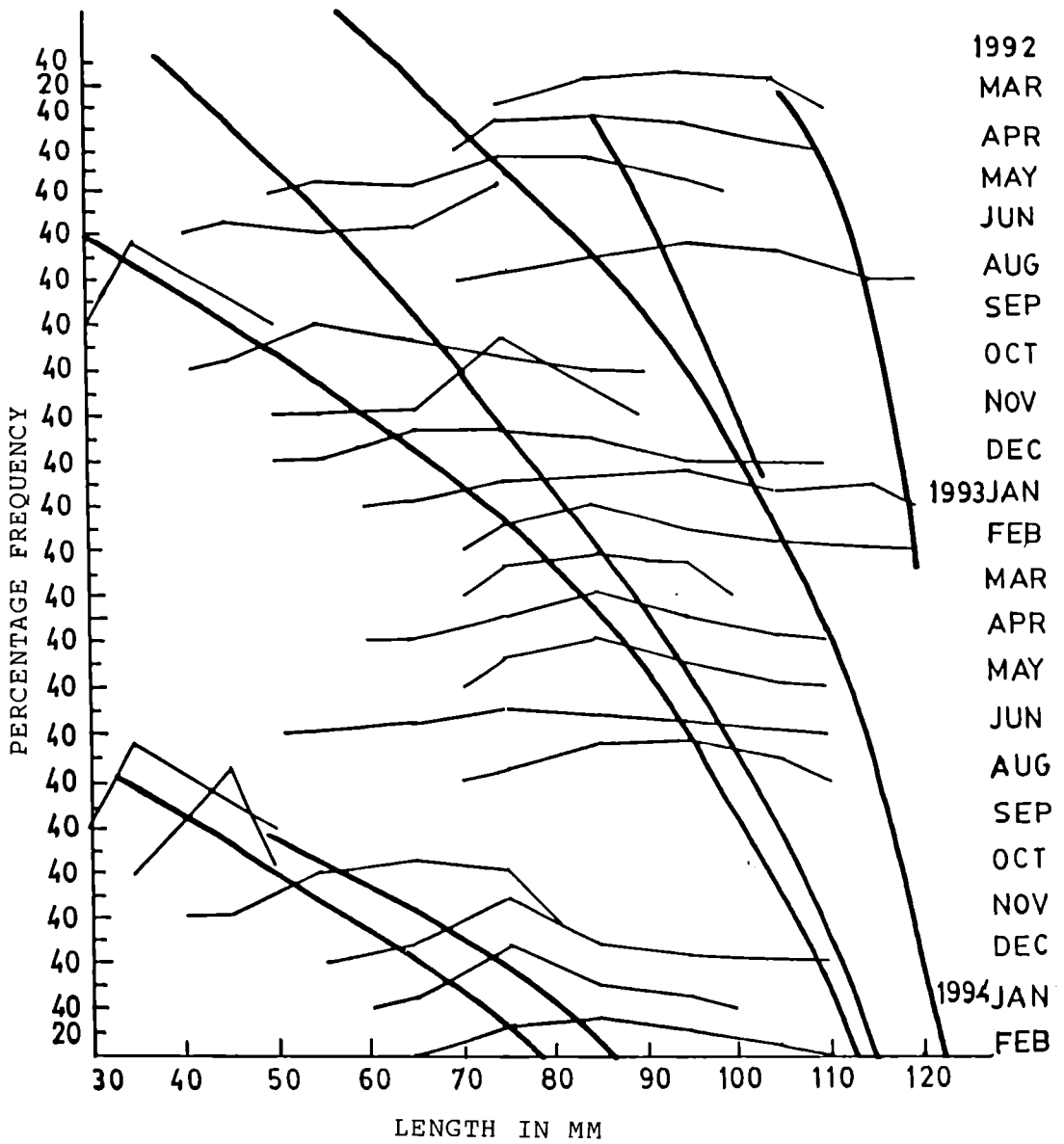


FIG: 2: GROWTH CURVES CONNECTING THE MONTHLY MODES OF FEMALE O. nepa FOR MODAL PROGRESSION ANALYSIS

CHAPTER 7

REPRODUCTIVE BIOLOGY

Introduction

A study of the reproductive aspects of any fish stock is a very important tool in the study of fishery biology. Studies on the maturation and depletion of gonads is basically aimed at understanding and perhaps predicting the changes which the population as a whole undergoes during the year. The information on the sex ratio is useful to estimate the reproduction potential in animals. These studies are essentially meant for elucidating both short term and long term variations in the production of fish broods which are finally recruited in the population as exploited stocks. Knowledge of the minimum length at sexual maturity is essential to ensure a sustained yield by regulating the mesh size of the net, to ensure that the smaller fish also may have an opportunity to spawn atleast once in their lifetime.

Among various stomatopods, the reproductive biology of the Japanese mantis shrimp, Oratosquilla oratoria was studied by Kubo et al. (1959) while the the spawning ground of this species in Tokyo Bay was reported by Ohtomi and Shimizu (1991) whereas Roberto and Enrico.(1993) had studied different

immunoelectrophoretic forms of yolk proteins marking in different stages of maturity in female Squilla mantis.

As regards the studies on Oratosquilla nepa in Indian waters are that of Sukumaran (1987) who studied the size at maturity,spawning season,sex ratio and fecundity from South Kanara coast.Recently,James and Thirumilu (1991) observed the above aspects in Oratosquilla nepa collected from the trawling grounds off Madras. On the contrary, Alikunhi,(1975) worked on the growth, maturity and spawning of Squilla nepa Latreille under laboratory conditions.

Except for the above literature pertaining to Oratosquilla nepa, no other information is available on the reproductive biology of the species from Indian waters, especially from that of Cochin waters. Besides, no attempt has so far been made to study the fecundity indices, which is attempted in the present account.

Materials and methods

Random samples of O.nepa were collected at weekly intervals from the trawl catches at Cochin Fisheries Harbour, for a period of two years (March 1992 to February 1994).

Specimens were washed thoroughly in the laboratory and the total length and weight were taken to 0.1 cm and 0.01 g respectively. The stages of maturity of the fresh specimens were noted for both the sexes as according to Sukumaran (1987)..

The samples were preserved in 5 % formaldehyde and detailed studies were made in preserved specimens, whereby the dissection of the ovaries could be done at ease. The weight of the ovary was taken in an electronic single pan balance, while the length was recorded to the nearest mm. Further the ovary was preserved in modified Gilson's fluid (Simpson,1951) for a period of two weeks. For computing the fecundity, the gravimetric method was adopted wherein three subsamples were accurately weighed and the number of eggs in each subsample was counted and the average of the three so arrived at was multiplied by the total weight of the ovaries using the formula,

$$F = n G / g,$$

where F = Fecundity

n = number of eggs in the subsample

G = the total weight of the ovary.

g =is the weight of the sub sample in the same units.

The fecundity (F) was correlated with several variables such as total length in mm, body weight in g,ovary length (OL) in mm and ovary weight (OW) in g using regression analysis.

In addition, Gonadosomatic index GSI was calculated using the formula :

$$GSI = \frac{\text{wt of the gonad}}{\text{total body wt}} \times 100$$

for both sexes monthwise.

Classification of the maturity stages of the gonads.

Males:

The testes were classified into 3 stages .

(a) stage 1.(Immature) :Testes slender, thread like and extending upto 1/3rd the body cavity length.

(b) stage 2.(maturing): testes white and black midline extending upto 1/2 the length of the body cavity

(c).stage 3.(mature): testes thick creamy and opaque and the black midline extends upto the caudal peduncle,

Females

The ovaries were classified into 5 stages(Sukumaran,1987).

(a) Stage 1.(Immature): The ovary is thin and transparent,showing no sign of development.

(b) Stage 2.(Early maturing): The ovary is slightly enlarged and pale yellow in colour. The ova shows signs of development.

(c) Stage 3.(Late maturing) :The ovary is lemon is lemon yellow in colour, enlarged extending from the carapace to the last abdominal segment. Due to the accumulation of yolk, the ova are not visible.

(d)Stage 4.(Mature): The ovary is deep orange or reddish brown in colour, very much enlarged, extending dorsally from

the posterior region of the carapace right upto the telson.The ova are spherical, round or ovoidal as well as brittle.

(e) stage 5.(spent) :The ovary is flaccid and dirty yellow or white.Here there is the presence of a few mature ova as well as a number of broken ones.

Results.

(1) Development of ova to maturity and the frequency of spawning:

The percentage frequency of the ova diameter in various stages of maturity are shown in Fig.1. In the immature stage 1, the prominent mode was at 0.025mm In stage 2, the prominent mode was discernible at 0.05mm and it was while the eggs having diameter 0.125mm that constituted the second mode. In stage 3, eggs having 0.075 mm accounted for about 22.32 %. One major mode and 2 minor modes were discernible in the 3rd stage.of maturity. The major mode was observed at 0.075mm and the minor modes were at 0.15mm and 0.2mm.Stage 3.In stage 4,the highest mode was at 0.175mm.Stage 4 also had a minor mode at 0.075mm. In stage 5, that is the spent stage, it could be observed that there was a single prominent mode at 0.05 mm.

2).Seasonal occurrence of the maturity stages.

Percentage occurence of various maturity stages of males and females in different months during 1992 to 1994 was recorded with a view to assess the spawning season of Oratosquilla nepa.(Fig 2 & 3). The highest percentage of fully mature ovaries (stage 3 & 4) in O.nepa was during June 92 and November 92 during the period 1992 while in 1993, the same was noted in April and July. However spent individuals were totally absent during these periods.

Among the males, fully mature testes (stage 3) occured from March to June 92. With the imposition of the trawling ban from 20th June to3rd August 1992, sampling could not be undertaken for the month of July. Henceforth, mature individuals were found in August. The highest occurence of the mature males was reported in 1993. Since the lifting of the trawling ban, mature males were totally absent upto December. Their reappearance for the second time was during the months of January and February 1994. In the case of the females,mature ovaries were present in the specimens throughout the year except during the ban period and September 92 and October 93. The highest percentage of the occurence of mature ovaries was during

June and November 1992 and July, August and November of the second year. From this it can be inferred that O.nepa breeds twice in a yearin Cochin waters. The peak spawning during 1992 was noticed in the month of June while in 1993, it was April/ July.

The occurence of specimens with spent gonads during August, December 92 and May 1993 would suggest the continuous recruitment of juveniles to the fishery stock. Stage 4 dominated in most of the females throughout the study period. The dominance of matured specimens was noticed during June 92 (100%). Similarly, the dominance of matured specimens during November 92 and the subsequent dominance of the spent individuals during December 92 of the same period. It would appear that O.nepa spawns twice in a year in Cochin backwaters.

In general, the occurence of highest numbers of this species with ripe gonads was encountered during June, July and November of the study period which would suggest that they are most likely to be the peak spawning seasons.

(3)Gonadosomatic index.

The monthly fluctuation of the gonadosomatic indices are shown in fig 4. It can be seen that in the males,the mean GSI increased rapidly from April to June and thereafter showed a decline upto October. An increase could be noted and reached its peak in February 1993 in (1992-93) while in 1993-94 the the trend was almost similar except for the slight decline seen in April. In the females, the mean GSI value showed an increased trend from April upto July. An improvement could be seen upto November and then decreased till January. An increase was observed thereafter. Similar trend was observed in the females in the following year. The high GSI value during June and November during both the years indicate high spawning activity during these months. However a steep fall during May,September and December may indicate the discharge of the gametes. Although the trend is the same in both the years, the mean GSI values differ. The peak spawning,as inferred from GSI values is in full agreement with that of occurence of the maturity stages.

(4) Minimum size at first maturity.

Estimates of length at first maturity (length at which 50% are mature i.e (L=50) was estimated and is shown in Fig 5. It could be seen that no male or female below 50mm (TL) was found to be mature. The percentage of mature males and females increased steadily and 100% maturity could be noticed in the length group from 100 to 109 mm(TL) in the males and 110-119 mm in the females. The length at which 50% of the individuals attain maturity was 55 mm for the females and 50 mm for the males. Thus it would appear that males attain sexual maturity earlier when compared to the females.

(5)Fecundity

The number of eggs likely to be released in each spawning was enumerated by counting the large and opaque eggs. In the present study, the relationship between fecundity with other variables such as total length,weight,ovary length and ovary weight was calculated. Mature ovaries of stage 3 and 4 were only used for fecundity estimation. Fecundity varied from 10,300 to 8,55,429 in the size range of 59 mm to 116 mm.

(a) Relationship between fecundity and total length

A logarithmic relationship between these variables is given by the following equation :

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

where "F" represents the fecundity

"L" the total length

"a" and "b" are the constants estimated by the method of least squares and the equation so arrived can be expressed as follows:

$$\text{Log } F = 1.314031 + 0.1309 \log L$$

Expected fecundity values were calculated for the minimum and maximum lengths based on this formula and a straight line was fitted to the data as shown in fig 4a.

The correlation coefficient (r) value of 0.8219 was estimated between fecundity and total length and shows a high degree of correlation between them.

(b)Relationship between fecundity and body weight.

The relationship between fecundity and body weight can be expressed as

$$\text{Log } F = -1.1565 + 0.4172 \log L$$

The correlation "r" value between these two variables was 0.7714.

(c) Relationship between fecundity and ovary length

The relationship between fecundity and ovary length is as follows :

$$\text{Log } F = 0.12049 + 0.01876 \log L$$

The correlation "r" between the two variables was 0.6963

(d) Relationship between fecundity and ovary weight

Here the relationship between the two variables can be expressed as

$$\text{Log } F = -3.2448 + 0.07249 \log L$$

The r value was of 0.7285.

(6)Sex ratio

The sex ratio of the males and females of O.nepa during the years 1992- 94 showed considerable variation. The results of the chisquare test of the sex ratio are given in Table1. During 1992 -1993, the males outnumbered the females for 3 months (March,April and September)while in the subsequent year,they outnumbered the females twice during (July and

December). However the chisquare test showed no significant deviation from the expected 1:1 ratio during the entire period of study. The total chi square values during the period 1992 -93 and 1993-94 did not deviate from the expected 1:1 ratio.

Discussion

Observations on the maturation and spawning of Oratosquilla nepa shows that the peak spawning seasons of this species in Cochin waters is June and November during 1992 and and April to July during 1993. Sukumaran (1987)reported that Oratosquilla nepa of South Kanara coast spawns peaks to be at March -Jun and Sept-October. Kubo(1959) observed that the Japanese mantis shrimp Oratosquilla oratoria spawns in the month of June. These results can favourably be compared with the present findings. Earlier reports also suggest that it spawns twice a year and this is very much in agreement with that of the present findings. The peak spawning period of O.nepa was found to be protracted during 2 to 4 months and the presence of a large number of mature specimens commercial catches is noteworthy.

According to Ohtomi and Shimizu (1991), the peak

spawning of Oratosquilla oratoria was April, May,July and August. However James and Thirumilu (1991) had observed that O.nepa of Madras waters showed maximum breeding activity in March, June, October, January and December. This would suggest the coast wise difference in breeding activities of O.nepa especially along the south east and the south west coast of India.

The pattern of fluctuation of the gonadosomatic indices also show that these values are invariably higher in June/July and Oct /Nov of the females while in the males,high values could be noticed in June/October. It may therefore be inferred that the occurence of fully mature specimens were high during this period. Since there is no literature pertaining to the GSI of any other stomatopod and therefore a comparison is not possible.

The gonad index is considered to be a measure of the average stage of the reproductive population (Giese,1959). This ratio bears a relationship to the gonad development and gonad maturity during different times of the year. This has been used in crustaceans, (Subramanyan,1963). There is a possibility of the mature individuals occurring in July if not for the ban imposed by the government. Since the lifting of the trawling

oan, mature specimens could be found during the months and August.

The study of the sex ratio in O.nepa conforms with the 1:1 ratio in the present study and this is not in full agreement with the findings of Oratosquilla nepa of south Kanara (Sukumaran,1987). According to him, the sex ratio showed variation from the 1:1 ratio. According to Sukumaran(1987), the females predominated over the males. The overall sex ratio also indicated that the females dominated by occupying 62.2 % of the total population. James and Thirumilu (1991) also noticed the occurence of males in slightly lesser proportion and the dominance of females thus showing full agreement with the present findings. Finally this would also suggest a similarity in the sex ratio in the population of O.nepa inhabiting the same coast.

The length at first maturity according to James and Thirumilu,(1991) was estimated as 73.2 mm in the case of the females and this is conforming with the present findings. This would indicate the difference in attaining length at first maturity in O.nepa in the east and the west coast. The author also reported that the mature females were rare in specimens less

than 60mm in length, but this observation is at variance with the present finding in which the presence of matured specimens was worked at 59 mm. Sukumaran (1987) observed that the smallest female with fully mature ovary measured in 68 mm size while in the present study, females with 60 mm size showed signs of maturity.

The total number of eggs in the late maturing female of 108mm (Sukumaran 1987) had 678 200 ova which is comparable with the results of the present study of 620997 eggs. A proportionate increase in fecundity could be seen with body length and these findings are in full agreement with the findings of Patra,1976 ; Shakuntala,1976 ; Lee and Menu, 1981. Thus it can be concluded that O.nepa spawns twice in a year in Cochin waters (June and November).

Table 1 Sex ratio of O.nepa in different months showing Chi-square values

Months	Male	Female	% of Males	% of Females	Chi-square value	F:M
March 92	249	131	65.53	34.47	36.64*	1.90 : 1.00
April	225	162	58.14	41.86	10.26	1.39 : 1.00
May	155	290	34.83	65.17	40.96	1.00 : 1.87
June	203	228	47.10	52.90	1.45	1.21 : 1.00
July			Trwling Ban			
August	79	110	41.80	58.20	5.08	1.00 : 1.39
September	233	116	66.76	33.24	39.22	2.00 : 1.00
October	176	195	47.44	52.56	0.97	1.00 : 1.11
November	182	203	47.27	52.73	1.15	1.00 : 1.12
December	168	314	34.85	65.15	44.22	1.00 : 1.87
January 9	186	213	46.62	53.38	1.83	1.00 : 1.15
February	130	252	34.03	65.97	38.96	1.00 : 1.94
March	111	218	33.74	66.26	34.80	1.00 : 1.96
April	157	217	41.98	58.02	9.63	1.00 : 1.38
May	119	212	35.95	64.05	26.13	1.00 : 1.78
June			Trwling Ban			
July	237	173	57.80	42.20	9.99	1.37 : 1.00
August	98	196	33.33	66.67	32.67	1.00 : 2.00
September	134	151	47.02	52.98	1.01	1.00 : 1.13
October	63	83	43.15	56.85	2.74	1.00 : 1.32
November	136	147	48.06	51.94	0.43	1.00 : 1.08
December	250	163	60.53	39.47	18.33	1.53 : 1.00
January 9	199	258	43.54	56.46	7.62	1.00 : 1.29
February	128	233	35.46	64.54	30.54	1.00 : 1.82

* Chi-square values in all the months are not significant at 5% and 1% level

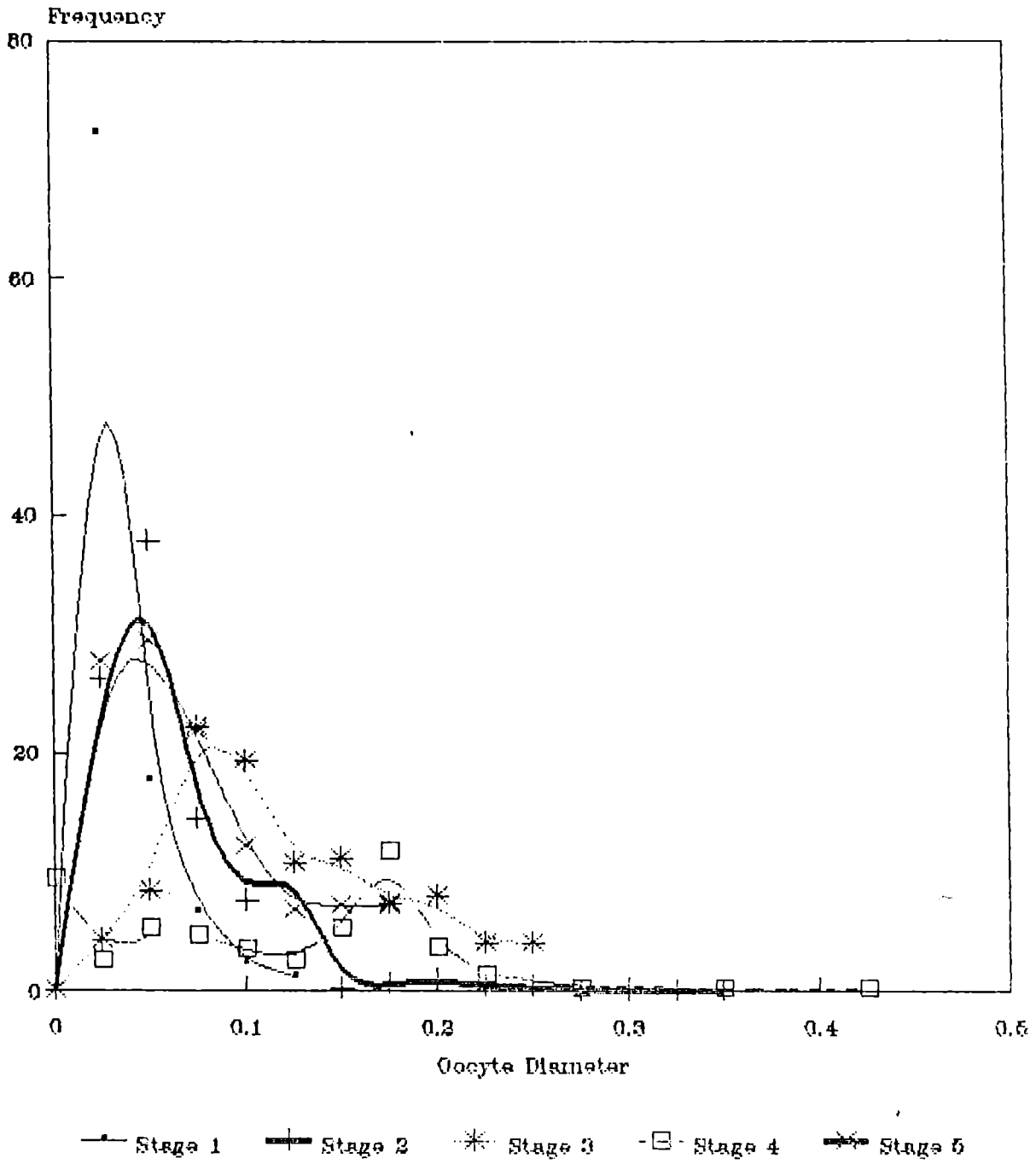
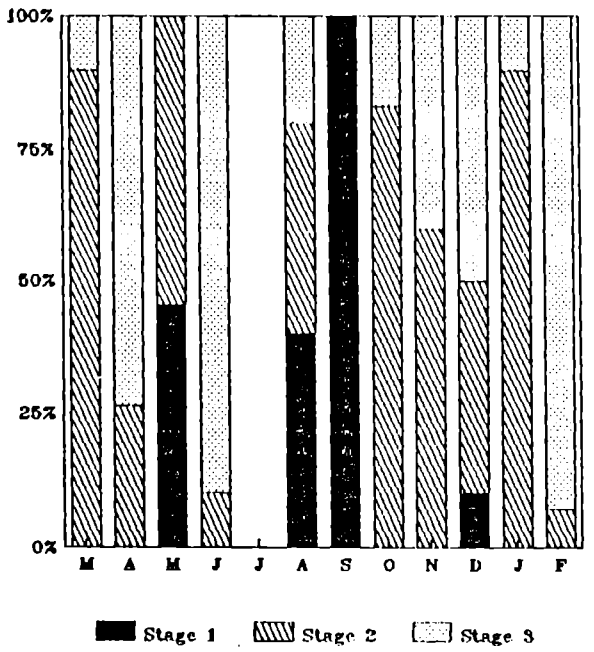
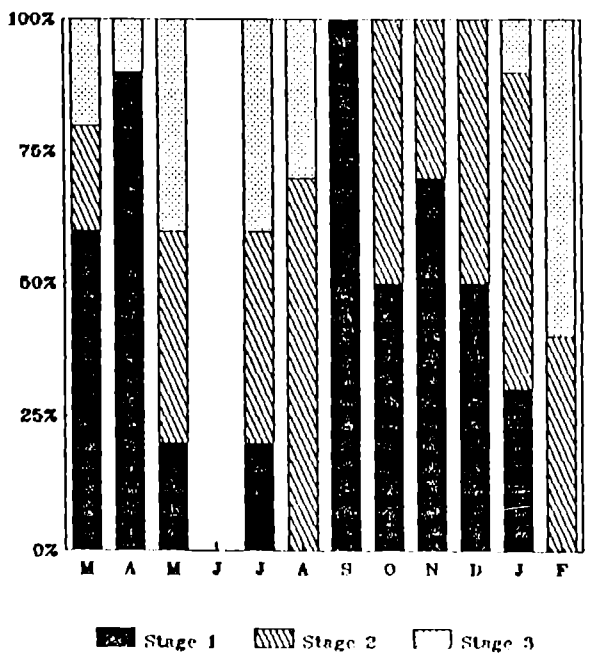


FIGURE 1: PERCENTAGE FREQUENCY OF OVA DIAMETER IN VARIOUS MATURITY STAGES OF O. nepa

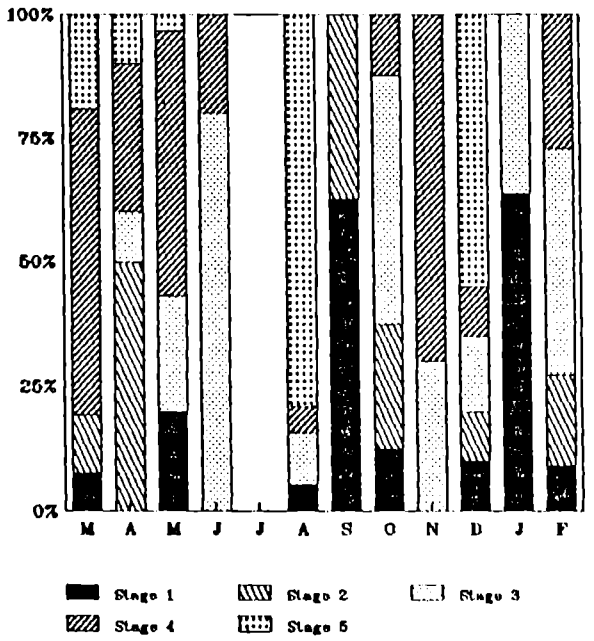


1992 to 1993

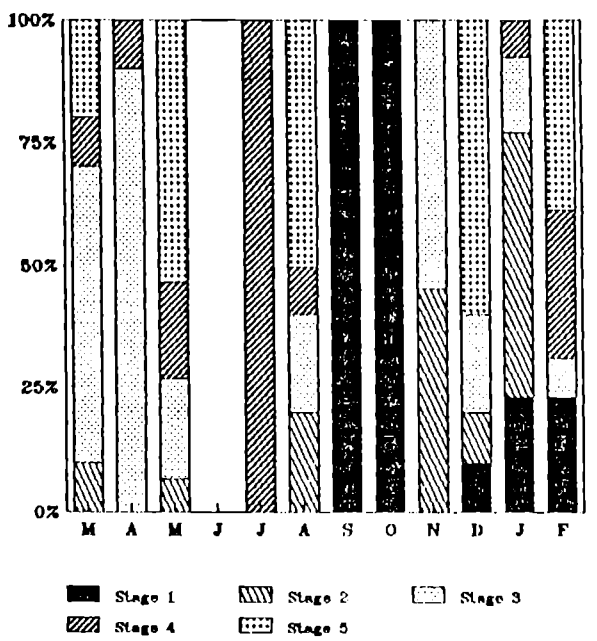


1993 to 1994

FIGURE 2: PERCENTAGE OCCURENCE OF VARIOUS MATURITY STAGES OF MALES IN DIFFERENT MONTHS

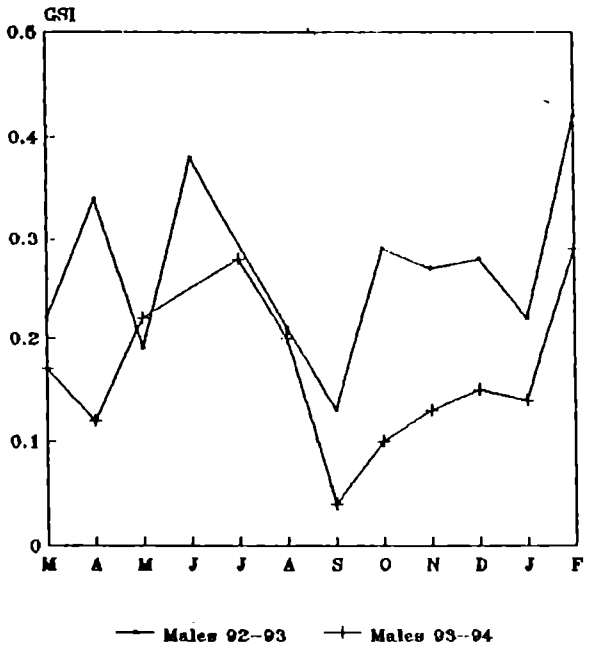


1992 to 1993



1993 to 1994

FIGURE 3: PERCENTAGE OCCURENCE OF VARIOUS MATURITY STAGES OF FEMALES IN DIFFERENT MONTHS



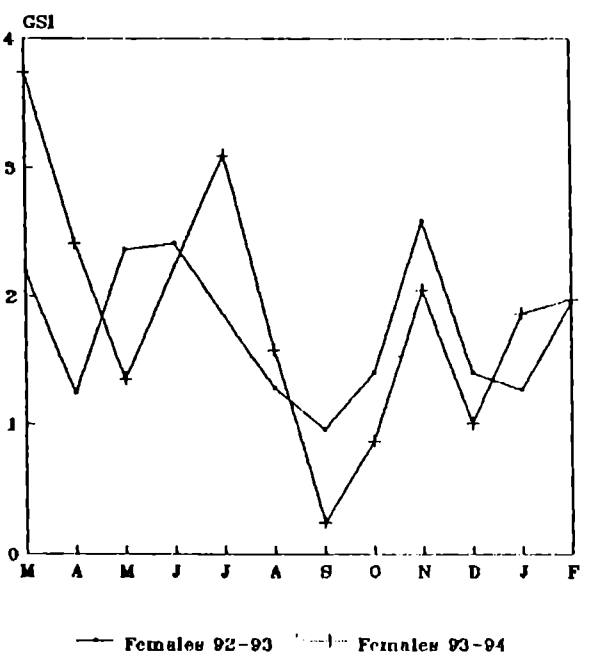


FIGURE 4: MONTHLY VALUES OF GONADO-SOMATIC INDEX

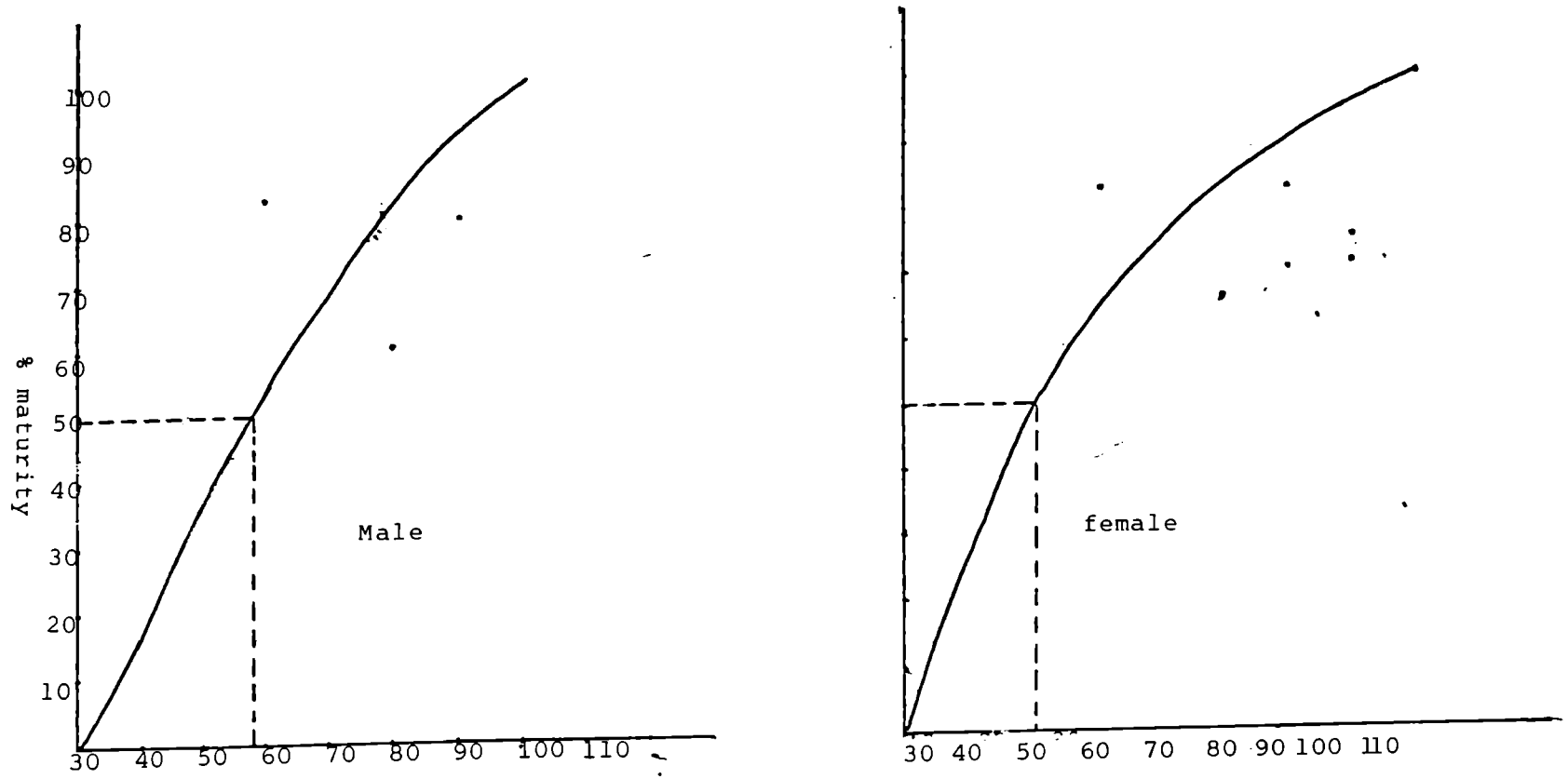


FIG.5: SIZE AT FIRST MATURITY OF O.nepa

CHAPTER 8

BIOCHEMICAL COMPOSITION

Introduction.

A number of authorities have suggested that man will turn to the ocean for the protein which will be required by the foreseeable increase in population. The possibility of utilising stages lower than fish in the food chain is appealing, because total yields may be many fold greater than those now available.

For Oratosquilla nepa,which will become an economically important group, a knowledge of the biochemical composition of the body is important not only for the evaluation of their utility for food or other purposes, but also for a more balanced utilisation of the resource. It is also necessary to have data on the composition in order to make the best use of them as food and in order to develop the technology of processing fish and fish products. It has also a bearing on culinary techniques.

A review of the works done on the proximate chemical composition of the stomatopod Oratosquilla nepa show that of Garg et al (1977) while isolating protein from squilla and jawala prawn had analysed the moisture, ash, fat, total nitrogen and

chitin nitrogen. Govindan (1984) had given a comparative statement of the proximate chemical composition of squilla, jawala prawns and prawn shell waste. Ahamad and Mohammed (1985) calculated the biochemical composition of the mantis shrimp for utilising it as a compounded feed in penaeid culture. Lekshmy et al (1985) had worked on the seasonal proximate composition of squilla, its use for the production of various products having high nitrogen content.

The present study envisages an evaluation of the biochemical composition from more of a commercial view point than sex wise since in the commercial utilisation,generally greater stress is given to "better quality " of the meat. Hence if estimation such as these are based on sex, it will be little appreciated.

Material and methods.

Fresh Oratosquilla nepa of varying size groups without sorting sex wise was collected from the Cochin Fisheries harbour and analysed for proximate composition.

The whole squilla as well as the meat was taken for

proximate analysis. Standard methods were used to determine the moisture, protein and ash contents (AOAC,1975). Crude fat was estimated by extracting the moisture free sample with petroleum ether (40-60 degrees centigrade). Sodium and Potassium were estimated by the method of AOAC (1970) using the flame photometer(Elico model 26 D). Carbohydrate was analysed adopting the phenol sulphuric acid method of Du Bois et al.(1956). Chitin nitrogen was estimated by the method followed by Garg etal. (1977) by digesting the crude fibre obtained after alkali digestion and estimating the nitrogen in the digest by microkjeldahl.

Results.

(1)Whole squilla

Moisture, protein, fat and ash are the main constituents of fish and shellfish. The proximate composition of the whole and flesh of O nepa is shown in Table 1. The moisture content was 78.22 % (70.33 -to 83.33 %). The protein content was 44.59% (46.79% - 51.6%) and the fat content was 2.86 % (2.13 - 3.3%). The chitin nitrogen was found to range from 0.99% to1.2%. The carbohydrate content varied from 1.59% to 2.65%.The

sodium content ranged from 34.6mg/100g to 81.6mg/100g. As for in the case of potassium, it ranged from 58.8 mg/100g to 100.80 mg/100 g. The ash content ranged from 27.8to 30.13 %..

Seasonal variation

Fig 1 shows the seasonal variation in the biochemical composition of whole squilla

(a).Moisture

The moisture content in the whole squilla showed marked variation during the course of one year. Before the onset of the monsoon, by May, the water content rose rapidly to 83.33 % and continued more or less at that level upto December. During the early part of the year,from January to March, it could be observed that the water content remained more or less steady at about 71.6% on an average.

(b) Protein

The protein content showed variation during the entire period of study. Very high values were observed during January at 51.6 %.At the onset of the summer season, in March,the values decreased and it continued to fall during the following months up

to August. It could be found that from October up to December a fluctuation was observed in the protein values, whereby, an increase followed by a decrease was observed simultaneously.

(c).Fat.

An increase in the fat values was observed during March at around 2.9 % and the same was also observed during May In view of the trawling ban imposed by the government, samples could not be collected during the months of June and July. From the month of May, before the onset of the monsoon season, when the water content of the body rose to 83.33 %, the fat content was found to increase and then decrease in the following months ; which is noticeable in the month of August and it continued till October. By December,the values had reached 3.13%.

(d) Ash

The values of the ash content were found to increase from February onwards registering an increase in the values. Specimens with high ash content were observed during the months of August, September and October. In the beginning of the year, the ash content were found to be constant. Since the shell constitutes a major part of chitin, the chitin nitrogen and the total nitrogen was also estimated side by side (Table 2). Low

values of chitin nitrogen was observed during August, September and October.

(2) Flesh.

The flesh of O.nepa contains high water content around 82.75 % (range 79.2 to 85.6 %). At the same time, it could be observed that these values are higher than that of the whole squilla. Also, when compared with the whole, the protein content of the flesh is higher between 64.89 % to 74.9 % The fat content also showed slightly high values at 3.12 %, ranging between 2.7 to 3.55 %. The ash content of the flesh comes to around 11.88 % (8.57 - 15 %).This value is comparatively lower when compared to the whole sample and this could be attributed to the fact that it is because of the presence of the shell that the ash content of the whole sample is higher. The carbohydrate content of the flesh ranged between 1.89 - 2.78 % at an average of 2.55% %. The sodium content of the flesh comes to around 98.4 mg /100g and the potassium content is around 88.19 mg /100g. These values are higher than that of the whole sample.

Seasonal variation: Fig 2 shows the seasonal variation in the flesh of O. nepa during a period of one year.

(a) Moisture

An increase in the moisture content of the flesh was observed during the initial part of the year. From 79.2 % it reached 85.6 % by October. There was a slump in the values of moisture content during the month of November. By December, the values had increased and reached its highest at 85.79 %.

(b) Protein

There was a decrease in the values of protein during the beginning of the year right up to May. By monsoon, the values were found to pick up and from then onwards an increase was observed in the values till the end of the year.

(c) Fat.

A fluctuation was observed in the fat levels during the period of study. Although during the initial part of the year, there was increase in the values; by April , the values had fallen considerably. After that there was a noticeable increase in the fat content of the flesh under study.It went on increasing at a steady rate and by November reached around 3.33 %

(d)Ash.

The ash content was found to increase during the beginning of the year and by October it reached around 15%, almost double the value than in the beginning of the year. There was a fall in the ash content of the flesh during the month of November and by December, they again showed an increase in the ash content at 12.68 %.

There was not much variation in the carbohydrate content of the flesh during the entire period of study. At the same time, it could be observed that the carbohydrate content of the flesh is higher than that of the whole sample. Also it could be observed that there was considerable chitin nitrogen in the flesh of O. nepa although they were found at comparatively low levels. The chitin nitrogen in the flesh has a role in the formation of the exoskeleton and hence there are traces of chitin nitrogen in the flesh.

Discussion.

According to Mukundan et al.(1981), the moisture content of shellfish is comparatively high when compared to that

of fish probably in accordance with the well known fat moisture relationship. The moisture content of the crab is around 79.23 % and that of the prawn comes to around 77.39%. In the case of O.nepa,the moisture content of the whole sample is about 77.16 % and that of the flesh comes to around 82.75%, whereas in the fish, it comes to about 71.19% in the case of the Mackerel. It could be observed that O.nepa has considerable protein content. According to Anandakumar (1986), who worked on the gastropod Hemifusus pugilinus, the higher protein value may be due to their less energy expenditure for reproduction. This may be the reason behind the high protein value of O.nepa too.

With reference to the ash content, it could be observed that O.nepa has considerable ash almost double that of the prawn Metapenaeus dobsoni, which is around 15.79 % and that of Acetes species which is around 17.11 %. The content of sodium and potassium is found to be higher in the flesh when compared to that of the whole sample.

The increase in the average values of fat content of fish could be attributed to the variation in size and geographic location of the catch (Venkataraman and Chari, 1951; Stansby,1953).

According to Garg et al (1977), in general the total nitrogen and fat,(ether extractable) contents of Squilla are lower and the ash and chitin nitrogen contents higher than those of the Acetes spp. The protein content of prawns ranges from 44.2 (A. indicus) to 70% (P. carinatus) on moisture free basis. Fatima and Magar(1965 a,b)worked on the chemical composition and nutritional constituents of Penaeid prawns.It has been found that O. nepa contains more protein than Penaeid prawns. The average chitin content in the integument or shell of Decapods comes to around 13.9 % ; the remainder is presumed to be inorganic. The importance lying in the analysis of carbohydrate is that sugar in fish prevents deterioration of protein and improves the water retention of the flesh.

The sodium content of individual species of salt water fish ranges from 34-96 mg/100g with an average of 68 mg/100g. The level of Potassium has been found to be 240-400 mg/100g for marine fishes. Variation in the amount of sodium and potassium are related to the size of the animal and the fishing season. Sodium is higher for crustaceans and molluscs compared to teleosts and the reverse applies to potassium. Sodium levels are appreciable in shellfish and are considered to be important in

food due to their involvement in coronary heart disease, hypertension and osteoporoses. (Swaminathan, 1991)

According to Sunderrao etal.(1992) the mineral composition of shellfish is 164 mg/100g and that of potassium 185mg/100g,which is comparatively higher than that of O.nepa.One month before the start of the monsoon period, the moisture content of O.nepa is found to increase. At the same time, an inverse relationship has been observed in the protein content of the whole as well as the flesh. Hence this dilution of the body fluids has a marked effect on the level of organic constituents in the body. There is a variation in the trend exhibited by the fat and the protein values. Fat is found to increase in March followed by a fall in the following month. An increase was observed in the next month and then its fall. It then begain to rise only during November and December. This difference in the seasonal trend of fat may be the result of spawned individuals present in the samples taken for fat analysis. It was also observed that in the food and feeding habits of O.nepa, the maximum number of gorged stomachs were observed during the month of December. This was the time when the highest fat content was observed in the samples.

The inverse relation which the organic constituents hold to water level in molluscan bivalves as observed by Durve and Bal (1962) and Mohammed (1979) agrees with the present findings.

The peak spawning season was observed to be June-July and November It could be noticed that there was a decrease in the protein levels. The same was observed in the mollusc Nucula sulciata according to Ansell (1974) where the proteinaceous nitrogen content falls with spawning. Hence it can be inferred that spawning leads to a fall in the protein content. At the same time, it could be observed that as soon as the monsoon period is over and the salinity of the medium shows a trend back to normalcy, the physiology of O.nepa must begin to recuperate The increase in the levels of protein is an indication of the improved metabolism in a more or less favourable environment. At the same time, spawning acts as a check on protein levels.

Fat shows a fall in the level with monsoon and spawning in the whole sample. Both the reductions could be explained as a reaction to the increasing water content of the body which happens both with the monsoon and spawning. Many workers have attributed the variation in fat content to some factors like sexual development, time of spawning, age, season and feeding

conditions (Bruce, 1924; Wilson,1939; Venkataraman and Chari, 1951). In the case of the flesh of O.nepa, the fall in the fat levels were found to coincide with the time when the maximum number of the spent individuals were present. Hence the fall in the fat content at the end of spawning indicates that a major part of the accumulated fat is used due to spawning. The same was observed in the crab,Podopthalmus vigil as according to Radhakrishnan and Natarajan(1979). The rise in the fat levels could also be attributed to the season. In both the whole and the flesh, it was observed that maximum fat levels were during the months of May and November. According to Venkataraman et al.(1968), in the black pomfret, a rise in the fat level was found to coincide with the onset of the summer season. In the case of O.nepa too, this explanation is partly in agreement.

According to Barnes et al.(1963), the protein content can provide the glucose and nitrogen needed for the formation of chitin and so the decrease in protein is most probably associated with the energy expenditure and also the formation of chitin by the cyprid. It was observed that the chitin nitrogen was very low during September and October when juveniles were dominant.

In view of the considerable content of organic compounds, there is every possibility of utlising O.nepa for human consumption. An understanding of the proximate composition of the stomatopod is of paramount importance in the evaluation of the nutritional properties,particularly when the meat has to be processed. In this context it is very important to note that an idea of the proximate composition is very important in product development studies. A very good instance is that in the future, with the increase demand of products from O nepa, there is the possibility of Surumi like products coming up.

Table 1. Proximate Composition of O.nepa

	Whole (%)		Flesh (%)
Moisture content	78.22		82.75
Protein	44.57	(DWB)	68.31
Fat	2.86	"	3.12
Ash	27.61	"	11.88
Chitin Nitrogen	1.05	"	0.75
Carbohydrate	2.29	"	2.55
Sodium	54.33 mg/100g	"	98.4 mg/100g
Potassium	65.39mg/100g	"	88.19mg/100g

Table 2. Total Nitrogen and Chitin Nitrogen in Whole O.nepa (%)

Months	Total Nitrogen	Chitin Nitrogen
Jan	8.74	1.03
Feb	8.14	0.98
Mar	7.28	1.02
Apr	7.12	1.01
May	6.97	0.94
Jun	--	--
Jul	--	--
Aug	6.76	0.65
Sept	6.86	0.68
Oct	6.64	0.75
Nov	7.12	0.91
Dec	6.52	1.03

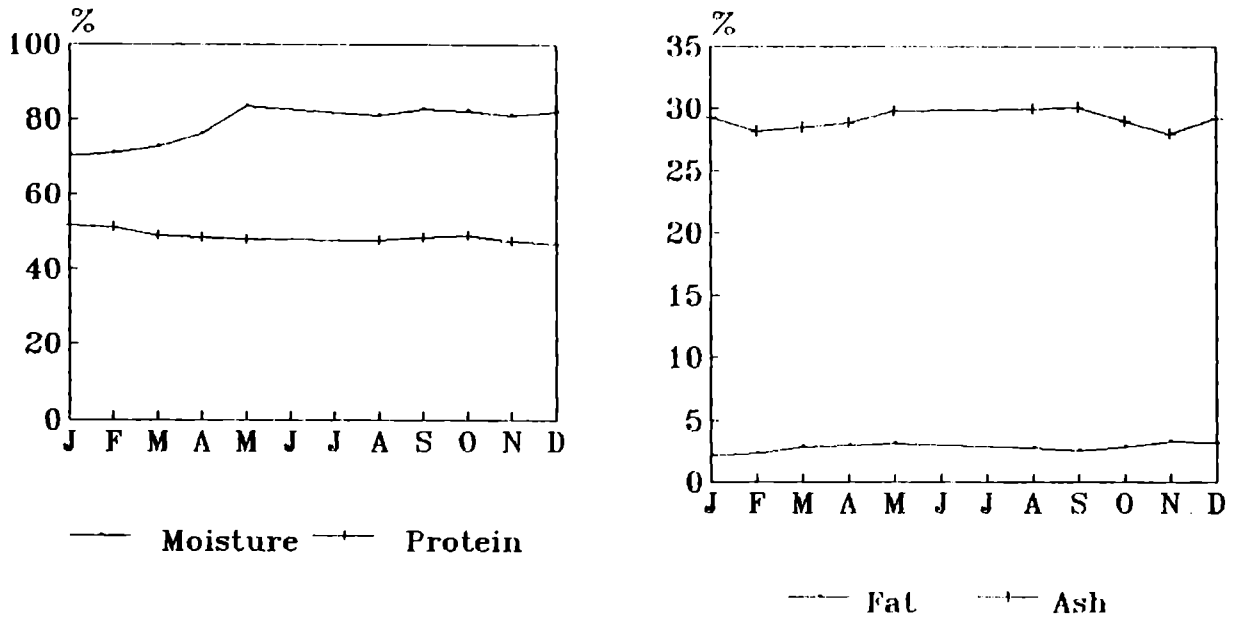


FIGURE 1: SEASONAL VARIATION IN THE BIOCHEMICAL COMPOSITION OF WHOLE SQUILLA (O. nepa)

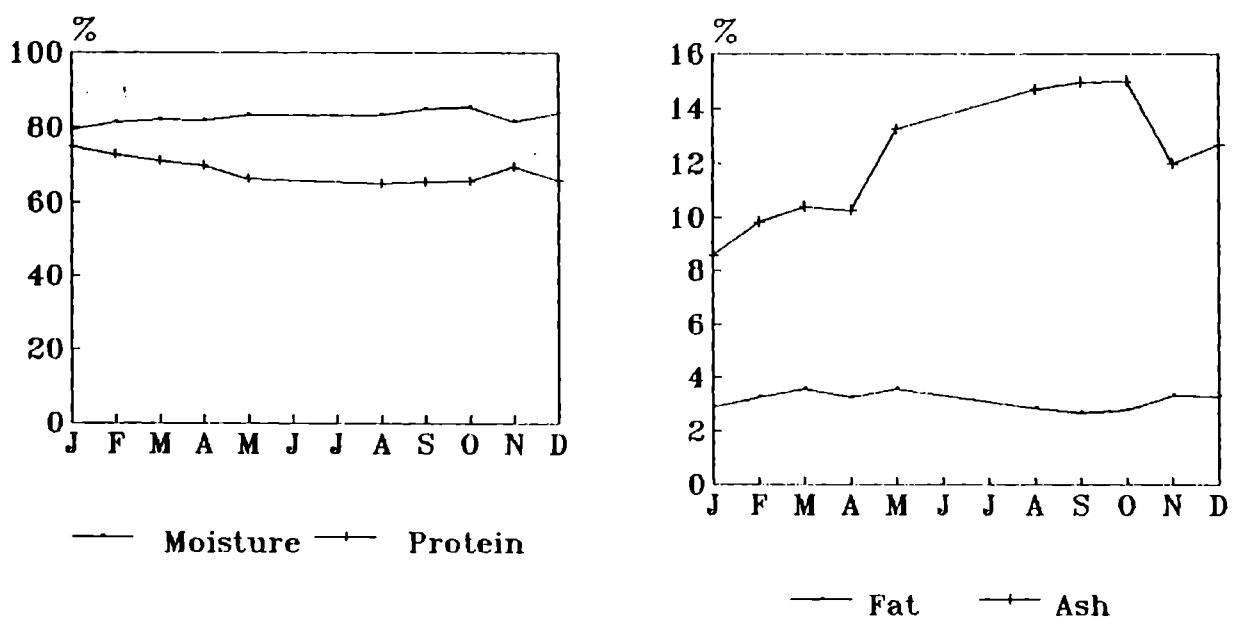


FIGURE 2: SEASONAL VARIATION IN THE BIOCHEMICAL COMPOSITION OF SQUILLA MEAT (N. nepa)

CHAPTER 9

ICE AND FROZEN STORAGE STUDIES

INTRODUCTION

The stomatopod Oratosquilla nepa forms an important component of the trawl catches in Cochin waters. Up till date, inspite of the fact that it is being landed in larger quantities, it has not been used as a product for human consumption ;except for the fact that it is being used as fertilizer, animal feed, chitin and chitosan. In view of the fact that our shrimp resources are getting lesser day by day, the stomatopod can be taken as an alternative source of crustacean protein.

The very fact that it has high protein, comparable to that of shrimp,around 42 % on dry weight basis, and of course higher than that of some fishes adds as a plus point. Hence the need has arisen for the exploitation of this resource by adopting preservation practices like, icing ;for short term preservation and freezing for long time preservation so as to increase the shelf life and to minimise spoilage. In view of the above reasons underlined, as a preliminary step to the utilisation of the resource, storage studies were conducted on Oratosquilla nepa. The keeping quality of O.nepa during icing and freezing were

studied.

Work done on the ice storage studies of fishes are that of Shewan and Jones (1957) who had studied the chemical changes occurring in chilled fish. Among the work done on the biochemical aspects, nucleotide degradation during chill storage has been investigated extensively in fish (e.g.Jones et al,1964).

During postmortem storage, slower autolysis of the accumulated inosine monophosphate through inosine to hypoxanthine is the reaction of interest. Hypoxanthine accumulates from the moment of death and provides a useful index of storage time in ice, and of eating quality for many fish species (Burtet al.,1969) Among the work done on the ice storage characteristics of crustaceans are that of Chinnamma etal., (1970) who studied on the crab (Neptunus pelagicus, Scylla serrata). Among the molluscs, mention has been of the mussel (Mytilus edulis) and the clam (Villorita cornucopia). As early as 1952 Alford and Fieger(1952). had worked on the non microbial nature of black spots in ice packed shrimps. Later, Bailey et al(1956) conducted objective tests on the quality studies with reference to ice stored shrimp. Velankar and Govindan (1959) and Velankar

etal. (1961) studied the spoilage of prawns at $0^{o}C$.

With reference to the degree of hypoxanthine formation, Arai,(1966) had worked on the nucleotides in marine invertebrate muscle.Riaz et al.(1981) had determined the rate of Inosine monophosphate degradation and hypoxanthine formation at the temperature of melting ice to determine how long the shrimp Penaeus merguensis could be kept under ice in fresh, edible, acceptable condition for the freezing industry.

MATERIALS AND METHODS.

The fresh samples of the stomatopod, Oratosquilla nepa were obtained from the catches made from the trawlers operating in Cochin waters. The samples were kept in ice from the time of catching till they were used for the experiment, the duration not exceeding four hours. They were then brought to the laboratory and washed thoroughly with potable water which was chlorinated It was then graded to size group 7-12cm, packed inpolythene bags and then placed embedded in crushed ice in an insulated box. They were kept in whole condition. For ice storage studies, a sample for zero day was taken immediately after landing but before washing and tested for

microbiological, organoleptic and biochemical quality.

Trimethylamine (TMA) and Total Volatile Nitrogen (TVN) were tested under the biochemical analysis. They were determined by the microdiffusion method of Conway (1947) from the trichloroacetic acid extract of the muscle. In the microbiological analysis, the Total Bacterial Count was determined by the standard pour plate method using Tryptone Glucose Beef Extract Agar. Plates were incubated at 37 degrees centigrade for 48 hours and the counts were noted. Escherischia coli was determined using Tergitol -7 agar and Coagulase Positive Staphylocci was determined using Baird Parker Agar. Salmonella was determined as per the method recommended by AOAC (1975). Organoleptic characteristics of O nepa cooked in 1 % NaCl for 10 minutes was determined by trained panel and the scoring was done using 10 point Hedonic scale ; 10 being very good,1 being bad and 4 being just acceptable. In addition, an examination of the organoleptic characteristics of the raw samples were conducted by the panel to study the extent of changes as per Anon.,1985. Hypoxanthine was estimated by the silver salt method making use of the perchloric acid extract of the muscle (Jones and Murray., 1962).

RESULTS.

1.Ice storage studies

The pattern of development of the various spoilage indices in the whole Oratosquilla nepa are shown in Fig 1,2and 3. Fig 1 shows the changes in the Total Bacterial Count in the iced samples. It begins to increase after 3 days. By about 11 days, the count reaches the order of nearly 2.0 X 10^5 per gram of the muscle. E. coli, Staphylococcus and Salmonella were not present in the initial samples as well as the samples drawn subsequently during ice storage.

On the first three days, the bacterial count decreased due to the destruction of the mesophilic bacteria by cold shock and it later picked up with the multiplication of the psychrophilic strains in the iced samples. Escherischia coli was found in negligible quantities during the initial period and they diminished totally after 3 days in iced storage. Coagulase Positive Staphylococci and Salmonella were not found during the period of the study.

Fig.2 and 3 show the biochemical changes in iced

O.nepa. Fig. 2 shows the trend of changes in the Trimethyl amine content in the samples. On the zero day of storage, TMA could not be detected; but was detected after 1 day of ice storage in ice. At the end of 11 days, when the mantis shrimp had pronounced off odour, the TMA values were well above 20 mg% in all the three sets of experiments.

Fig. 3 shows the changes in the Total Volatile Nitrogen in three sets of experiments. The TVN values were less than 20 mg % in all sets of experiments till three days of storage and thereafter showed an ever increasing trend during the entire period of study.

Table 1 shows the changes in the hypoxanthine levels in squilla meat during ice storage.It could be observed that by the 7th day,the values reached 1 mg /mole indicating the starting of spoilage. By the fifth day itself it had reached values nearly reaching one indicating the onset of spoilage.

Table 2 shows the changes in the organoleptic quality of Oratosquilla nepa stored in ice. It could be observed that the material iced upto 7 days maintained a good appearance according to the opinion of the taste panel constituted for this

purpose. In the case of odour changes, it was noticeable slightly after the 7th day onwards. The overall score for 0 day was 7 indicating good quality of the material. By the end of the 11th day, the score was reduced to 1 showing that the sample was totally unfit for human consumption.

DISCUSSION.

Ice storage.

The period elapsing before any rise occurs in the values of spoilage indices can be considered the limiting duration of storage of the whole shrimps at $0^{o}C$, when it cannot be considered fresh. In the case of O.nepa, the period is 3 days. Velankar et al.(1961) had reported that in the case of prawns it is 5 days. According to Chinnamma et al.(1970) in the case of edible mussel(Mytilus edulis),clams (Villorita cornucopia) and crab (Scylla serrata and Neptunus pelagicus), the material remains in organoleptically acceptable condition for 8, 9, 8 and 11 days respectively during ice storage. In fact this period is lower in O nepa when compared to the one that reported for the other crustaceans, thus showing that the mantis shrimp O nepa spoils faster than the others.

Both adenosine mono phosphate and inosine mono phosphate may contribute a meaty flavour (Hashimoto, 1965), and their disappearance may lead to loss of flavour. According to Kassemsarn et al. (1963), in cod muscle, degradation of inosine to hypoxanthine, followed with a very rapid accumulation of the latter between 7 to 11 days.In crustaceans, Riaz, et al. (1981) in a study of the hypoxanthine indices as a quality of the shrimp Penaeus merguensis, had reported that hypoxanthine increases slowly during early storage and from an initial level of 0.075 micromole/g in fresh shrimp, reached a level of 0.953 micromole/g at 12 days storage. In the case of O nepa, the initial level in the fresh sample was 0.123 micromole/g and is in agreement with the above results where it increases slowly during early storage. But by the 5th to 7th day and from then onwards it was found to increase, thus showing that O.nepa spoils faster. By the end of the 11th day in ice storage O.nepa was found to have Hx values reaching nearly 2 micromoles per gram. According to her, perhaps a Hypoxanthine value of 2 micro mole/g, of the muscle may indicate doubtful quality. Part of the reason according to her for the flavor deterioration in ice stored shrimp could be related to the degradation of IMP and to the increase in Hx in imparting a bitter taste to seafood plus a concurrent loss of IMP which is an important flavour complement in seafoods.

The duration of spoilage in ice till spoilage sets in appears to be seven days judging by the biochemical, bacteriological and organoleptic standards.Bailey et al. (1956) have described three stages in the quality phase lasting for the first 4-5 days, followed by the phase of lowered quality but when the shrimps are still edible till the end of about two weeks and the spoilage phase after the two week period. In the case of the mantis shrimp O.nepa the final stage in the quality lasts for the first 3 days followed by a phase of lowered quality when they are still edible upto 7 days when spoilage sets in.

The blackening of the mantis shrimp as is the case of the prawns was noticed by the 5th day of iced storage. In the industry, blackening of shrimps is a major commercial problem. On raw shrimps, it can cause a major marketing problem.Several methods are suggested to control black discolouration. Removal of the head followed by thorough washing helps to reduce blackening CSIRO (1976) permits 30 ppm SO2 in meat as the upper limit and IS :2237 (1985) permits 100 ppm. Japanese standards also recommend 100 ppm residual sulphite. The Export Inspection Agency specifies that the tolerance limit for black spot on shell comes up to 10 %.In the case of the meat, black spot should be

completely absent. According to Chakraborthy,(1992) 0.3 % metabisulphite was sufficient to control black spot in P. monodon and P. indicus during ice storage for 5 days. A dip in 0.4 % metabisulphite for 30 seconds prevented black spot in M. monoceros for 5 days in ice storage. At the same time, it could be noticed that discolouration has no influence on the TMA,TVN and the bacterial population. According to Alford and Fieger (1952) this is not unexpected since blackening is an enzymatic reaction.

The determination of TMA is useful for detecting the onset of spoilage. It was observed that there is a significant rise in trimethylamine values from the 9th day onwards indicating loss in quality on the number of days elapsed in storage.

As for in the case of the bacterial population, they reached significant magnitudes only after 7 days of ice storage. In fact this bacterial count at that storage can be regarded as an indication of spoilage and the setting of loss of edibility. When compared to that of prawns, it reaches highest values by 10-15 days in ice. In the case of Metapenaeus the bacterial count was found to increase from an initial value of $3x10^5$ to $6.54x10^7$ by the time it is spoilt.

Since the bacteriological study was conducted keeping in view the interest of the seafood industry, the bacteria of significance to the industry of India was only considered ie E coli, Staphylococci, Salmonella in addition to Total Bacterial Counts. The bacterial count was found to be less when compared to that of ice stored shrimp as reported by Iyengar et al.;1960, Velankar & Govindan et al., 1959.;Velankar et al.,1961.The reasons could be attributed to the proper washing with chlorinated water and packing of the samples in polythene bags and then kept in ice storage which thus minimised the chances of contamination through contact.

As for the organoleptic quality under study, it can be stated that O. nepa can be kept in ice storage upto 7 days. Eventhough the laboratory studies show a shelf-life of 7 days, it is advisable for the industry not to keep the material for more than 5 days as a safety measure for further processing.

2. FROZEN STORAGE

Introduction

Kamasastri et al.(1967) had worked on the development of peroxide value and free fatty acids in the lean fish, Pomfret. Among the works done on the molluscs those on squid by Joseph et al.,(1977) is worth taking note of.

Among the Crustaceans, Bethea and Ambrose (1961) studied on the freezing aspects of Crab meat. In addition, Pillai et al.(1961) conducted studies on the biochemical, microbiological aspects of fish and frozen prawns. Lekshmy et al.(1962) had studied the quality assessment of frozen prawns. In 1963,Gangal et al. had studied the freezing of crab meat. Similar work was carried out by Fatima and Magar,.(1965 a & b) in prawns caught from Bombay coast. Mathen & Thomas.,(1987) had worked on thawing losses in prawns. Chinamma., (1990) worked on the thawed yield of the crab Scylla serrata.

MATERIAL AND METHODS

In the case of the samples taken for the frozen storage study, the samples were treated in the same way as that above but here, the samples were frozen in the plate freezer at a temperature of -40 degrees centigrade. They were then stored in the cold store at temperature between -18 to-23 degrees centigrade. Samples were taken out at monthly intervals for analysis. Trimethylamine (TMA) and, Total Volatile Nitrogen (TVN)were determined by adopting the method as in the case of ice storage. Likewise the bacteriological studies as well as the

organoleptic assessment was conducted using the above procedure. In the case of the cold stored sample, thaw drip was estimated by thawing the samples at room temperature. It was drained in a glass funnel over a cylinder when no more drip falls in 2 minutes. The volume of drip and the weight of the pieces were noted. The extent of oxidative and hydrolytic rancidity during frozen storage was also estimated. Free Fatty Acid (FFA) values were determined iodometrically (AOAC, 1975) and the Peroxide Value (PV) was estimated according to AOAC., 1980.

RESULTS

Fig 4 shows the variation in the percentage of thaw yield during frozen storage. In the initial stages, the loss in thaw yield was comparatively low. After two months the loss increased.

Fig 5 shows the changes in the Total Bacterial Count of O.nepa during frozen storage. There was a progressive fall in the bacterial count till 3 months of storage. After 5th month, the bacterial count was found to be stabilized at a low level. E coli, Staphylococcus and Salmonella were not present in the beginning or during the course of the study.

Fig 6 and 7 show the changes in the Trimethyl Amine and the Total Volatile Nitrogen content of O nepa during frozen storage. The initial values of TMA was nil indicating that it was negligible. There was an increase in the TMA values after 6 months of frozen storage reaching 12-15 mg %. From then till the end of the 10^{th} month, the TMA values reduced considerably. In the case of Total Volatile Nitrogen, they were found to reach the highest value in about 4 -5 months. After that they were found to reduce till the 10^{th} month. After 7 to 10 months of storage it can be inferred that out of 28 mg% of Total Volatile Nitrogen, Trimethylamine accounts for 4.2 mg %.

Fig 8 and 9 show the changes in the extent of oxidative and hydrolytic rancidity of frozen stored O.nepa. In the case of the changes in the free fatty acid values, it could be observed that by the end of the 9th month of storage, they reached very high values. It was from the 3rd month onwards that a rise in the free fatty acid value was noticed ; as observed in fig 5. The development of free fatty acid was quite rapid between 3 to 4 months of storage.

Fig 9 shows the changes in the peroxide value in O.nepa during frozen storage. Here, it could be observed that

they reached the highest values between the 3rd to the 5th month of storage. By the end of the 9th and the 10th month of frozen storage, they were found to have reached lower values.

Table 3 shows the changes in the organoleptic qualities of O.nepa during frozen storage. It could be observed that during the initial stages right upto the 5th month, the material maintained a good appearance. As for in the case of the odour upto the 5th month, there was favourable odour in the material and it was only after this that the off odour started developing. The incidence of samples having dehydration due to cold storage was absent till the 9th month. Pieces having discolouration were noticeable by the 3rd month onwards but only in incidental cases Pieces with black spot were noticed from the fifth month onwards. Black spot does not affect the edibility of such shrimp, but it is a sign of poor handling aboard the trawler, and the shrimp are considered of poorer quality (Anon,1985). In the seafood industry it is a very serious problem. Broken and damaged pieces were visible after thawing the frozen sample from the 3rd month Foreign vegetable matter was completely absent throughout the storage period. Since grading was done initially carefully there were very low incidence of non uniform pieces. In the case of the cooked O. nepa it could be

observed that the texture, odour and flavour was not favoured by the taste panel from the 5th month onwards. The results of the Hedonic scale showed that by the 5th month, the material in the opinion of the taste panel was just acceptable. From then onwards it was not considered acceptable by the taste panel

Discussion

According to Mathen & Thomas(1987), the thawing losses are 0-6% which increase to 6.6 and 18.2% after 6 months of frozen storage in prawns. It is generally observed that frozen prawn meat of commerce suffers extensive thawing losses averaging 10% even within a short freezing periods. According to them, the raw as well as the frozen prawn meat available in the industry has low dry matter (Mathen et al.; 1968). In the present study too, there is agreement with the above result, that is, when the thaw drip increases within a short period, and reaches the highest values during the second month. Chinnamma etal. (1990) had reported that the thawed yield was 96.8 % in 20 weeks (about 4months) 94.62 by 7 months, 94.62 % by 10 months and by the end of 1 year, it reached 93% in the crab Scylla serrata. The trend observed in O.nepa is to some extent agreeing with that of the above study.

According to Pillai, et al.(1961), the TMA content of the fresh prawn varied from almost nil to about 3 mg N %.The variation in the TMA content during the initial period of study upto 5 hours is almost negligible. This was also found to be true in TVN. In the case of O.nepa too the same was observed.

Fathima and Magar (1965a & b) had observed in prawns of Bombay coast that in the initial stages, the count was considerably reduced to a figure much lower than the initial values, but after 5 months of storage, it increased and kept on increasing slowly but steadily. Values about $1.0x10^6$ and above hinted towards spoilage. According to Lekshmy et al.(1962) in the frozen storage studies on the prawns there is a progressive fall in the bacterial count during storage by more than 90% of the bacteria getting destroyed during a period approximately 300 days; In the case of O.nepa,the bacterial count showed a sudden decline in the beginning due to cold shock and after about five months was found to stabilize and thereafter with a gradual increase.

In the case of the development of the extent of hydrolytic and oxidative rancidity during frozen storage, among the fishes, it has been observed by Kamasastri et al.(1967) that

in Pomfret, a lean fish, the free fatty acids have doubled during a period of 6 months from an initial of 7.65 to 14.14 %.An increase in the values of FFA in the case of O.nepa was also observed though it was not double but more. In milk fish, Chanos chanos, there is a gradual increase in peroxide value during frozen storage due to the oxidation of fat; this also agreed with the findings in O nepa a period of 4-5 months after which a gradual decline was noticed in the values.

Kamasastri et al.(1967) in the organoleptic scoring of the cooked meat of Pomfret had reported that the samples could not be kept stored for more than 7 months. In the case of the mollusc Loligo duvaucelli(squid) the hedonic score is 1.2 by the end of the 9th month for the raw and 5 for the initial. For cooked squid the organic score is 2 at the end of the 9th month. In O nepa, the hedonic score was observed to be 2 in the case of the cooked and the raw samples at the end of the 9th month..

In general, among crustaceans the storage life may range from only a few weeks, as in the case of the blue crab (Cancer sapidus) and the northern lobster(Homarus americanus) to upto 1 year or more for the king crab and spiny lobster. The

storage life of the the king crab,was reported to be 6 months or more at -18 to -23 ^{0}C if protected from dehydrates.

In view of the heavy landings of this stomatopod during some parts of the year,it is suggested that it could be kept iced properly for about 3 to 5 days before processing. Although it could be kept in good condition in ice upto 7 days, the latter has been recommended as the best time. In the case of the samples that are to be kept for frozen storage before processing, it has been recommended that a storage life of 3 to 5 months has been found to be favourable before processing. In view of the keeping qualities of this stomatopod, it can be concluded that it is possible to process and develop products for human consumption out of O.nepa.

Table 1 Changes in the hypoxanthine values of O.nepa during ice storage

Days in Ice	Hypoxanthine u gm/mole
0	0.1237
1	0.1866
3	0.8262
5	1.0802
7	1.8381
9	0.4537
11	0.9874

TABLE 2

CHANGES IN ORGANOLEPTIC CHARACTERISTICS DURING ICE STORAGE.

DAYS IN ICE.	0	1	3	5	7	9	11
Raw material							
General appearance	G	G	S	S	S+P	P	P
General odour	G	S	S	S	S+P	P	P
Deterioration	ab	ab	ab	ab	pr	pr	pr
Black spot	ab	ab	ab	pr	pr	pr	pr
Broken and damaged	ab	ab	pr	pr	pr	pr	pr
Legs, bits, veins, Loose shell,hanging Meat.	ab	ab	ab	ab	pr	pr	pr
Foreign veg matter	ab	ab	ab	ab	ab	ab	ab
Non uniformity	ab	ab	ab	ab	ab	ab	ab
Texture	MT	MT	MT	MT	MT	ST	ST
Cooked material							
Texture	7	7	5	5	4	2	1
Odour and flqvour	7	7	6	4	4	2	1
Ovarall Score	7	7	6	5	4	2	1

G= Good, S= Satisfactory, P= Poor, pr= present, ab= absent, MT= moderately tough, ST= Slightly tough.

Table 3 Organoleptic characteristics of O.nepa during frozen storage.

Raw material

Months	0	1	2	3	4	5	6	7	8	9	10
No of pieces	12	11	12	10	11	10	10	9	10	10	9
General appearance	G	G	G	G	G	G	S	P	S	P	P
General odour.	G	G	G	G	G	G	S	P	P	P	P
Dehydration	-	-	-	-	-	-	-	-	3	5	8
Discolouration.	-	-	-	2	1	-	1	2	5	9	9
Deterioration.	-	-	-	-	-	-	2	3	6	7	7
Black spot	-	-	-	-	-	3	3	2	5	8	7
Broken and damaged pieces		-	-	2	4	3	2	5	3	4	6
Legs, bits and veins	-	1	1	2	3	4	3	6	8	6	8
foreign vegetable matter	-	-	-	-	-	-	-	-	-	-	-
non uniformity	-	-	-	-	-	-	-	-	1	-	-
Texture.	**MT	MT	MT	MT	MT	MT	MT	*ST	ST	ST	ST
Score.	7	7	6	6	5	5	4	3	2	1	1

Cooked (Scores)

Texture & appearance	7	7	6	6	5	5	4	3	2	2	1
Odour & flavour	7	7	6	5	5	5	3	2	1	1	1
Score.	7	7	6	6	5	4	3	2	1	1	1

MT= Moderately Tough, ST= Slightly Tough, G=Good, S=Satisfactory, P=Poor

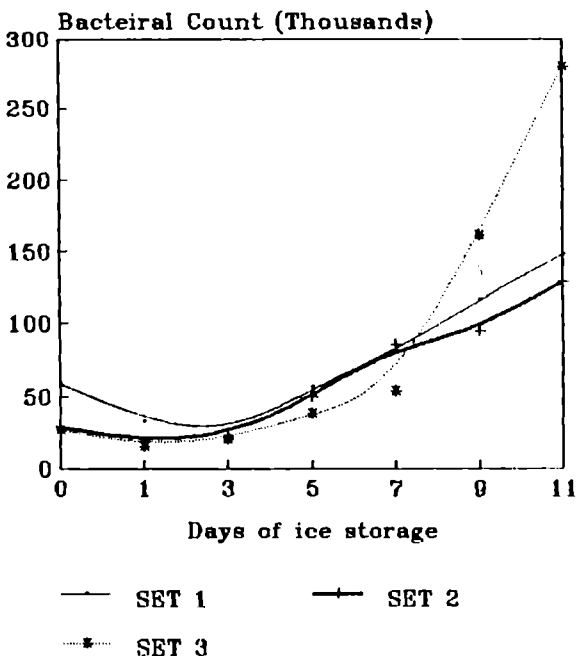


FIGURE 1:CHANGES IN THE TOTAL BACTERIAL COUNT IN O. nepa DURING ICE STORAGE

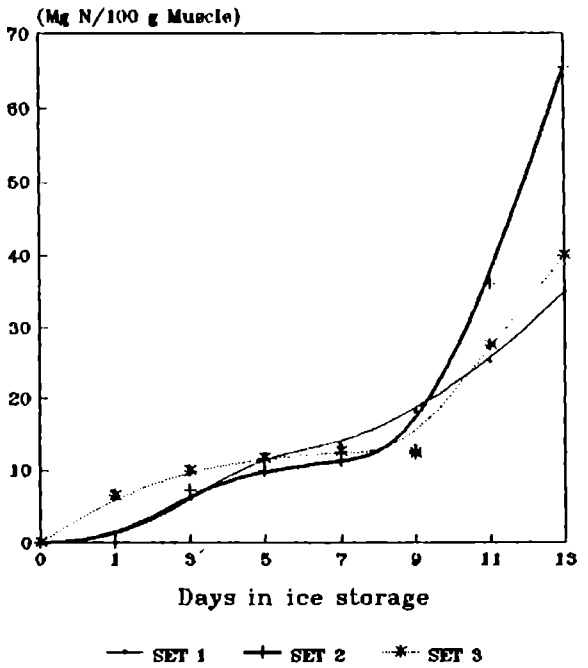


FIGURE 2:CHANGES IN TRIMETHYLAMINE CONTENT IN ICED SQUILLA (O.nepa)

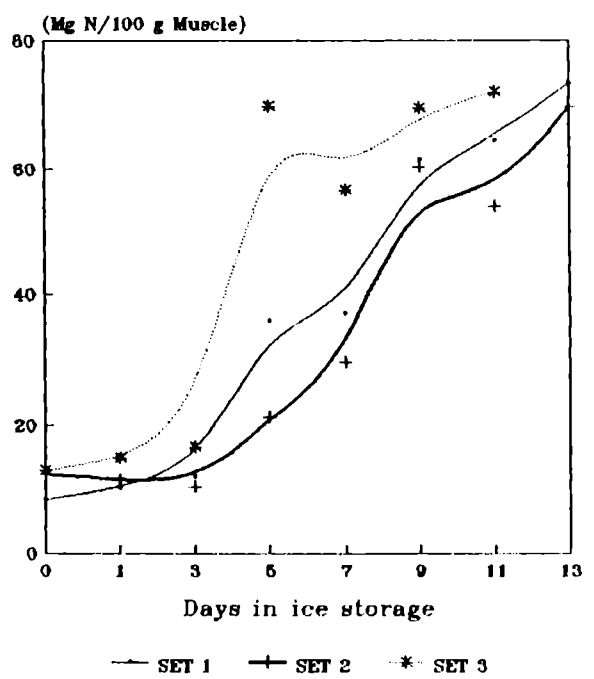


FIGURE 3:CHANGES IN TOTAL VOLATILE NITROGEN CONTENT IN ICED SQUILLA

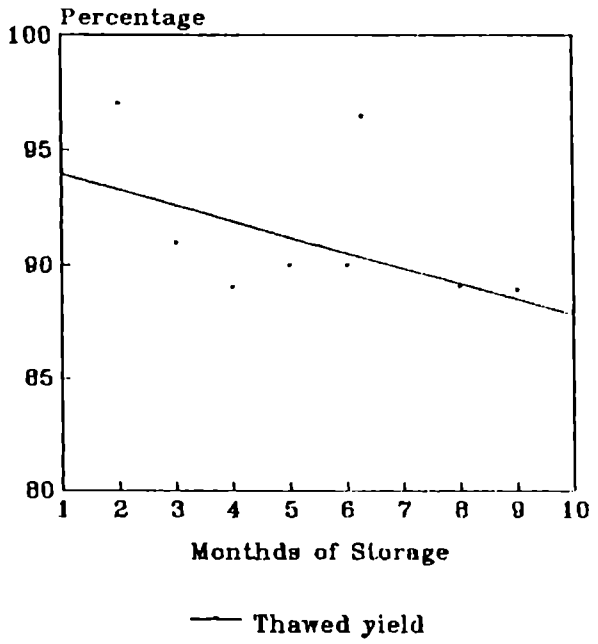


FIGURE 4: THAWED YIELD OF FROZEN SQUILLA IN DIFFERENT MONTHS

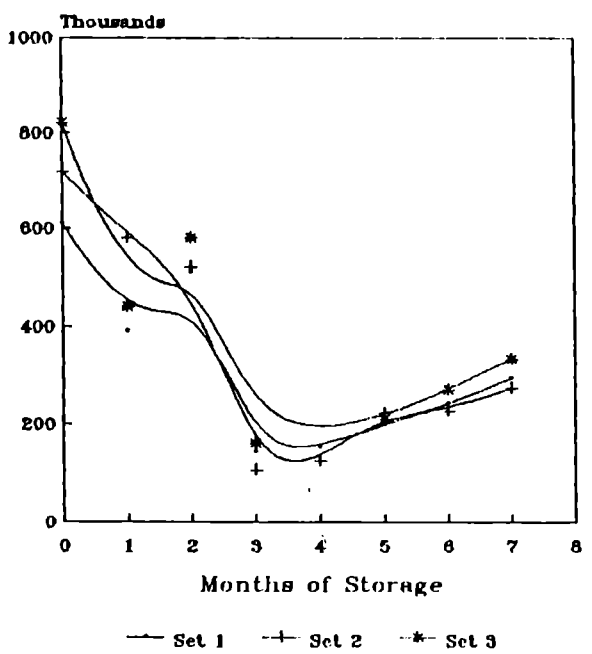


FIGURE 5: CHANGES IN THE TOTAL BACTERIAL COUNT OF O.nepa DURING FROZEN STORAGE

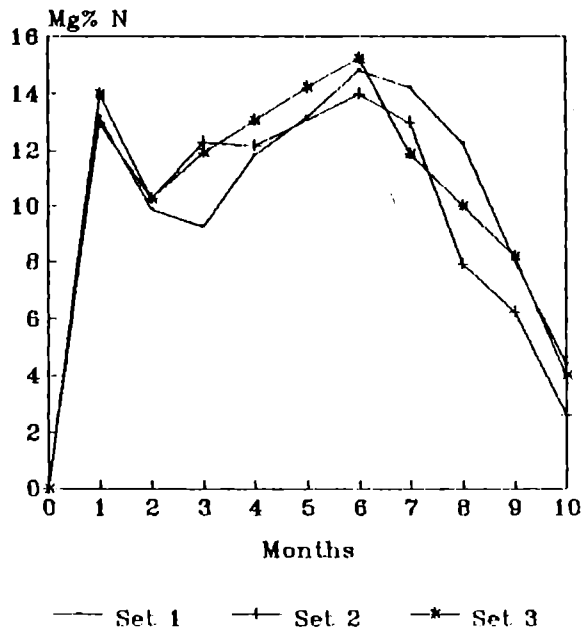


FIG.6: CHANGES IN TRIMETHYLAMINE CONTENT DURING FROZEN STORAGE OF O. nepa

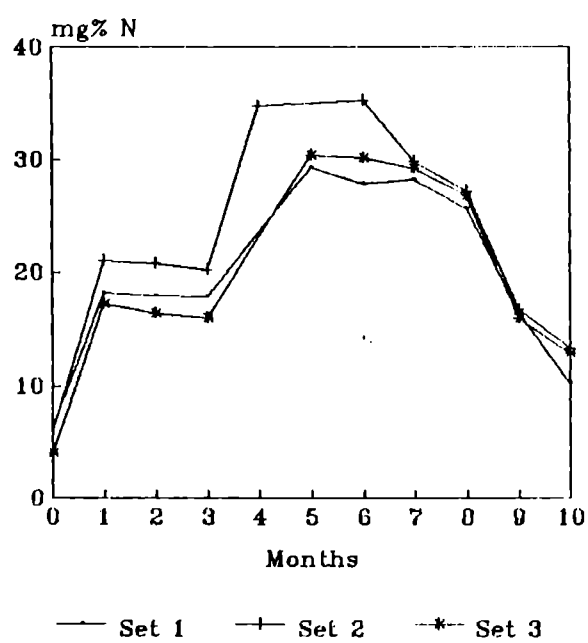


FIG.7: CHANGES IN THE TOTAL VOLATILE NITROGEN DURING FROZEN STORAGE OF O. nepa

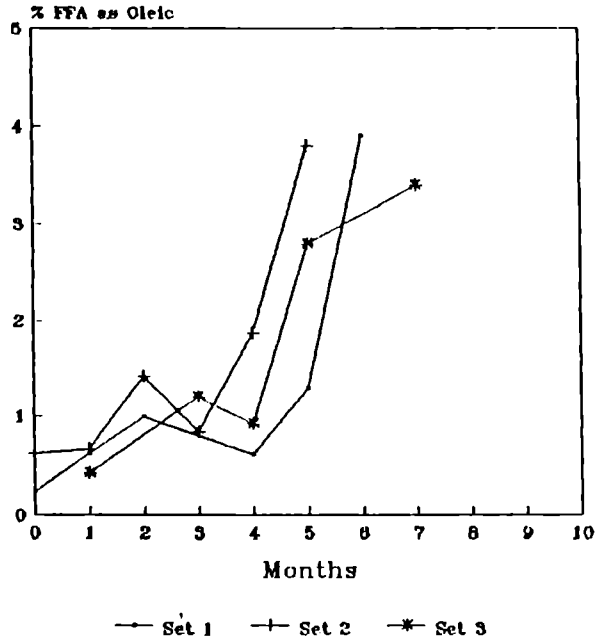


FIG: 8: CHANGES IN FREE FATTY ACID DURING FROZEN STORAGE

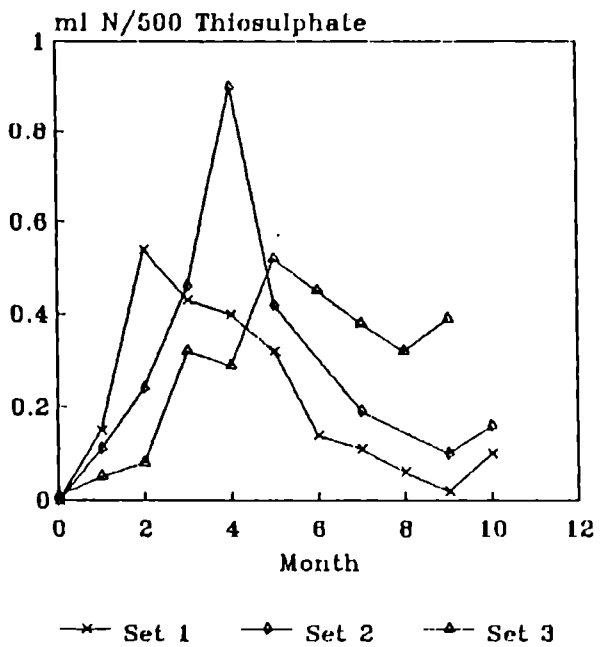


FIG: 9: CHANGES IN PEROXIDE VALUE DURING FROZEN STORAGE

CHAPTER 10

PRODUCT DEVELOPMENT.

Introduction.

India, which ranks 7th in the world fish production, is on the threshold of a blue revolution as a steady growth of the fishery sector during the past few years. At the same time, it is worth noting that a significant proportion of the total available catch consists of commercially unimportant varieties and hence are underutilised. This has thus resulted in the industry processing only selected varieties of fish , leaving several of them unutilised.

There is the need for the utilization of the total fish catch so as to compensate the depletion of the commercially important fish stocks.In view of the nutritional importance of the fish as human food, attempts are made to utilise O. nepa which forms a component of the bycatch of shrimp trawls. Four products fit for human consumption were developed. They were pickles and this was followed by mince based products like cutlets, fingers and flakes. In addition , in view of the importance given to chitin and chitosan currently, a study of the comparative aspects of chitin and chitosan developed out of

O.nepa and the prawn Parapeneopsis stylifera was conducted.

1.Pickles .

Fish preservation methods developed during 50,000 B.C , when man changed from eating food to eating them cooked. Among them, pickling is one of the oldest methods of preserving food material. Pickles have been of commercial importance in some developing countries like Korea , where pickles are made out of anchovies, shrimps , squid, oyster and sea urchin.

Previous studies on pickles from fish in India are that of Devadasan et al.,1975. Effective procedures were worked out Vijayan et al. (1989) had reported the possibility of developing pickles from low cost marine fish and Chattopadhyay et al.(1985) on low cost fresh water fish. Behanan et al. (1992) had made a comparative study of the fish pickles prepared with a combination of juices. Among the molluscs a series of works by Yellappa and Chandrasekharan (1989) on Clams; Gupta and Basu (1985) on the blood clam and Sukumar et al.(1994) who developed pickles out of the edible oyster. Another recent work is that of Dhanapal et al.(1994) who worked on chank pickles. Among the works done on crustacea, are that of Jawahar and Shetty (1994) who worked on prawn pickles. Since no pickle had been developed

out of the stomatopod O.nepa, a study was conducted on pickles developed out of this and its acceptability and storage study was conducted.

Material and methods.

Fresh O.nepa was iced immediately after catching and brought to the laboratory They were washed thoroughly and iced properly for about 18 hours. The meat was extracted after this time because it enabled easier extraction of the meat. Meat was extracted by cutting with a pair of scissors on the side of the mantis shrimp from the abdominal region up to the 5th thoracic region. This was adopted as the best method for manual extraction of the meat, because a higher yield was obtained through this method. Pickles were prepared as follows.

Fried the meat in minimum oil for about 45 minutes and set apart. Fried the ingredients 2-5 in the remaining oil and then added chilly powder and turmeric and mixed well under low flame for a few minutes. Removed from the fire and mixed the meat with vinegar and sufficient quantity of boiled and cooled water to completely cover the ingredients. Mixed thoroughly and added salt to taste.

Ingredients

1.	Squilla meat.	1000g
2.	Ginger	180g
3.	Garlic	80g
4.	Chilli	50 g
5.	Turmeric	5g
6.	Asafoetida	11g
7.	Cummin	25g
8.	Mustard	11g
9.	Fenugreek	5g
10.	Chilli powder	35g
11.	Spice mixture (pepper, cardamom, cinnamon & cloves)	11g
12.	Vinegar(3% CH3COOH)	450 ml.
13.	Water (boiled and cooled)	400-600 ml
14.	Gingerly oil	250 ml.

After mixing together all the ingredients, the pickle was left to mature for 2 days and then packed in clean dry bottles and sealed air tight. While packing care was taken to prevent the exposition of the meat and a layer of oil was always kept covering the pickle at the top and previously heated and cooled gingelly oil was added if necessary to ensure a protected layer of oil at the top. The product was stored at room

temperature and periodically examined for changes in the chemical, microbiological and organoleptic characteristics.

For the determination of the pH, a representative sample of 10 g including the meat, oil, spices etc was ground thoroughly to a smooth paste, diluted with 20 ml water and the pH of the resulting solution was measured using a digital pH meter. Sodium chloride was estimated by standard method of AOAC (1970). The moisture content was determined by the method of AOAC (1975). Total Plate Count was determined by using Tryptone Glucose Beef Extract Agar. Coagulase Positive staphylococci was determined as per FDA(1973) and Salmonella was detected by the method of Galton et al.(1968). The organoleptic qualities were assessed by a taste panel of 8 members using a 5 point scale.

Results.

20.00%. yield of meat was obtained on processing of squilla.Table 1 shows the chemical changes in the pickle for a period of 6 months. There was a decrease in the pH values throughout the period of study. At the same time, it was observed that the pH was below 4.5. The pH at the beginning of the study was 4.46 , by the end of 6 months of storage, the pH

was stabilised at 3.72. NaCl did not show much significant variation through out the period of study. The moisture content was found to show decreasing values.

The result of the microbiological analysis is shown in Table 2. The Total Bacterial Count was found to show a gradual reduction during storage. By the end of the 6 month, the values had increased. Escherischia coli, Staphylococci and Salmonella were absent throughout the study. It was also observed that molds could be sighted by the 6th month of storage.

The results of the organoleptic changes as scores is shown in Table 3. Sensory attributes like appearance, colour , texture and taste were assessed under organoleptic assessment. It was observed that throughout the study period, the appearance was rated to be good. The colour was observed to be reddish brown during the initial period of study. At the end of 6 months, the colour had started fading, thus rated as fair by the taste panel. In the initial period , the odour was good but at the end it was rated as poor due to the off odour being developed. In the beginning , the texture was tough but later on it started getting soft. According to the opinion of the taste panel the pickle had the taste similar to that of prawn.

Discussion.

According to Dhanapal et al.(1994) in the chank pickle the pH registered a decreasing trend from 5.03 to 4.56. This decreasing trend was also observed in O.nepa. But at the same time, it was observed that the pH at the beginning of the study was lower than that reported for chank pickles. According to the above author, the decreasing trend in the pH could be due to the uptake of acid by the meat during storage. At the same time, the pH values of the blood clam pickle as reported by Gupta and Basu (1985) was almost similar to that of O.nepa. According to Sugumar et al. (1992), a low pH inhibits most of the bacterial activity.

The pH of the pickle prepared from prawn by Jawahar and Shetty (1994) was also higher than that made out of O.nepa The same decreasing trend was observed in the fish pickles prepared by Chattophadhyay and Bhattacharya.(1985). The values of the pH as according to Behanan et al.(1992) is in agreement with our present study, where the values were below 4.5

The NaCl content of the freshwater fish such as E.

vacha was 3.48 , 3.76 for G. guerus, and 3.53 for S.canula. This falls within the range for O.nepa pickle. In the case of the mollusca, clam pickle, NaCl was found to increase with acetic acid treated pickle. The reverse was observed in the case of O.nepa, where there was a slight decrease in the Nacl levels by the 6th month of storage.

In clam pickles, the moisture content was found to decrease and this observation was in agreement in the case of O. nepa pickles. The only difference was that in O.nepa, a slight increase was noticed in the 4th month of storage but in clam pickle , it was during the 3rd month of storage.

The absence of E.coli, Staphylococci and Salmonella throughout the study is in agreement with the other studies. According to Abraham and Jeyachandran , (1993), the absence of the above organisms are reported to be inhibited in pickles with high salt and low pH. According to Karunasagar etal. (1988), low pH inhibits most bacterial activity though some bacterial groups like staphylococci are reported to grow in pickles with pH less than 4. This does not agree with our findings because it was observed that inspite of the pH coming down to 3.88 in O.nepa, it could be observed that there was no incidence of Staphylococci.

The reduction in the bacterial population in the initial stages of storage and later on the increase may be due to the multiplication of acid tolerant bacteria as observed by Vijayan et al. (1982)and this bears agreement with the present study.

After 3 months of storage, the meat was found to be soft, at the same time, the flavour was found to be good. In the opinion of the test panel, the flavour was found to be good later on than when compared to the initial. This could have been due to the ageing of the pickle combined with the proper mixing of the ingredients on further storage. By the 6th month, the product was only rated 4 owing to disliking the pickle due to the off odour.

On the whole, based on the organoleptic, chemical and microbiological characteristics it could be concluded that it keeps for up to 6 months.

New product development in marine fish processing is based on making use of adequately utilised, cheap or seasonal surplus of raw material resource. Also, it can be complete when we take into consideration all aspects of raw material resources, profitability and consumer response. Based on the above reasons, this pickle made out of O.nepa has been found to be worth developing for human consumption in India.

2.Minced based products.

Introduction

Mince based products is reported to be originated in Japan some 800 years ago. Mince based products are commonly known in Japan as fish gelly products (Ramachandran, 1995). Tanikawa (1985) reported the processing of various types of products from fish mince. It is one of the best form of products which is popularly marketed as convenience foods in the developed countries. In Japan alone about one million tonnes of mince based products from a variety of fish and shell fish are marketed (Ramachandran,1991).

A review of the literature on mince based products is that of cutlets reported by Jose et al,(1984) who worked on the cutlets made out of the horse mackerel , ribbon fish and chorinemus. Zain (1979) reported on the development of spicy minced fish from Tilapia, a product almost similar to cutlet. So far no cutlet has been prepared out of O.nepa.

2. Fingers

Nair et al. (1982) had worked on the biochemical changes of fish fingers held at frozen storage. Reddy et al. (1992) had developed fingers from croaker and perches and studied the storage behaviour.

3.Wafers

Venugopal and Govindan (1967) had worked on the development of fish flakes using cheap variety of trash fish. Yu et al. (1981) had experimented on the production and acceptability of fish crackers, a product similar to that of wafers "keropok " as it is called in Malaysia.

Material and methods

(a)Cutlets

The meat is cooked in boiling water for 30 minutes, drained and cooled.Make boiled potatoes into a paste and mix with cooked fish and salt and turmeric powder. Fry the onions , ginger and chilli in ground nut oil till brown and add to the mixture. Heat and then add powdered spice and mix well and mould

into cutlets. Dip in egg white batter and roll over bread powder.

Ingredients

1. Cooked meat.	1000g
2. Cooked potato	500g
3. Peeled and chopped onions	250g
4. Ginger pieces	30g
5. Green chilly	20g
6. Pepper powder	3g
7. Clove powdered	3g
8. Cinnamon powder	3g
9. Turmeric powder	2g
10.Salt	30g
11 Oil	125ml

The methods of analysis were same as that adopted in the analysis of the pickles.

(b).Fingers

Minced meat is mixed in water to get a dough. It is shaped as slabs and frozen. It is then cut into uniform size of 6X 1.5 X1 cm and packed in polysheet. It is then frozen and then are rolled in bread crumbs and stored at -20 degrees

centigrade. Before use, they are flash fried for about 1 to 2 minutes in ground nut oil at 160 -170 degrees centigrade.

Ingredients.

1. Meat	1000g
2. Wheat flour	749 g
3. Salt	8 g
4. Egg	80g
5. Milk powder	60 g
6. Vegetable fat	90g
7. Monosodium glutamate	15g
8. Baking powder	15g

Breading mix

1. Wheat flour	400g
2. Whole egg	5 nos
3. Milk powder	30g
4. Salt	10g
5. Monosodium glutamate	10g
6. Bread crumbs	45 g

The methods of analysis are the same as that adopted in the previous cases.

(c).Wafers

Ingredients

1.Cooked meat	1000g

2.corn flour	500g
3.starch	1000g
4.salt	249g
5.water	1.3 litres

The sample was washed in chilled potable water to remove the adhering dirt and filth and drained in a perforated vessel. It was then ground to a fine pulp in a food processor (beaten egg was mixed well). All the ingredients were mixed except starch. Starch was added at the end and the dough was made and fed to a dismantable cylindrical stainless steel mould. Fine holes were provided in the mould for easy flow of steam. The mould was autoclaved and steamed for 30 mts for cooking and gelatinisation of the mass. After steaming, the mould is cooled and chilled to harden the cooked mass. The hardened mass is removed from the mould and cut into slices. The slices are then dried in the sunlight for 2 days and packed in polythene bags.

The analysis was conducted as in the case of the previous products adopting the same methods. In addition, the degree linear expansion of the wafers was also noted by following the method adopted by Yu et al. (1981). For this the unpuffed wafer was ruled with 5 lines across. Each line was measured before and after puffing. The% linear expansion was calculated as follows

% linear expansion =

$$\frac{\text{Length after puffing} \times \text{Length before puffing}}{\text{length before puffing}} \times 100$$

Results

Cutlets

Table 4 shows the chemical changes in the cutlet. It could be observed that the NaCl content was found to decrease by the 3rd month when compared to the initial value. The same trend was noticed in the moisture content of the samples.

In Table 5 changes in the microbiological characteristics of the cutlets show that E.coli, Staphylococcus and salmonella were totally absent. At the same time, it was observed that the Total Plate Count was found to show a decreasing trend by the end of the 3rd month of storage.

In Table 6, the changes in the organoleptic characteristics of cutlet show that the product was rated as good throughout the period of storage. In the mean time,cutlet was also made with the frozen sample to find the changes in the preference between the iced cutlet and the frozen one. It could

be observed that there was no preference as such between the products except for the fact that a slight salty taste was observed in the frozen cutlet.

Fingers

Table 7 shows the changes in the chemical characteristics of fingers. The NaCl content was found to decrease during the 3rd month of storage. There was considerable increase in the moisture contentby three months of frozen storage.

The microbiological changes in the fingers during storage are depicted in Table 8. It could be observed that during the initial part of the study, the Total Bacterial Count was found to increase. But by the end of the study the values were found to reduce.*E.coli*, Staphylococci and Salmonella were not present during the study period.

Table 9 shows changes in the organoleptic characteristics of the fingers stored in frozen condition. Throughout the period of study the product was favoured by the testpanel. But with reference to the colour of the finger, it

was observed that the panel did not find the colour of the finger at the end of 3 months to be satisfactory. By the end of the study , its colour when fried had turned to dark brown colour ; besides the fishy odour was found to be prominent by the end of the 3rd month.

Wafers.

Table 10 shows the chemical changes in theof the wafers during a period of six months of storage at room temperature. The moisture content of the wafer was reduced to 8.5 % by the end of 6 months. This has good bearing on the properties of the material. In Table 11, the changes in the microbiological characteristics show that there were no incidence of E.coli, Staphylocci and Salmonella in the samples. The Total Bacterial Count was found to show a decrease in the values by the 6th month of storage when compared to the initial quality of the material

Table 12 shows the changes in the organoleptic characteristic of the sample. The colour of the wafers was light brown when fried till the 5th month of storage. But by the end of the 6th month, it was observed that it attained a lighter shade. By the 6th month of storage the preference of the test

panel towards the wafer was reduced. Also the rate of crispness of the fried product was reduced by the 6th month. A slight salty taste was observed in the sample during 5th and 6th month. Wafers were prepared with frozen meat of squilla to test the preference between the two. It was observed that in the frozen wafer, except for the appearance of white patches on the material before frying, the fried product was favoured equally as that of the wafer prepared from iced samples.

Table 13 shows the degree of extensibility of wafers prepared from O. nepa meat. It was observed that the degree of extensibility was found to change during storage, from 16.66% in the initial stages it was found to increase upto 72.22 % by the end of six months.

Discussion

In the cutlets, the reduction in the moisture content is attributed to the addition of ingredients to the cooked meat. The quality and frozen shelf life of cutlets depends on the species. It is generally believed that cutlets prepared from lean fishes are generally good. According to Jose et al.(1984), the cutlets from the ribbon fish were found to yield soft meat

and the cutlet from them have soft texture. The same was observed in the case of cutlets prepared from O.nepa. Also general preference is towards cutlets prepared from less fatty fish since they are prone to oxidation. Since O. nepa has a fat content around 2 to 3 % on dry weight basis the chances of oxidation are less. Inspite of the fact that cutlets were prepared from both iced and frozen meat of O.nepa they were liked equally by the taste panel constituted for the purpose. A good cutlet according to Jose et al.(1984) is firm, crispy and savory. Also they had outlined the disadvantages of cutlets prepared by mixing fishes together , which is attributed to the mixing of the bile. The moisture content of the raw cutlet prepared from O.nepa is almost the same as that of ribbon fish. The absence of any off taste in the cutlets throughout the study is in agreement with the observations of Grantham (1982). According to him, since oxidation is a surface effect, the coating with egg white functions as a oxygen barrier, thus preventing fat oxidation. The effect of freezing on the bacterial population is found to be erratic.and hence difficult to predict. Generally a reduction in the counts is noticed and the number will continue to fall during storage.

Hence it could be inferred it is not necessary that

cutlets be prepared out of fresh samples, it is possible to prepare cutlets out of frozen meat of O.nepa. The added advantage is the fact that in case of bulk landings, it is possible to store the raw material and then develop cutlets at a later time. In fact it has been proved in the previous chapter that it could be kept under frozen storage for upto 3 to 5 months.

In the case of the fingers, Nair,(1982) observed that the moisture was found to increase by 3 months and this observation agrees with the findings of fingers prepared out of O. nepa. At the same time, a decrease was observed in the bacterial counts during the period of study, this observation has also been observed by several workers like, Reddy et al.(1992).Generally during frozen storage there is a reduction in the bacterial count. Hence it could be inferred that it is possible to develop fingers out of O.nepa. Generally fingers are kept only up to 3 months, hence the study was conducted only for a period of 3 months.

In the case of the work done on the acceptability of wafers, the study conducted by Venugopal and Govindan (1967) had shown that the moisture content of the fish flakes to be around

7.3 % but the wafers prepared out of O.nepa were found to have a higher moisture content. At the same time, it could be observed that the moisture content was found to reduce throughout the storage period. This could be linked to the reduction of the bacterial count, hence the inference that the gradual destruction of microorganisms being due to low water activity in the product. Also the reason attributed to the selection of tapioca flour for the preparation of the product is due to the low cost of the raw material and also is in agreement with the observation of others who have worked on the wafers. They have attributed it to crispiness . According to Siaw (1979) crispness is the most important factor governing product acceptability and this is in agreement the present findings. Also the need for gelatinisation in the manufacture of wafers has been linked to the rate of expansion as according to Yu et al. (1981). Thus it can be concluded that it is possible to develop wafers out of the meat of O.nepa and it can keep stored at room temperature for up to 6 months. Also in case it is not possible to develop wafers immediately on catching , there is the possibility of keeping the raw material in the cold store and then processing at a later date. Another advantage lying in the utilisation of the frozen stored meat is the fact that the meat extraction becomes easier.

3.Chitin and Chitosan

Introduction

The prawn processing industry of India turns out 60,000 tonnes of waste every year containing 10% of chitin on dry weight basis. According to Madhavan and Nair,(1975) the stomatopod O. nepa has been found to have a rich source of chitin

The important study on Chitin and chitosan are that of Radhakrishnan and Prabhu (1972), Madhavan and Nair (1974), Nair and Madhavan (1975). With reference to chitin and chitosan developed out of O.nepa, the works of Madhavan and Nair (1975) and that of Moorjani et al.(1978) are commendable. Madhavan (1992) also give a detailed account of the novel applications of chitin and chitosan. A Global interest in chitin and chitosan was demonstrated by 3 international conferences (Anon,1977; 1982; 1985a). The interest in the development of chitin and chitosan arises out of its varied uses as coagulant in chromatography, paper, film and fibres , textiles , photography , medical adhesives and coatings and as agricultural. The present study deals with the development of chitin and chitosan out of the stomatopod O.nepa and the marine prawn Parapeneopsis stylifera.

A comparative study was conducted to find out the quality of chitosan between the two.

Material and methods

The proximate analysis of O.nepa and Parapeneopisis stylifera were conducted. Standard methods were adopted , in the analysis of the moisture , fat and protein (AOAC., 1975). Chitin nitrogen as according to the method of Garg et al.(1977).

Chitin and chitosan were prepared following the method of Nair et al. (1975). The fresh waste was washed in water and heated to boiling with 3 % NaOH for 30 minutes. The residual protein was removed by heating the residue to boiling with equal volume of 3% NaOH solution., draining off the alkali and repeating the process once again. The liquor was drained off and the residue washed and demineralised by immersing in 1.25 N HCl at room temperature for 4 hours (time modified as against the standard procedure). The residue is drained and washed with water. It was then dried and this is called chitin. The yield is noted. Then the remaining portion after draining and washing with water was subjected to the final process of deacetylation dipping in 1:1 (w/w) NaOH. solution for 2 hours at 100 degrees

centigrade. The alkali is used for deacetylation of the subsequent batches. The deacetylated mass was washed several times till free of alkali , dried in the sun , pulverised to required size and stored. The yield was noted and the viscosity was determined in 1 % acetic acid. The instrument used for viscosity measurement is the Viscometer Model HAAKE Viscotester VT-02.

Results

Proximate composition of the mantis shrimp O. nepa and that of the prawn Parapeneopsis stylifera is shown inTable 14. It can be observed that the chitin content of O.nepa is found to be higher than that of the prawn. Chitin nitrogen is a very important factor in the manufacture of chitin and chitosan. The flow chart(Figure 1) depicts the different stages and the yield at the end of each process in the manufacture of chitin and chitosan from O.nepa and P.stylifera. It could be observed that the yield of chitosan from P.stylifera comes to 1.2 % and that of O.nepa comes to around 2.53%. With reference to the colour of chitosan obtained from the prawn,it was observed that it has a pinkish tinge and hence there is the need for bleaching. At the same time, in the case of chitosan prepared from the squilla ,

there is no need for bleaching since it is pure white. The viscosity of the chitosan from prawn and squilla were measured and it was observed that it is 220 centipoise in the case of the prawn and in squilla , it was 650 centipoise.

Discussion.

The present results on the comparative study of chitosan prepared from the prawn and squilla shows that chitosan of high viscosity and thus higher grade is obtained squilla. This observation is in total agreement with the findings of Nair (1975) who reported that the viscosity of O.nepa as higher than that of prawns.The viscosity of chitosan from squilla was reported to be 340 centipoise and that of the prawn 180-200 centipoise. With reference to the yield of chitosan ,Moorjani et al.1978, who had worked on the production of chitosan of high viscosity had confirmed that chitosan prepared from the fresh material is always preferred to that of dried material; the reason being the exoskeleton was affected by bacterial contamination during drying because of the high protein and moisture content.

In view of the advantages of the chitosan in the

stomatopod O.nepa it is suggested that the shell can be utilised as chitosan because of the innumerable properties it exhibits. Finally , it can be concluded that every part of this stomatopod can be utilised without any waste. As a result of the proper utilisation of the resource, the problem of protein starvation can be bridged. In addition there is possibility of getting protein in a cheaper form in view of the escalating prices of shrimp in the market. In countries like Japan where mince based products originated, there exists about 800 different varieties of mince based products in the market. This is possible mainly by utilising underutilised fishes or shellfishes or fish which has no market as fresh fish or whole fish. Same is the case with squilla which is now not consumed. To utilise squilla the best method is to extract the meat and prepare mince based products as described in the text .

Table 1

Chemical changes in pickles prepared from O.nepa

Duration	pH	NaCl (%)	Moisture (%)
initial	4.46	3.03	64.34
7 days	4.29	3.03	63.58
14 days	4.22	3.55	63.82
21 days	4.22	3.26	64.88
30 days	4.20	3.38	65.50
60 days	3.88	3.55	66.40
90 days	3.93	3.64	64.13
120 days	3.78	2.93	68.62
150 days	3.72	2.89	63.78
180 days	3.72	2.92	62.99

able 2
icrobiological changes in pickles prepared from O.nepa

uration	E.coli	Staphylococci	Salmonella	T.P.C/gm
ıitial	-	-	-	1.96×10^{3}
days	-	-	-	1.92×10^{3}
days	-	-	-	1.66×10^{3}
days	-	-	-	1.25×10^{3}
days	-	-	-	5.98×10^{2}
days	-	-	-	2.85×10^{2}
days	-	-	-	1.60×10^{2}
days	-	-	-	1.21×10^{3}
days	-	-	-	3.60×10^{3}
days	-	-	-	4.35×10^{2}

Table 3
Organoleptic changes in pickles prepared from O.nepa

Duration	Appearance	Colour	Odour	Texture	Taste
Initial	4	4	4	4	4
7 days	4	4	4	4	4
14 days	4	4	4	4	4
21 days	4	4	4	4	4
30 days	4	4	4	4	4
60 days	4	4	4	4	4
90 days	4	4	4	3	4
120 days	4	3	3	4	4
150 days	4	3	3	3	3
180 days	4	3	2	3	3

Note: 5=Exellent; 4=Good; 3=Fair; 2=Poor

Table 4
Chemical changes in cutlets prepared from Oratosquilla nepa

Duration	Nacl (%)	Miosture (%)
initial	1.4527	66.77
7 days	1.4738	67.26
14 days	1.4767	65.66
30 days	1.5754	64.79
60 days	1.6687	63.35
90 days	1.3055	62.54

Table 5
Microbiological changes in cutlets prepared from Oratosquilla nepa

Duration	E.coli	Staphylococci	Salmonella	T.P.C /g
Initial	-	-	-	2.05×10^{4}
7 days	-	-	-	4.9×10^{5}
14 days	-	-	-	3.6×10^{5}
30 days	-	-	-	1.4×10^{5}
60 days	-	-	-	1.6×10^{2}
90 days	-	-	-	1.2×10^{2}

Table 6
Organoleptic changes in the cutlets prepared from O.nepa

Duration	Colour	Appearanc	Flavour	Texture	Odour	Score
Initial	brown	good	good	soft & crispy	good	8
7 days	brown	good	good	soft & crispy	good	7
14 days	brown	good	good	soft & crispy	good	7
30 days	brown	good	good	soft & crispy	good	7
60 days	brown	good	good	soft & crispy	good	7
90 days	light brown	good	good	only soft	good	6

Table 7
Chemical changes in fingers prepared from O.nepa

Duration	NaCl (%)	moisture (%)
Initial	1.32	42.92
1 month	1.20	42.88
2 months	1.15	48.17
3 months	0.92	48.88

Table 8
Microbiological changes in fingers prepared from O.nepa

Duration	E.coli	Staphylocci	Salmonella	T.P.C /g
Initial	-	_	-	1.9×10^{4}
1 month	-	_	-	1.5×10^{4}
2 months	-	_	-	1.0×10^{4}
3 months	-	_	-	5.0×10^{-3}

Table 9
Organoleptic changes in fingers prepared from O.nepa

Duration	Odour	Flavour	Texture	Colour	Hedonic
Initial	good	good	soft and crispy	brown	8
1 month	good	good	soft and crispy	brown	7
2 months	good	good	soft and crispy	brown	7
3 months	good	good	moderately tough	dark brown	6

Table 10
chemical changes in wafers prepared from O.nepa

Duration	NaCl (%)	Moisture (%)
Initial	1.33	9.80
1 month	1.31	9.56
2 months	1.27	9.33
3 months	1.33	9.22
4 months	1.36	9.40
5 months	1.36	8.90
6 months	1.39	8.50

Table 11
Microbiological changes in wafers prepared from O.nepa

duration	E.coli	Staphylococci	Salmonella	T.P.C /g
Initial	-	-	-	1.20 X10
i month	-	-	-	1.65 X10
2 months	-	-	-	1.60 X10
3 months	-	-	-	4.40 X10
4 months	-	-	-	1.03 X10
5 months	-	-	-	1.10 X10
6 months	-	-	-	1.00 X10

Table 12
Organoleptic characteristics of Wafers prepared from O.Nepa

Duration	Odour	Flavour	Colour
Initial	good	good	brown
1 month	good	good	brown
2 months	good	good	brown
4 months	good	good	brown
4 months	good	good	brown
5 months	satisfactory	good	light brown
6 months	satisfactory	good	light brown

Table 13
Degree of extensibility of wafers prepared from O.nepa

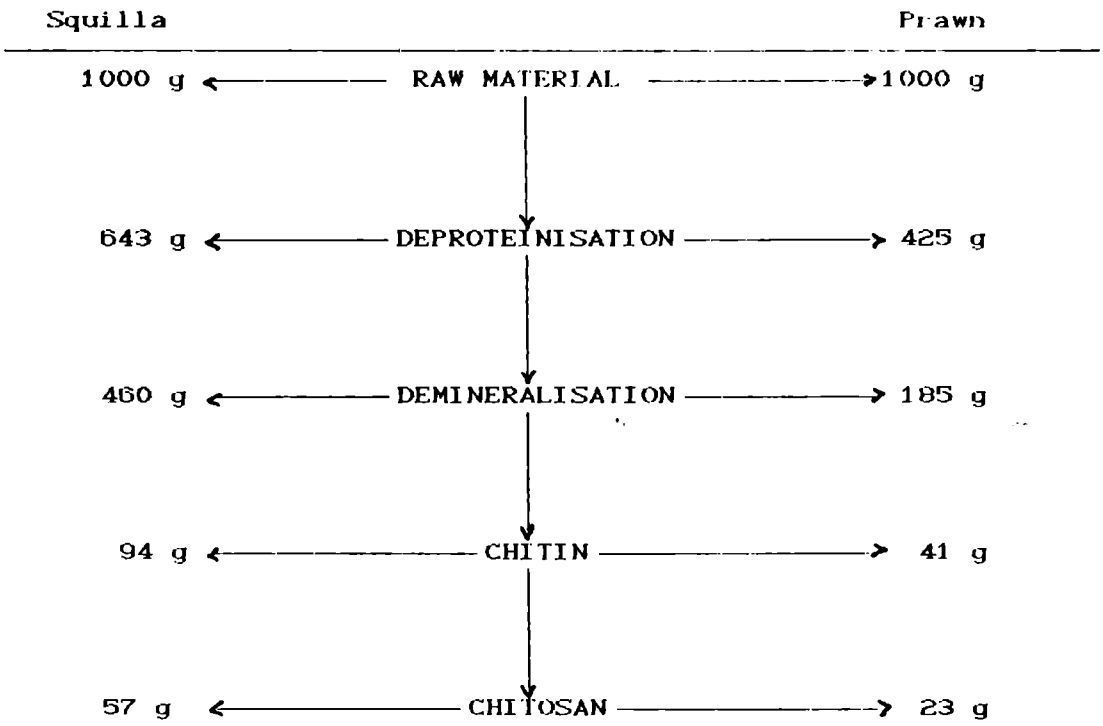
Duration	% Extensibility
Initial	16.66
1 month	33.33
2 months	50.00
3 months	53.55
4 months	61.23
5 months	66.66
6 months	72.72

Table 14 Proximate composition of O.nepa and P.stylifera

Composition	O.nepa	P.stylifera
Moisture (%)	77.99	75.28
Protein*	45.26	30.92
Fat*	2.59	2.20
Chitin Nitrogen*	0.98	0.85

*% dry weight basis

Fig 1 Flow chart showing the processing of chitin and chitosan from Squilla and Prawn and the yields at different stages of processing



SUMMARY

The results of the survey in Cochin Fisheries Harbour revealed that the stomatopods form a major component of the bycatch of the shrimp trawlers. Among the stomatopods, Oratosquilla nepa is found be the most dominant species and is found in the catches up to 50M depth. They are landed both by the mechanised as well as the traditional crafts of Cochin. This species have been reported to be in abundance in other states of India. They have also been reported from the Indo West Pacific, Atlantic and the Mediterranean. The important biological aspects of significance such as distribution of the species and its abundance; length weight relationship; food and feeding; age and growth, reproductive biology, which are more relevant for the utilisation of this resource for human consumption and industry have been studied in detail. In order to study the keeping quality of the material a detailed study has been conducted on its ice storage behaviour, frozen storage behaviour and the seasonal fluctuations in the biochemical characteristics of O nepa. This has been done with a view to utilise the resource for producing different products for human consumption and for industrial use. Methods of processing products like squilla pickle, squilla wafers, squilla cutlet and fingers have been

standardized for ready reference for use by the industry. The species is identified based on the external morphological characters. The distribution, seasonal abundance and the magnitude of the landings were assessed. It is observed that their distribution extends from $76^{o}05'E$ to $76^{o}12'E$ longitude and $09^{o}45'N$ to $10^{o}15'N$. They are found in maximum numbers during the months of January and July which would suggest two peaks of abundance. A decline in their numbers are noticed during the months of September and October. They are found abundantly during the pre-monsoon and latter half of post monsoon months. The average annual landings of O nepa in Cochin comes to 8,906 tonnes. The dominance of large sized samples occurs mainly in January.

The length weight relationship is worked out for the males, females and the indeterminants. They are expressed as follows :

Females $W = 0.000001722\ L^{3.37063}$

Males $W = 0.000002052\ L^{3.42866}$

Indeterminants $W = 0.00005612\ L^{2.557412}$

Since the relationship of the 3 are found to differ a combined relationship could not be derived. With reference to the Kn values, they were found to be high during the months of March -June and then September.

A detailed study on the qualitative and quantitative aspects of food in O. nepa was studied based on the 1034 stomachs collected during 1992- 1994. Variations in the food components with respect to size groups and season were observed. The gastrosomatic index was also studied. O. nepa is found to feed on crustaceans, detritus, molluscs, diatoms, worms, fish remains, animal matter etc. The seasonal changes in the food contents could be attributed to the changes in the abundance of food as well as due to environmental factors. Molluscans were present in the bigger size groups while it was totally absent in the smaller size groups. GSI showes high values in the males during April, May and in the females, it was May and August. Low values were observed in the males during September and December while in the females it was May and September.

Age and growth was estimated based on the length frequency distribution for the period 1992-1994. The growth equation for the sexes were as follows

Males Lt = 86.2566 mm

Females Lt = 97.1416 mm

The reproductive biology of O nepa was studied in detail. The sexes could be differentiated by the external morphological characters. The spawning season was found to be in June and then in November. The developmental stages of ovaries were quantified into 5 stages and the testes into 3 stages. The gonadosomatic indices were high during April/ June and then February when more mature and ripe specimens could be encountered. Low values of GSI were observed during October. The occurence of the spent individuals was during August/ december in the first year and May in the second year the average size at which 50% mature was 50mm in the males and 55mm for the females. Fecundity showed significant relationship between the total length, total weight,ovary length and the ovary weight. The sex ratio between the males and the females showed no significant deviation from the 1:1 ratio.

The biochemical analysis of O nepa showed that it has considerable chitin nitrogen. A comparison between the flesh and the whole squilla showed the flesh contains a higher content of protein and moisture. The organic constituents like moisture, protein, fat were found to show marked variation But at the same

time, it was observed that carbohydrate and chitin nitrogen did not show much variation throughout the study period The high levels of fat were found to be linked with the reproductive condition of the stomatopod. High values of protein is observed during November-January and that of fat during May-June and Sept-October. This can be directly corelated with the pre-spawning fatting of the animal.

The study of the storage characteristics of O nepa. revealed that the material can be kept in good condition in ice for 3-5days (good to eat period) while the frozen samples from 3-5months. But for the processing industry it is recommended that the iced material be processed within three days. A detailed study has been carried out to work out the possibility of utilising this otherwise wasted material for human consumption and industrial use. Processing methods for the production of cutlets, wafers, fingers and pickles could be standardized and is available for adoption by the industry. Shelf-life was found to be 6 months in the case of the pickles and the wafers. The best keeping time for the fingers and the cutlets was found to be 3 months. It was also observed that in case it is not possible to process the material immediately after landing, it can be iced and stored temporarily upto five days

before processing. The study on the storage behaviour of the samples and its subsequent use for the preparation of different products mentioned above shows that the frozen material is also suitable for further processing into products like cutlets, fingers, and wafers. Also it has been suggested that for the extraction of the meat, it is easier to extract the meat after keeping the raw material in ice for about 18 hours and then removing the shell. This helps in getting a better yield. Hence there is scope for the development of products out of squilla for human consumption.

A comparative study was conducted to find the comparison of chitin and chitosan prepared out of O nepaand the prawn Parapeneopsis stylifera. It was observed that chitosan prepared out of O nepa is far superior to that of one prepared from prawn shell. This study was carried out in view of the current utilisation of squilla as a raw material for chitin and chitosan.

It can be concluded that there is scope for developing products out of squilla for human consumption. Since this is the cheapest available form of animal protein efforts should be taken to prevent the throwing overboard of this

resource and instead utilising it to the fullest. With this in view, a knowledge of the biological aspects will help in the judicious exploitation of the resource.

RECOMMENDATIONS

1. In the present crisis of over-exploitation and depletion of commercially harvested fishery stocks, the very effort should be made to utilise new resources like squilla which are so far not commercially harvested. The squilla (O nepa) stock in Cochin supports a full scale commercial fishery.

2. Trawlers which are now aiming for shrimps can be utilized with sufficient modification in the gear and the operation for harvesting squilla within 50 meters depth.

3. In order to conserve the resource in the beginning of commercial exploitation itself, adequate conservation measures should be enforced taking into account its spawning season, life cycles and the like which have been established in the present study.

4. The material can be iced or frozen for distribution to the endusers or processors.

5. Test panel results shows that it could be utilized for human consumption.

6. While formulating products from the squilla its biochemical status also should be taken into account like spent time, ripe time, season of maximum protein, season of maximum fat, season of maximum moisture and the like. This gives better quality and shelf-life to the products prepared out of it.

7. Squilla can also be utilized for the production of industrial products like chitin and chitosan.

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