STUDIES ON THE BIOLOGY, ECOLOGY AND FISHERY OF THE SEA CUCUMBER *HOLOTHURIA (METRIATYLA) SCABRA* (JAEGER) FROM SOUTH EAST COAST OF INDIA

THESIS SUBMITTED
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
OF THE
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

B. K. BASKAR

POST GRADUATE PROGRAMME IN MARICULTURE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
KOCHI - 682 031

JUNE **1991**

C E R T I F I C A T E

This is to certify that the thesis entitled **Studies on the Biology, Ecology and Fishery of the sea cucumber *Holothuria (Metriatyla) scabra* (Jaeger) from southeast coast of India,** embodies the research of original work conducted by **Mr. B.K. Baskar** under my supervision and guidance. I further certify that no part of this thesis has previously formed the basis of the award of any degree, diploma, associating fellowship or other similar titles or recognition.

(P.S.B.R. James)

Director,

Central Marine Fisheries

Research Institute,

Kochi - 31.

Kochi,

June, 1991

DECLARATION

I hereby declare that this thesis entitled **Studies on the Biology, Ecology and Fishery of the sea cucumber *Holothuria (Metriatyla) scabra* (Jaeger) from southeast coast of India** is a record of original and bonafide research carried out by me under the supervision and guidance of **Dr. P.S.B.R. James, Director,** Central Marine Fisheries Research Institute, Kochi and that no part there of has been presented before for any other degree in any university.

Kochi,

June, 1991

(B.K. Baskar)

ACKNOWLEDGEMENT

I wish to express my deep gratitude to **Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute, Kochi,** my supervising teacher whose unstinted guidance , sustained interest and constructive criticism enabled this work to materialise.

I am very much indebted to the **Officer-in-Charge** of **Tuticorin Research Centre of CMFRI** took a keen interest in my work program and extended all laboratory facilities for carrying out the work. I wish to acknowledge with gratitude all help and encouragement given by him. I am grateful to Officer-in-Charge, Mandapam Regional Centre of CMFRI for his timely help.

I wish to record my sincere thanks to **Dr. D.B.James,** Scientist, Central Marine Fisheries Research Institute, Tuticorin for his valuable suggestions and comments. I also acknowledge the help of scientists of Tuticorin Research Centre of CMFRI. My thanks are due to Shri. M.Srinath who helped me in the statistical analysis of the data.

I would like to place on record my sincere thanks to **Dr. K.Rengarajan, Dr.N.Sridhar, Dr.Manpal and Miss.P.Prathibha,** Scientists, CMFRI, Kochi for their valuable comments.

I also cherish fond feelings of gratitude to my fellow research scholars **Mr. Kuldeep Kumar Lal, Mr. N. Ravi, Mr. A.K.V. Nasser, Miss. Shanthi Thirumani, Miss. Sheeba Susan Mathew and Miss. B. Santh Begum.** Thanks are also due to all the staff members of PGPM, CMFRI, Kochi.

I thank the **Indian Council of Agricultural Research** (ICAR), New Delhi, for offering me the **Senior Research Fellowship** to carryout this work.

I acknowledge with thanks to my friends **Mr. An. Sathappan, Mr.N. Narayanan,** for their help and kind co-operation in designing this work.

I wish to acknowledge with special thanks to **M/S. Super Computer Centre, Tuticorin,** for their timely help rendered in bringing out this thesis neat and prompt.

(B.K. BASKAR)

CONTENTS Page No.

PREFACE

Among the echinoderms, holothurians are commercially important. Certain species of holothurians are processed and the processed material is known as *Beche-de-mer* or *Trepang* in trade parlance. *Beche-de-mer* is considered a Chinese delicacy. At present, India is earning a foreign exchange of more than one crore rupees by exporting *beche-de-mer*. This product has no internal market. It has been introduced by the Chinese and is in existence in the Gulf of Mannar and Palk Bay for more than one thousand years. It has high nutritive value and also considered to have certain medicinal properties. The main international markets are Hongkong, Singapore and Malaysia.

In view of its commercial importance and increasing demand in the international market there are great prospects for culturing holothurians in coastal waters. A knowledge on the biology and ecology of holothurians is desirable for proper exploitation. Very little information is available on these aspects in *Holothuria (M.) scabra*, probably the most important species commercially at present. It has been successfully induced to spawn and later reared at the hatchery of CMFRI at Tuticorin (James *et al.* 1988, 1989). Some work has been done on the reproductive cycle of *H. (M.) scabra* by Krishnaswamy and Krishnan (1967). A detailed study on the anatomy and regeneration

of digestive tract of this species was worked out by Mary Bai (1978, 1980, 1989). Jones and Mahadevan (1966) reported on the association of *Pinnotherus decanensis* from the Gulf of Mannar. Mondy and Cowan (1980) reported the occurrence of pearl fish *Encheliophis vermicularis* (Osteichthys : Carapidae) in *H. (M.) scabra*. James (1973) pointed out the importance of *H. (M.) scabra* in *beche-de-mer* industry. However, there is no detailed information on the biology and ecology of the animal. In order to fill up this gap and to provide first hand information, the present investigation is taken up from the southeast coast of India.

The present thesis is divided into three parts *viz* biology, ecology and fishery. The thesis has eleven chapters of which chapter one comprises of a general introduction. The second chapter gives a detail account of the material utilized as well as the methodology adapted. Chapter three deals with a general survey of the distribution pattern of *H. (M.) scabra* as observed in this investigation. The food and feeding behaviour of holothurians is dealt in chapter four, while biochemical analysis of nutrients in sediments as well as that of the digestive tract of *H. (M.) scabra* is given in chapter five. Chapter six deals with length-weight relationship using the equation $W = a L^{b}$ and a statistical analysis of the covariance.

Reproductive biology is dealt in chapter seven which includes gonad index, maturity stages, spawning season, size at first maturity, fecundity and sex ratio. Chapter eight gives a clear picture of the age and growth of *H. (H.) scabra* using Von Bertalanffy's Growth Formula. The observations on the behaviour of burrowing and locomotion are discussed in chapter nine. Chapter ten deals with the present status of the holothurian fishery. The highlights of the present investigation are given in chapter eleven under the heading summary which is followed by the list of references.

B.K.Baskar

CHAPTER 1

INTRODUCTION

India has a vast coastline of about 6100 Km out of which two million hectares (Bal and Rao, 1990) is suitable for farming fishes, crustaceans, molluscs and other marine organisms. As marine capture fisheries have almost reached the optimal levels of exploitation intensive farming of selected species is an urgent need to meet the demand both of our local as well as export market. A pre-requisite for this is a thorough knowledge of the various aspects such as the biology, food, feeding behaviour, spawning cycle, breeding season, size at first maturity, fecundity, sex ratio, induced maturation, growth etc.

Holothurians among echinoderms are a promising group for culturing in coastal waters in order to meet the export demand and augment our foreign exchange as they are still not very popular in the domestic market. *Beche-de-mer* or *Trepang*, a product obtained from sea cucumber is an important seafood item having great demand in the international market notably in Hongkong, Singapore and Malaysia.

Holothurians are exclusively marine and generally sluggish, benthic animals found on muddy or sandy substratum and also attached to rocks. They are collected mainly by skin diving.

They have the power to eviscerate and regenerate the lost parts in due course and this unique ability makes the animal to escape from predators.

Holothurians though distributed throughout the Indian coast are found more on the southeast coast of India comprised by the Gulf of Mannar, Palk Bay and the Andaman and Nicobar Islands and also at the Lakshadweep Islands. They occur in large numbers wherever reefs are present.

More than 650 species of holothurians are known from all over the world, about 200 species of holothurians are known in the seas surrounding India, of which about 75 species are from the shallow waters within 20 m depth (James, 1989a). About a dozen species are of commercial value used for the *beche-de-mer* industry.

The processing of *beche-de-mer* along the Gulf of Mannar and Palk Bay is carried out for two species *Holothuria (M.) scabra* and *H. spinifera* and at the same time there is an indication of over exploitation of these species especially *H. (M.) scabra* at certain areas as reported by James (1989a). Moreover, due to over exploitation, the Government of India imposed a ban on export of *beche-de-mer* below 3 inches size (75 mm) with effect from August 1982. To diversify over fishing of *H. (M.) scabra* from the

southeast coast, *beche-de-mer* resources for other species can also be exploited.

In order to culture animals away from the natural habitat, a clear picture of the natural food ingested by them, feeding behaviour, and the preferred particle size of food should be obtained to assure better survival. The food and feeding habits of holothurians have been investigated by a few workers. Sloan and Von Bodungen (1980) gave an account on the distribution and feeding of the sea cucumber, *Isostichopus badionotus* of the Bermuda Platform in relation to shelter and sediment criteria. Mosher (1980), Sibuet (1984), Massin and Doumen (1986) recorded the distribution of holothurians with reference to habitat, behaviour and feeding activity. Kinosita and Tanaka (1939), Yamanouchi (1942), Tanaka (1958a), Ferguson (1973), Hauksson (1979) and Massin (1982) reported on the diet of different species of holothurians. Fankboner (1981) re-examined the mucus feeding behaviour of the sea cucumber, *Leptopentacta elongata*. Sambrano *et al.* (1990) have also described the feeding of holothurians.

Massin and Jangoux (1976), Roberts and Bryce (1982), Smith (1983) and Cameron and Fankboner (1984) explained the tentacle structure and feeding behaviour of different species of

holothurians. Fankboner (1978) gave an account on the suspension feeding mechanisms of the armoured sea cucumber, *Psolus chitinoides* . Roberts (1979) studied the deposit feeding mechanisms and resource partitioning of tropical holothurians.

Hammond (1979) observed the feeding ecology and substrate relations of sediment ingesting holothurians from a shallow reef lagoon, Discovery Bay, Jamaica. The patterns of feeding and its activity in deposit feeding holothurians was studied (Hammond, 1982b). Yingst (1982) described the factors influencing rates of sediment ingestion in *Parastichopus parvimensis*, a deposit feeding holothurian. The particle size selection and sediment of deposit feeding holothurians have been analysed by Powell (1977), Taghon *et al.* (1978), Levin (1979), Hammond (1981, 1982a) and Taghon (1982).

A few investigators attempted the biochemical analysis of the gut contents of holothurians. Tokuhisa (1915) commented that holothurians extract organic matter out of sand or mud taken together. Hunt (1925) stated that holothurians ingest the plankton and organic deposits contained in sand or mud. Clark (1954) noted that holothurians and other bottom dwelling animals generally extract organic matter out of sand or mud which pass through their intestine. Newell (1965) suggested that bacteria provide the main food source for organisms ingesting particulate

detritus material. Hargrave (1970) examined the ability of a deposit feeding holothurian to utilize different fractions of organic matter available in bottom sediments.

Lawrence (1972) analysed the carbohydrate and lipid levels in the intestine of *Holothuria atra*. The role of dissolved compounds in the nutrition of benthic invertebrates, uptake in relation to organic content of the habitat was examined by Southward and Southward (1972). Bakus (1973) reported that tropical holothuroids occur maximum in coral reef environments and grow to a large size, while subsisting mainly on sediments which contain only low concentration of organic carbon. Marshall *et al.* (1975) observed the particulate and dissolved organic matter in coral reef areas. Yingst (1976) investigated the utilization of organic matter and constituent food items in shallow marine sediments of *Parastichopus parvimensis*, an epibenthic deposit feeding holothurian. The sediment ingested by *Holothuria tubulosa* was examined (Massin, 1979).

Pavillon (1981) stated the importance of Dissolved Organic Matter (DOM) for marine invertebrate larvae. Moriarty (1982) examined the organic carbon, nitrogen and bacterial biomass in the sediments and gut contents of *Holothuria atra* and *Stichopus* chloronotus on the great Barrier reef. Akhnut'era *et al.* (1982)

estimated the composition of organic matter in the intestinal contents of the bottom detritus feeding holothurians. The role of dissolved organic matter in the nutrition of deep sea benthos was attempted by Southward and Southward (1982). Hammond (1983) investigated the ingestion and assimilation of various forms of organic carbon by the aspidochirote holothuroids *Isostichopus badionotus, Holothuria mexicana* and *H. arenicola*, in the shallow back-reef lagoon on the Western side of Discovery Bay, Jamaica. Coates *et al.* (1984) noted the effects of grazing by deposit feeders on biogenic hydrocarbons in coral reef surface sediments. Moriarty *et al.* (1985) recorded the productivity of bacteria and microalgae and the effect of grazing by holothurians in sediments on a coral reef flat.

There is little information on the relationship existing between the length-weight in holothurians which along with other parameters is of vital importance in establishing the yield. (Conand, 1981, 1988, 1990; Choe, 1963; Lawrence, 1979 and Tyler *et al.* 1987) Similarly, the reproductive cycle plays a major role in understanding the life history and the annual regeneration of stocks.

Very little information is available on the reproductive biology of the holothurians in India. Krishnaswamy and Krishnan (1967), Krishnan (1967, 1968) studied on reproductive cycle

of *H. (M.) scabra*. Jayasree and Bhavanarayana (1989) have studied the reproductive and biochemical constituents of *H. leucospilota*. Colwin (1948) studied the spawning of the holothurian *Thyone briareus*. Hyman (1955) briefly explained the reproduction of different species of holothurians. Tanaka (1958b) made a detailed study on the seasonal changes occurring in the gonad of *Stichopus japonicus* and its biology was studied by Choe (1963).

Pearse (1968) briefly explained the patterns of reproductive periodicities in four species of Indo-Pacific echinoderms. Summers *et al.* (1971) described the fine structure of the acrosomal region in spermatozoa of two echinoderms *Ctenodiscus* (starfish) and *Thyone* (Holothurian). Moore and Lopez (1972) reported the factors controlling the seasonal variation in spawning pattern of *Lytechnius variegatus*. Rutherford (1973) studied the reproduction, growth and mortality of the holothurian *Cucumaria pseudocurata*. Bakus (1973) reviewed the biology and ecology of tropical holothurians. The spermatogonia, spermatocytes and spermatids of *Cucumaria lubrica* were described by Atwood and Chia (1974). Fontaine and Lampert (1976) explained the fine structure of the sperm of a holothurian. Green (1978) and Costello (1985) made an account on the annual reproductive cycle of holothurians.

Engstrom (1980) and Franklin (1980) studied the reproductive biology and some aspects of the population ecology of holothurians. Shelley (1981) gave an account on the distribution, reproduction, growth and fishery potential of holothurian in the Papuan coastal lagoon. Conand (1981) made a detailed study on the sexual cycle of three commercially important holothurian species from the lagoon of New Caledonia. Mosher (1982) and Mc Even (1988) observed the spawning behaviour of the holothurians. Harriott (1982) made an account on the sexual and asexual reproduction of *Holothuria atra* at Heron Island Reef and Great Barrier Reef. Conand (1982) briefly explained the reproductive cycle and biometric relations in a population of *Actinopyga echinites* from the lagoon of New Caledonia, Western Tropical Pacific.

Orgche and Gomez (1985) made a preliminary report on the reproductive periodicity of *H. (M.) scabra* at Calatagen Batarjas, Phillippines. Harriott (1985) carried out work on the reproductive biology of three congeneric sea cucumber species *Holothuria atra*, *H. impatiens* and *H. edulis* at Heron Reef, Great Barrier Reef. Conand (1986, 1988, 1990) made a detailed study on the fishery of holothurian resources of Pacific Island countries. Cameron and Fankboner (1986, 1989) gave an account on the reproductive biology of the commercial sea cucumber *Parastichopus*

californicus, reproductive periodicity, spawning behaviour, development, recruitment and juvenile life stages.

Induced breeding is a widely adopted technique to make animals breed in captivity so as to increase their numbers and this helps in studying the early developmental stages. The most popular form in which holothurians are used for human consumption is *beche-de-mer* has great scope for industrialization as it fetches good foreign exchange. *Beche-de-mer* processing has been taken up by many industries along the coastline where there is a predominance of holothurian population but it is suffering a severe setback on account of the already stated dwindling resources of the few commercially important holothurian species as well as the poor knowledge of proper processing of *beche-de-mer* lowers its value in the International market.

Holothuria (Metriatyla) scabra (Jaeger, 1833)

Identifying characters of *H. (M.) scabra* are : Twenty tentacles; pedicels irregularly arranged on the flattened ventral 'sole'. Papillae usually quite large and conical and irregularly arranged dorsally, a lateral flange of papillae sometimes evident, a 'collar' of papillae around the base of the tentacles often present; anal papillae variously developed; body wall usually quite thin about 2mm (1-5 mm) thick, and gritty to touch;

body usually flattened ventrally, arched dorsally; size small to moderate, upto 400 mm long; calcareous ring quite well developed with radial plates upto three times as long as the interradials; spicules consisting of well developed tables with smooth disc and spire either of moderate height or high; terminating in a few to many small spires, tables rarely absent; buttons simple, with moderate sized irregularly arranged knobs and three to ten pairs of relatively large holes, according to Rowe (1969).

From the above information, it is evident that no detailed studies on the biology, food, feeding habits, length and weight relationship, size at first maturity, maturity stages, spawning season, fecundity, sex ratio, burrowing behaviour and locomotion, fishery etc., of *Holothuria (H.) scabra* particularly from Indian waters have been made (Plate I). In view of this, a detailed study **on the biology, ecology and fishery of the sea cucumber *Holothuria (Metriatyla) scabra* (Jaeger) from south east coast of India** , has been undertaken to provide first hand information on its biology, ecology and fishery.

The main objectives of the present study on *H. (H.) scabra* are:

1. To survey the distribution of the candidate species along the southeast coast of India.

Plate I. *Holothuria (Metriatyla) scabra*- Entire

PLATE I

2. To investigate the food and feeding habits, and to find out the relationship between the length of the animal to that of the digestive tract.

3. To estimate the biochemical constituents *viz.* organic carbon, organic matter, carbohydrate, nitrogen and protein from different regions of the digestive tract and from the sediments.

4. To evaluate the length and weight relationship using the equation $W = aL^{b}$.

5. To study the reproductive biology of the above species, dealing with maturity stages, spawning season, size at first maturity, gonad index, and its relationship with temperature and salinity. Relationship between total length, total weight, gutted weight, gonad weight and maturity stages, fecundity, sex ratio.

6. To find out the age and growth using modal progression analysis.

7. To observe the burrowing behaviour and locomotion in the laboratory.

8. To gather information on the fishery of this species.

CHAPTER 2

MATERIALS AND METHODS

The distribution of *Holothuria (M.) scabra* from Palk Bay and the Gulf of Mannar of southeast coast of India was studied to assess the availability of the resources along both the coasts. Generally fishing of holothurians is not very regular due to poor visibility thereby making skin diving impossible. The tallu valai at Tuticorin centre was operated round the year while seasonal skin diving was carried out at Kilakarai and Tirupalakudi.

Among these centres, Tuticorin was selected as the main centre as the holothurian fishery is conducted throughout the year and the specimens were caught by skin diving from October to March and by tallu valai for the rest of the period.

For the present work, specimens were collected from Tuticorin landing centre at fortnightly intervals from March 1988 to February 1990. Specimens were abundantly collected by skin diving near Van theevu and Kaswar theevu. On an average 30-40 specimens were collected in a month from the landing centres and transported to the laboratory in water containing 8% magnesium chloride to avoid evisceration. The total length (TL) of the samples was measured dorsally from mouth to anus to the nearest

0.5 cm by means of flexible tape, when the individuals were in turgid condition. The eviscerated individuals were discarded. The total weight (TW) to the nearest 5g; drained weight (DW) (following the opening of the body and the removal of coelomic water) to the nearest 5g; gonad weight (G) to the nearest 0.1g; gutted weight (GW) (following removal of gonads, alimentary canal and respiratory tree) to the nearest 5g were also determined according to the method described by Conand (1981).

2.1 Food and Feeding habits

The length and wet weight of the digestive tract were recorded and the alimentary canal was preserved in 10% formalin to study the food and feeding habits. The gut contents were analysed qualitatively and quantitatively and the details of the methodology adopted are given below.

2.1.1 Qualitative analysis

The gut content samples from different regions of the digestive tract *viz.* oesophagus, stomach and intestine were collected separately and observed for different food items.

2.1.2 Quantitative analysis

For quantitative analysis, gravimetric method was followed

(Roberts, 1979). The weight of each grade food item was expressed as percentage of the weight of the total gut contents. The gut content from different regions of the digestive tract were collected carefully, washed and dried in oven at 65^{O}C for 24 hours. The different particle sizes were segregated by passing them through seven different grades of standard sieves of 90, 125, 250, 500, 710, 1003 and 1680 μ, using an automatic sieve shaker. Each fraction was weighed and expressed as percentage of the total gut content weight.

2.1.3 Condition of feed

To ascertain the feeding conditions during various months, the degree of fullness of the stomach was noted before the stomach was cut. As no work has been reported in holothurians regarding feeding intensities, the stomach was classified as 'full', '3/4 full', '1/2 full' and '1/4 full' depending on the relative fullness and the space occupied by stomach contents. The stomach was designated 'full' when it was completely filled with food and its wall appeared very thin and transparent. It was considered '3/4 full' when it was in a partly collapsed condition, in which case the wall was usually thick. Stomachs termed 'empty' contained practically nothing in them. From the total number of holothurians examined in a month, the percentage occurrence of full, 3/4 full, 1/2 full, 1/4 full and empty

stomachs was estimated. The holothurian stomachs classified as full, 3/4 full and 1/2 full were considered to have actively fed, whereas those with 1/4 full had fed poorly.

2.1.4 Relationship between length and weight of gut and length and weight of animal.

The total length, total wet weight of the holothurian and that of the digestive tracts were measured. A relationship was made between the total length, digestive tract length, total weight and digestive tract weight.

2.2 Biochemical Analysis of Nutrients

The holothurian samples were collected from the bottom sediments and the sediment samples were taken from *H. (N.) scabra* by scraping only the top few millimeters of sediment where the individual lies. On return to laboratory the animals were immediately dissected and the sediment in their oesophagus, stomach, intestine was collected. Nearly 25-35 individuals were examined. The sediment samples, gut materials and faeces were rinsed with fresh water, dried and sieved to provide samples for the determination of organic carbon, carbohydrate and nitrogen.

2.2.1 Estimation of organic carbon

The total organic carbon and organic matter was analysed according to the method of Walkey-Black (1934).

Procedure : 0.5 to 1.0 g of sample was taken in a 500 ml conical flask and 10 ml of potassium dichromate solution and 20 ml concentrated sulphuric acid were added. After 20-30 minutes 175 ml of distilled water followed by 6 to 7 drops of diphenylamine indicator were added. The flasks were shaken well and titrated against ferrous ammonium sulphate solution. A blank control was also made. The colour becomes deep violet blue when ferrous ammonium sulphate was added drop wise with shaking. At the end point the colour becomes sharp green.

Calculation :

$$\text{Percentage of oxidizable organic carbon} = \frac{\text{Blank titre} - \text{Actual titre} \times 0.3 \times M}{\text{Weight of soil}} = \ \%$$

where 'M' is the concentration of ferrous ammonium sulphate solution.

The percentage of organic carbon was converted to total organic carbon by multiplying with the factor 1.33 and to percentage organic matter by multiplying with the factor 2.

2.2.2 Carbohydrate

Carbohydrate was analysed by Anthrone method (Roe, 1955).

Procedure : To 2 g of dry sediment, 10 ml of 15% TCA was added and kept for one hour after which it was filtered. 0.5 ml of the filtrate was taken and made upto 2 ml and 4 ml of anthrone solution was added. The mixture was heated in boiling water bath for 10-15 minutes and cooled in the dark for half an hour. The blue colour developed was measured at 620 nm. Glucose (100 mg in 100 ml) was used as standard. The concentration of carbohydrate was calculated from a standard graph and expressed in µg/g.

2.2.3 Nitrogen

Nitrogen was estimated by kjeldahl method as followed by Tanaka (1958a).

Procedure : One gram of sample was taken in a digestion flask, 10 g of potassium sulphate, 0.7 g mercuric oxide and 20 ml sulphuric acid were added. The flask was heated gently at an inclined angle until frothing subsided and a clear solution was obtained. Boiling was continued for an additional half hour. If frothing is excessive, a small amount of paraffin wax can be added.

On cooling, about 90 ml of distilled water was added and

recooled, then 25 ml of sulphide solution was added and mixed. A small piece of boiling chip was put to prevent bumping. 80 ml of sodium hydroxide solution was added while tilting the flask so that two layers were formed. The digestion flask was connected to the condensor unit, heated, the distilled ammonia was collected in 50 ml boric acid indicator solution. 50 ml of the distillate was collected after which, the receiver was removed and titrated against standard acid solution.

Calculation

$$\text{Percentage of nitrogen content of sample} = \frac{\text{ml. of acid} \times \text{normality of standard acid} \times 0.014 \times 100}{\text{Weight of sample (g)}} = \%$$

Percentage of Protein content = Nitrogen content x 6.25.

2.3 Size frequency distribution

The frequency distribution study was made to find out the growth of *H. (M.) scabra* using length was determined. The relationship between the characters considered as independent variables were computed by regression and correlation analyses. (Snedecor & Cochran, 1967).

2.4 Reproductive cycle

The gonads were preserved in 10% neutral buffered formalin for macroscopical and microscopical examination. The macroscopic observation was based on the form, colour and consistency of the gonad. Five maturity stages were recognised and classified accordingly by Krishnaswamy and Krishnan (1967). Earlier, Krishnaswamy and Krishnan (1967) recognised four stages of maturity in *H. (N.) scabra viz.* immature, mature, gravid and spent. In the present work mature stage has been divided into early mature and late mature to demarkate the stages more preciously, thereby making a total of five stages. In the case of females, the oocyte diameter was measured by means of an ocular micrometer, in order to establish their frequency distribution. These approaches permitted five stages of maturity to be defined for the present species.

For histological studies, standard methods were followed (Clark, 1981). A piece of gonad was fixed in Bouin's fluid and neutral buffered formalin at 10% dilution. Sections of 6 μ thickness were cut and stained with Delafield's hematoxylin and Mallory's Triple Stain (MTS).

2.4.1 Gonad Index

The gonad index (GI) was expressed as the ratio of gonad

weight to drained weight. The mean value was calculated for each sample and the standard deviation was computed (Conand, 1981). The gonad index was correlated with monthly sea water temperature and salinity recorded from Tuticorin coast. A relationship was established between the total length, total weight, gonad weight, gutted weight and maturity stages.

2.4.2 Size at first maturity

The size at first maturity is an important factor for stock management. The method followed was that described by Conand (1981). The percentage of individuals in maturity stages III, IV and V were recorded in size classes of total weight (TW) and gutted weight (GW) using the entire sample. Samples with stage I and II were excluded since the number of indeterminate individuals were found to be maximum at this time. The classes at which 0% to 100% of the individuals matured were determined on the curve. The point on the curve at which 50% of size classes are sexually matured (TW 50) may be taken as an index of size at first sexual maturity. This method assumes that the population consists of a single age class or that in a population containing several age classes, the older animals at stage III, IV and V will be larger than those attaining sexual maturity for the first time. The total length, total weight and gutted weight at first

maturity were calculated from the regression equation.

2.4.3 Fecundity

Fecundity was estimated by taking a weighed piece of mature ovary, counting the mature ova present therein and computing them to the total weight of the ovaries. Fecundity was related to total length, total weight and weight of gonad by logarithmic regression equation.

2.5. Burrowing Behaviour

Burrowing behaviour of *H. (M.) scabra* was studied in round bottom plastic troughs (25 cm height, 60 cm diameter and 50 liter capacity). *H. (M.) scabra* ranging in size from 20 - 24 cm previously acclimatized to laboratory conditions were introduced into these troughs containing 50 - 60 mm thick layer of beach sand and filtered sea water filled to capacity. The behaviour of the animals was observed till they had burrowed completely and this observation was repeated three times.

A similar experimental set up was used to study the influence of light on burrowing behaviour. The holothurian *H. (M.) scabra* was exposed to different light conditions *viz.* 12 hour light and 12 hour dark, 24 hour light and 24 hour dark. Three holothurians were introduced at 0900 A.M in each trough and

observation made at three hourly intervals for 48 hours. Both buried and semiburied specimens were considered as buried. During the dark hours, troughs with black cloth and for light, artificial light (400 - 500 lux) was provided. The experiment was conducted in triplicates.

2.6 Locomotion

Locomotion was observed in the aquaria (100 litre) containing 50 - 60 mm thick sand layer at the bottom.

2.7 Fishery

The holothurian landings were observed from Rameshwaram to Mallipattinam along the Palk Bay coast and from Pamban to Tuticorin along the Gulf of Mannar coast in the southeast coast of India. Five centres *viz.* Tirupalakudi, Rameswaram, Vedalai. Kilakarai and Tuticorin were selected for studying aspects of the fishery.

Holothurians are fished round the year. Along the Palk Bay coast, fishing is conducted from March to October and along the Gulf of Mannar from October to March. Observations on the particulars of the Catch Per Unit Effort were made by observing the number of specimens collected per unit per day.

The fishing of holothurians is carried out by skin divers at a depth of 4-20 m, by using a net bag in which the holothurians are stored and brought to the shore. In recent years, aluminium plates are used for the feet as improvised flippers to give greater utility for the skin divers. Tallu valai operation at a depth of 4-8 m also collected this specimen. The same specimen is also encountered as bycatch in bottom trawlers. The catch recorded by operating different gears, total landings in the respective centres and the method of processing of *beche-de-mer* are discussed in detail in the respective chapters.

PART I.

BIOLOGY

CHAPTER 3

DISTRIBUTION IN THE INDIAN WATERS

Holothuria (M.) scabra is widely distributed in the Indo-West Pacific region. It is known from the Mascarene Islands, East coast of Africa, Red sea, Southeast coast of Arabia, Sri Lanka, Bay of Bengal, East Indies, North Australia, Phillippines, China and Southern Japan and South-Pacific Islands (Clark and Rowe, 1971).It is a shallow water species found mainly in 2-10 m depth in slightly low saline areas and is commonly found on coral sand with muddy substratum (Sachithananthan, 1972).

In the seas around India, it is well known from the Gulf of Mannar and Palk Bay, where it forms a fishery. *H. (M.) scabra* has been recorded by Graveley (1927), James (1969, 1973, 1976, 1986 a&b, 1988, 1989) and Satyamurti (1976) from the Gulf of Mannar and Palk Bay. In the Andaman and Nicobar Islands, it has been reported by Bell (1887), Daniel and Haldar (1974), James (1983, 1986 a, 1987, 1989), Sooto *et al.*(1983) and Tikader and Das (1985). On the west coast of India, it is recorded from Bedi Port (Gulf of Kutch) by James (1969) and from Malvam by Parulekar (1981). *Holothuria ocellata* reported by Gopalkrishnan (1969) from the Gulf of Kutch appears to be based on *H. (M.)*

scabra. The locality labels seems to have been mixed up for the species named as *H. (M.) scabra* in the British museum from Maldives and the species is totally absent in the Lakshadweep. In Sri Lanka, it is reported by Ludwig (1887), Pearson (1913), Elanganayagam (1983), James (1986b), Elanganayagam *et al.* (1988).

H. (M.) scabra was found to occur at Pamban, Mandapam, Vedalai, Pudumadum, Periapattinam, Kilakarai, Ervadi and Tuticorin along the Gulf of Mannar coast. Along the Palk Bay, this species was noted at Rameswaram, Mandapam, Devipattinam, Tirupalakudi, Karangadu, Mullimunai, Tondi, Pasipattinam, Kottaipattinam, Manamelkudi, Kattumavadi, Sethubavachattram and Mallipattinam (Fig.1).

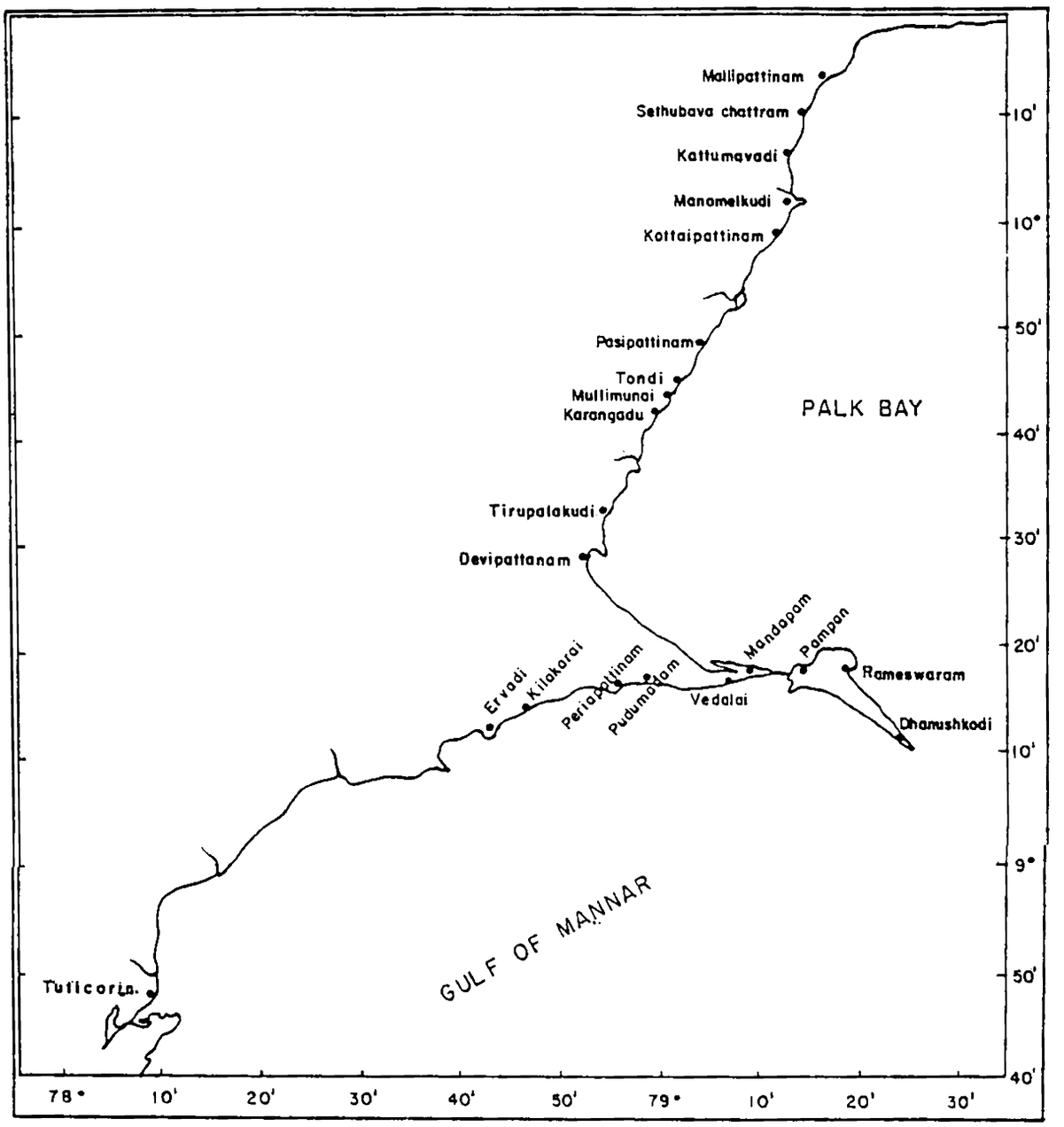


Fig. 1. Distribution of *H. (M.) scabra* along the Gulf of Mannar and Palk Bay Coasts.

CHAPTER 4

FOOD AND FEEDING HABITS

The aspidochirote holothurians shovel the surrounding substrate into their mouth by means of oral tentacles. The organic nutrients *viz.* organic carbon, organic matter, carbohydrate and protein available in the substrate are absorbed by the epithelial walls of the stomach as the food material passes down from oesophagus to intestine. The semidigested mass available in the intestine is eliminated as faeces in the form of pellets. Not much is known about the particle size of the substratum fed upon by holothurians as well as the biochemical constituents *viz.* carbohydrate, protein, organic carbon etc. available in both the substrate as well as in different regions of the digestive tract. There is also a lack of information regarding the feeding behaviour and feeding intensity in the holothurian *H. (M.) scabra.*

4.1 Digestive system

The digestive system of *H. (M.) scabra* consists of mouth located at the anterior end which is surrounded by a circlet of tentacles. Mouth leads into an oesophagus which occupies the centre of aquapharyngeal bulb. It is attached to the calcareous ring by a number of radiating bands of connective

tissue. The oesophagus leads into a yellowish coloured region called stomach. The intestine is looped within the coelom and arranged in descending and ascending order which runs towards the posterior end along the mid dorsal region. Then the intestine bends anteriorly along the left side of the intestine, runs along the mid dorsal region directly backward to the anus.

4.2 Results

4.2.1 Qualitative and Quantitative analysis

Analysis of the gut contents of *H. (M.) scabra* revealed the presence of fine mud, sand particles, shell debris, molluscan shells and algae.

Percentage contribution of different sized particles in the gut revealed a maximum and minimum during different months of the year. The <90 μ particles were maximum during March 1988 (6.8%) and minimum during July 1988 (0.7%). Similarly, the 90-125 μ particles were abundant during October 1988 (11.7%) and minimum in July 1988 (2.4%). The 125-250 μ particles showed a maximum in April 1988 (23.5%) and a minimum during July 1988 (9.8%), and particle range of 250-500 μ was abundant during August 1988 (47.8%) and minimum during June 1988 (32.2%). Like wise, the particle range of 500-710 μ was maximum in June 1988 (19.2%) and

minimum in April 1988 and February 1989 (6.1%). The range of particle size from 710-1003 μ was more in July 1988 (21.1%) while minimum was recorded in April 1988 (10%). The range of particle size from 1003-1680 μ was dominant in November 1988 (10.7%), while a minimum was seen in April 1988 (3.3%). The particles 1680 < μ were found maximum during November 1988 (6.6%) and minimum during April 1988 (1.3%). The same results were also observed during the year 1989-1990, with slight fluctuations in the percentage occurrence of different particle sizes.

From Table 1 and Figs. 2 & 3 it is clear that the percentage of particle sizes ranging from 250-500 μ were dominant in all the months as compared to particle sizes ranging from 125-250 μ and 710-1003 μ which were observed less frequently.

4.2.2 Particle size in relation to the size of holothurian

Details of the percentage occurrence of different particle sizes in the digestive tract of *H. (M.) scabra* in the different size groups during March 1988 to February 1990 are presented in Tables 2 & 3. It can be seen from the table 2 that during 1988-1989 the particle size ranging from 250-500 μ formed the dominant particle size of the food in all the size groups of holothurians (15-32 cm). During 1989-1990, 49.79% was dominant in the size range of 30-31 cm and 58.89% was recorded in 17-18 cm size (Table 3).

Table 1. Percentage occurrence of different particle sizes in the gut contents of *H. (M.) scabra* (March 1988 - February 1990)

	% of particle size (μ)							
Month	< 90	90-125	125-250	250-500	500-710	710-1003	1003-1680	1680 <
March'88	6.80	9.60	16.90	38.40	7.20	12.30	5.20	3.60
April	3.90	9.90	23.50	40.70	6.10	10.00	3.30	2.60
May	2.88	5.70	14.30	34.50	12.60	16.80	7.80	5.40
June	1.70	3.40	11.00	32.20	19.20	18.60	9.30	4.70
July	0.70	2.40	9.80	40.30	13.30	21.10	6.80	5.60
August	0.80	3.10	13.80	47.80	10.20	15.00	5.80	3.70
September	3.00	3.50	10.30	45.90	10.50	13.90	7.90	5.00
October	2.90	11.70	16.90	41.20	8.90	13.70	3.40	1.30
November	1.60	5.10	13.00	39.10	8.20	15.70	10.70	6.60
December	3.00	5.30	16.80	36.60	12.10	14.80	6.80	4.60
January'89	2.00	3.80	10.20	34.20	17.90	18.30	9.10	4.50
February	3.30	4.70	19.80	43.50	6.10	11.10	6.20	5.30
March	7.10	9.00	16.70	37.80	8.20	12.20	5.10	3.90
April	4.10	10.30	24.50	40.20	5.80	9.20	3.20	2.70
May	2.76	5.44	14.60	32.20	14.40	18.11	7.60	4.80
June	1.77	2.54	7.19	31.27	22.53	19.75	9.94	5.01
July	0.70	2.50	9.80	40.00	13.30	21.10	6.90	5.70
August	0.80	3.20	14.20	47.20	10.00	14.90	5.90	3.80
September	3.10	3.50	10.50	45.60	10.30	14.00	8.00	5.00
October	3.20	11.80	16.90	40.90	8.90	13.60	3.50	1.20
November	1.30	4.50	12.30	38.60	8.40	16.40	10.80	7.70
December	3.00	5.30	16.90	36.20	12.40	14.60	6.80	4.80
January'90	2.30	3.90	9.60	33.80	18.30	18.40	9.20	4.60
February	3.30	4.90	19.60	43.40	6.30	11.20	6.20	5.10

Fig. 2.

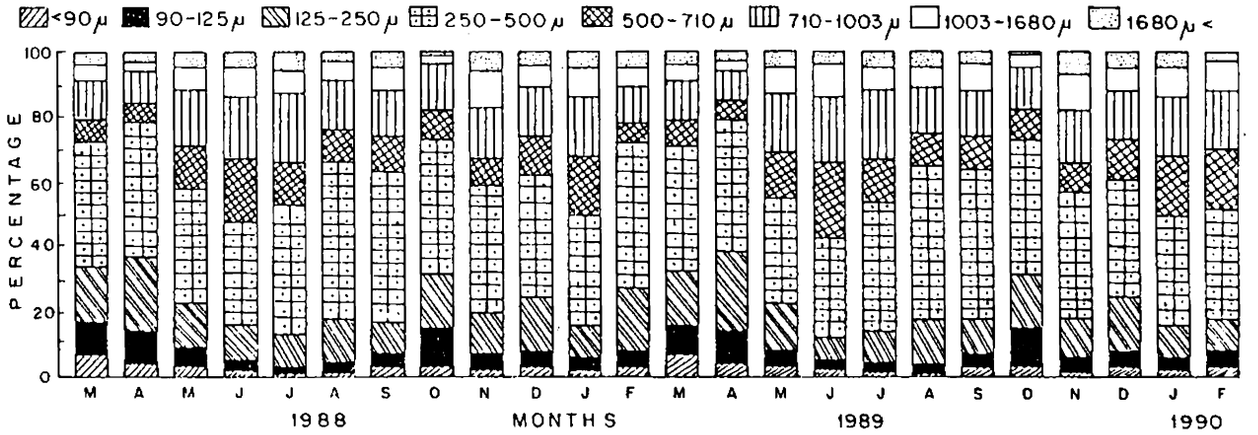


Fig. 2. Percentage of different particle sizes in the gut contents of *H. (M.) scabra* (March 1988 to February 1990).

Fig. 3.

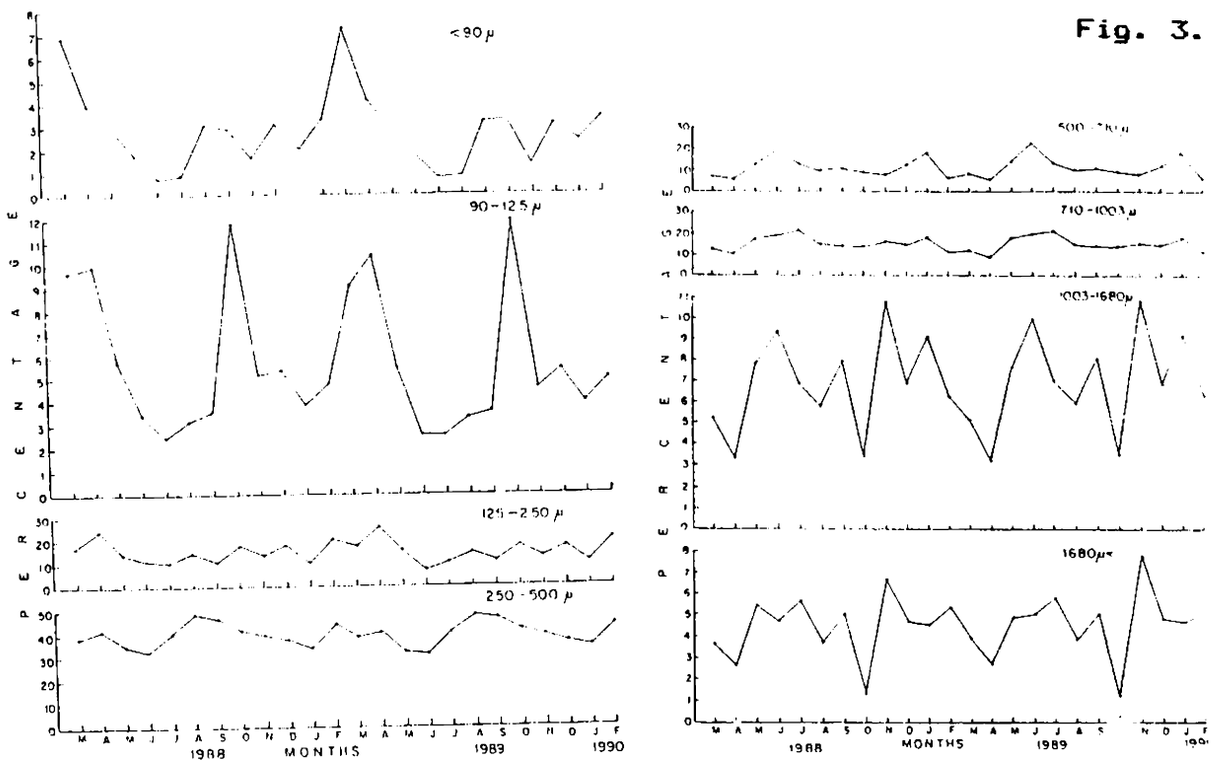


Fig. 3. Month-wise occurrence of different grade food particles (%) in the gut contents of *H. (M.) scabra* (March 1988 to February 1990).

Table 2. Percentage occurrence of different particle sizes in various size groups of *H. (M.) scabra* (March 1988 - February 1989)

Size group (cm)	% of particle size (μ)							
	< 90	90-125	125-250	250-500	500-710	710-1003	1003-1680	1680 <
15-16	9.35	16.25	23.38	21.80	7.79	13.45	4.94	3.05
16-17	3.15	8.67	14.73	34.57	12.92	14.08	7.81	4.07
17-18	2.72	9.92	19.37	36.60	7.37	15.80	6.66	1.56
18-19	2.50	8.70	22.00	38.20	5.60	15.30	6.40	1.30
19-20	2.00	6.83	16.98	36.49	12.11	15.15	6.61	3.84
20-21	3.25	6.13	12.65	40.06	10.78	14.30	7.56	5.27
21-22	5.02	5.37	20.48	41.98	10.71	13.90	5.39	2.86
22-23	3.67	4.16	13.89	39.63	12.56	28.93	9.92	7.97
23-24	1.83	4.27	18.47	39.81	11.22	12.25	7.42	4.73
24-25	1.39	3.40	11.24	39.86	12.60	18.77	7.51	5.23
25-26	2.97	6.70	12.64	41.46	9.71	16.13	6.57	3.83
26-27	2.04	3.19	10.24	35.03	12.84	19.41	9.67	7.57
27-28	2.81	4.41	11.96	27.31	18.88	20.82	8.72	5.09
28-29	1.59	1.24	6.02	21.08	8.49	21.72	17.07	22.80
29-30	2.90	2.70	9.70	34.00	20.30	22.60	6.20	1.60
30-31	3.69	7.74	24.96	49.91	5.31	6.12	1.86	0.41
31-32	2.20	7.60	28.20	41.60	6.60	9.20	2.80	1.80
32-33	2.30	6.55	30.29	47.14	3.67	6.67	1.84	1.54

Table 3. Percentage occurrence of different particle sizes in various size groups of *H. (M.) scabra* (March 1989 - February 1990)

Size group (cm)	% of particle size (μ)							
	< 90	90-125	125-250	250-500	500-710	710-1003	1003-1680	1680 <
16-17	2.33	6.17	10.73	39.20	11.95	14.01	9.52	6.10
17-18	1.26	3.37	17.00	58.89	3.30	7.05	4.76	4.38
18-19	2.30	9.20	21.00	35.80	8.40	16.00	5.30	2.00
19-20	2.65	5.38	15.99	41.77	10.72	14.98	5.46	3.04
20-21	3.98	7.62	16.77	38.12	9.64	13.59	6.06	4.21
21-22	3.10	6.12	14.01	43.05	11.15	13.76	5.95	3.23
22-23	2.22	4.57	14.55	42.95	11.08	16.35	9.48	4.67
23-24	2.26	4.59	14.34	41.77	11.50	14.41	7.05	4.07
24-25	1.51	3.30	9.64	42.99	12.68	19.10	7.13	3.66
25-26	1.88	3.14	12.21	34.09	12.05	17.56	9.60	9.49
26-27	1.35	2.33	7.80	35.81	13.99	17.85	9.97	10.91
27-28	1.37	5.70	10.49	28.78	19.46	21.39	7.62	5.19
28-29	0.36	1.97	5.84	45.27	13.24	23.74	6.42	3.15
29-30	0.82	3.05	9.10	24.61	19.12	31.02	7.89	4.37
30-31	1.89	5.91	24.31	49.79	5.10	8.14	2.60	2.25
31-32	1.82	5.83	25.25	50.30	4.28	17.84	2.42	2.26
32-33	1.62	2.43	21.32	44.08	7.86	12.99	5.47	4.24

The particle sizes below 90 μ and between 90-125 μ constituted 9.35% and 16.25% respectively during 1988-1989 in the 15-16 cm size holothurians. During 1989-1990, the <90 μ and 90-125 μ sizes formed 3.98% and 9.2% in the 20-21 cm and 18-19 cm size holothurians resp

The size of the anging from 125-250 μ were found maximum (30.29%) in roup of 32-33 cm during 1988-1989 while 25.25% was observed in the 31-32 cm size group of holothurian during 1989-1990. Particles size ranging from 500-710 μ were observed more frequently (20.30%) in size group of 29-30 cm during 1988-1989 while 19.46% were recorded in the size of 27-28 cm during 1989-1990. The percentage of particles ranging from 710-1003 μ were abundant in the 22-23 cm size group which constituted 28.93% in 1988-1989. However, this particle range constituted 31.02% in the size group of 29-30 cm during 1989-1990. The particle sizes ranging from 1003-1680 μ and above were recorded maximum in the size group of 28-29 cm constituting 17.07% and 22.80% respectively during 1988-1989, whereas 9.97% and 10.91% were found in the size group of 26-27 cm during 1989-1990.

The data for the two years March 1988 to February 1990 presented in Tables 2 & 3 showed that there was no significant preference in particle sizes in holothurian of different size

groups.

4.2.3 Condition of feed

The percentage occurrence of the categories of the intensity of feeding in the holothurian *H. (M.) scabra* are presented in figures 4 & 5.

Feeding activity among holothurians showed monthly variations. During March 1988 to February 1989, the holothurians fed actively during March to June, September, October to January 89. During the rest of the months, feeding was comparatively poor. In the subsequent year (March 1989 to February 1990) the holothurians fed actively from April to February 1990, while, feeding was poor during March 1989.

4.2.4 Relationship between length of animal and length of gut

Studies were undertaken to establish any possible correlations existing between the total length and the total weight of the holothurians with that of digestive tract. The details are presented in Table 4.

From Table 4, it is clear that there was no significant relationship between the total length of the holothurian and the length of the digestive tract. With an increase in length of the

Fig. 4. Percentage occurrence of the stomachs of *R. (M.) scabra* in various degree of fullness (March 1988 to February 1989).

Fig. 5. Percentage occurrence of the stomachs of *R. (M.) scabra* in various degree of fullness (March 1989 to February 1990).

Fig. 4.

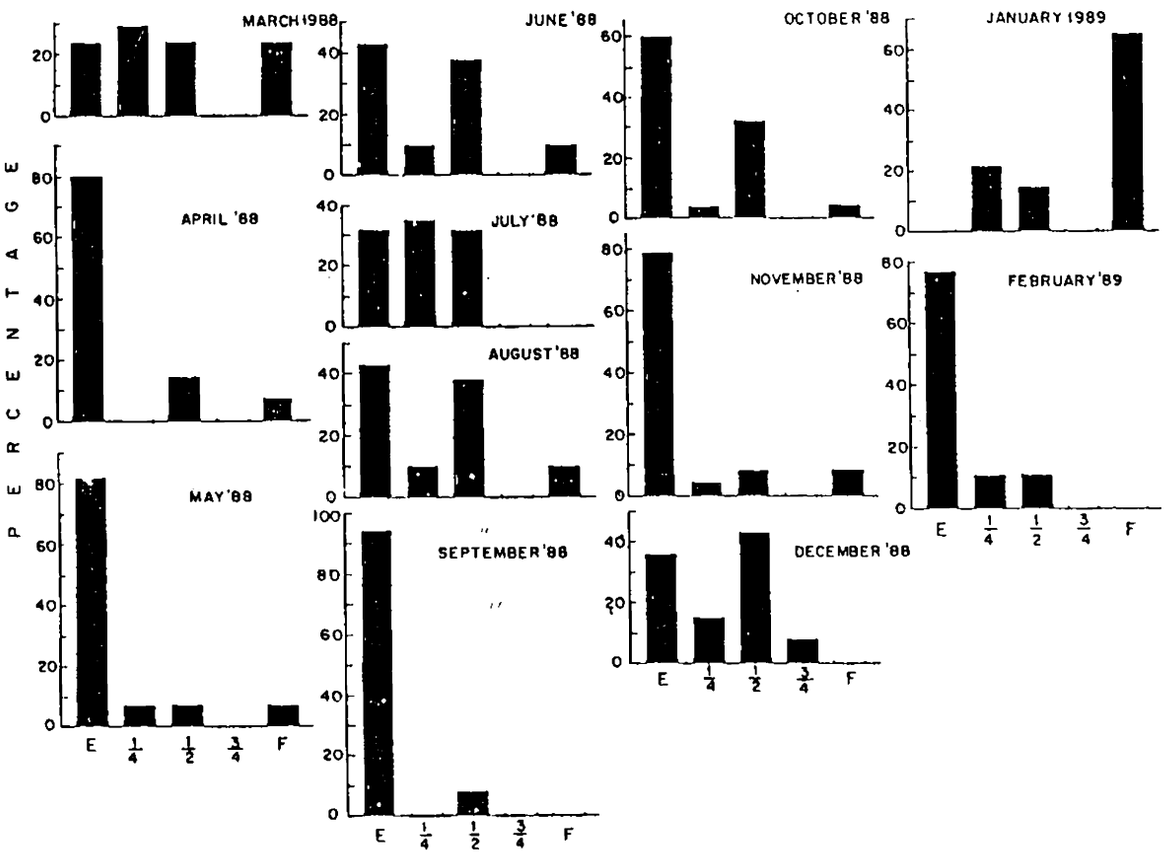

PERCENTAGE
MARCH 1988
APRIL '88
MAY '88
JUNE '88
JULY '88
AUGUST '88
SEPTEMBER '88
OCTOBER '88
NOVEMBER '88
DECEMBER '88
JANUARY 1989
FEBRUARY '89
E
1/4
1/2
3/4
F

Fig. 5.

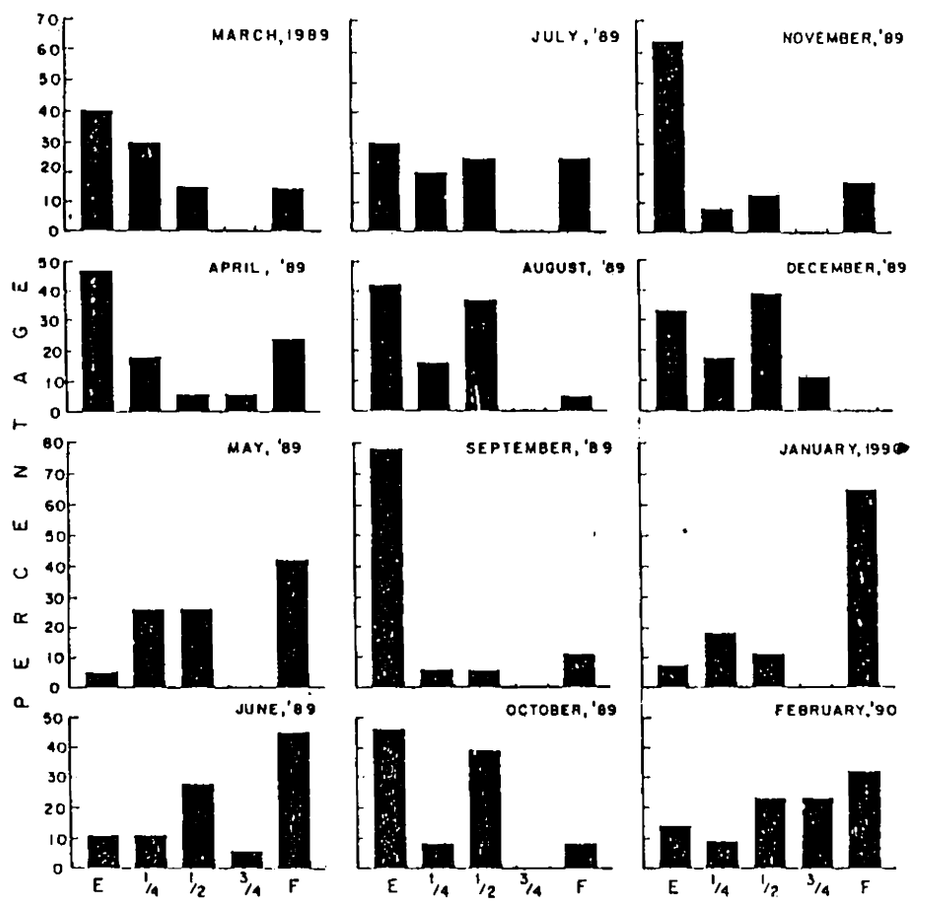

PERCENTAGE
MARCH, 1989
APRIL, '89
MAY, '89
JUNE, '89
JULY, '89
AUGUST, '89
SEPTEMBER, '89
OCTOBER, '89
NOVEMBER, '89
DECEMBER, '89
JANUARY, 1990
FEBRUARY, '90
E
1/4
1/2
3/4
F

Table 4. Correlation between the length and weight of *H. (M.) scabra* to that of the digestive tract.

Parameters	df	a	b	r	
Total length of the holothurian X length of the digestive tract	206	-36.289	2.944	0.42	NS
Total length of the holothurian X Wet weight of the digestive tract	206	-21.657	0.275	0.13	NS
Total weight of the holothurian X Wet weight of the digestive tract	206	19.822	0.058	0.13	NS

NS=non significant, df=degrees of freedom, a=constant, b=regression coefficient, r=correlation coefficient

individual there was a concomitant increase in the length of the digestive tract which was not significant. No relationship could be established between total length, total weight and wet weight of the digestive tracts.

4.3 Discussion

The present investigation indicated that *H. (H.) scabra* feeds on the organic content found along with the fine particles of mud, sand, shell debris, molluscan shells and algae. Similar results were observed by Bakus (1973) and Lawrence (1979). A few tropical species reportedly feed on plankton, organic matter on rocks, minute crustaceans and polychaetes (Bakus, 1973). A critical examination on feeding suggests that an array of food items may be typical to a number of tropical holothurians. These comprise of sand, shell, calcareous (coral) fragments, plant debris settled at the bottom, living and dead filamentous blue-green algae and diatoms, red algae *Halimeda* , fragments of sea urchin spines, holothurian ossicles, copepod exuvia, fish eggs, fish teeth and detritus (Bakus, 1968). Bacteria and foraminifera may be the major source of food for holothurians (Bakus, 1968). Jorgensen (1966) reported that bacteria are usually abundant when associated with detritus and may occur in highest concentrations in tropical waters. Choe (1963) briefly explained that the young individuals of *Stichopus japonicus* feed on microalgae and

detritus.

Lawrence (1979) analysed the gut contents of *H. atra*, *H. leucospilota* and *H. hilla* and reported the presence of particles ranging in size from sand to large particles along with organic debris. The gut of *H. difficilis* contained small particulate matter and organic debris, that of *Stichopus chloronotus* contained sand, and that of *Actinopyga mauritiana* contained very fine organic matter and particles of smaller size. The gut of *Afrocucumis africana* revealed small inorganic and organic particulate matter (Lawrence, 1979). Roberts (1979) reported that the deposit feeding holothurian utilizes surface sediments, found on sandy bottom, sea grass *Padina* in coral rubble. The sub surface sediments were used by *Bohadschia bivittata*, the only holothurians which burrow. Khripounoff and Sibuet (1980), in their study recorded the presence of nanoplankton, foraminiferans, bivalve, crustaceans, diatoms, radiolarians, nematodes, copepods, polychaetes and vegetable fragments in the gut contents of the deep water deposit feeding holothurians. James (1986c) reported fine mud in the intestine of *Phyrella fargilis* from Port Blair even though it lives among coarse sand. This shows that the holothurian rejects all sand particles while feeding. Tyler *et al.* (1987) have also mentioned the occurrence of sand grains, planktonic foraminifera, centric

diatoms and both scale and cyst like materials.

Quantitatively, *H. (M.) scabra* consumes particles of size ranging from 250-500 μ in diameter. The gut content indicating that the holothurian prefers the particles size of < 500 μ which constituted 62.15%. The present finding is closely related to the findings of Sloan and Von Bodungen (1980) who reported that particles of < 140 μ grain size formed 59.09% of the gut content of the holothurian, *Isostichopus badionotus*. Bakus (1968) reported in *H. difficilis* that 80% of particles are < 250 μ in diameter and the remaining comprise of calcareous fragments measuring upto 2 mm; *H. atra* feeds mainly on coral rubble measuring upto 2 cm. Glynn (1965) found that *Astichopus multifidus* feeds on 212 μ median sized fine grained calcareous fragments. Hauksson (1979) commented that *Stichopus tremulus*, selectively ingests coarser material (200-300 μ) from ambient sediments. Towonsley and Towonsley (1973) reported that *S. chloronotus* rejects particles (> 1 mm diameter) in favour of particles around 0.25 mm diameter. Roberts (1979) reported the mean particle size preference of 350 and 400 μ in *H. atra* and *Bohadschia bivittata* respectively. Roberts and Bryce (1982) mentioned that both *H. cinerascens, H. impatiens* selects the grain size of 125-250 μ; *H. edulis* prefer the particle size of 63-125 μ and the grain sizes 2000-3500 μ were preferred by *H.*

nobilis, *H. hartmeyeir* and *H. pervicax*.

From the above analysis, it was found that there was no significant difference between food items and grain size preference between small and large specimens of *H. (M.) scabra*. This confirms that *H. (M.) scabra* is a non-selective deposit feeder which engulfs the surrounding substrates into the mouth by means of oral tentacles and eliminates the semidigested waste as faecal pellets. The occurrence of particle size < 500 μ in large numbers indicated that *H. (M.) scabra* prefers muddy-sandy substratum. In the present study, no relationship could be established between the body size and particle size of food. Of *H. (M.) scabra* which agrees with the results obtained by Glynn (1965) and Lawrence (1979). However, Bakus (1973) reported a very high positive correlation between the body size and particle size in *Holothuria difficilis*. The reason might be due to habitat selection and the sediments ingested by the holothurians of different body sizes. The size of food particles in holothurians varies from species to species as well as the locality (Bakus, 1973). Choe (1963) did not observe any relationship between the particle size and the size of the holothurian, *Stichopus japonicus* a non-selective deposit feeder. Sloan and Von Bodungen (1980) also found no evidence of particle size selection by *Isostichopus badionotus* over a limited size

range of individuals. Similar observations were made by Yamanouchi (1939) for *H. atra* and *Stichopus variegatus*.

During the course of gut content analysis in *H. (M.) scabra* showed that during spawning season the holothurian fed actively. But, Fish (1967) reported that in *Cucumaria elongata* the individuals remained dormant from October to late April and the feeding behaviour was seasonal.

No significant relationship could however be established between the total length of the holothurian and the length of the digestive tract in the present study.

CHAPTER 5

BIOCHEMICAL ANALYSIS OF NUTRIENTS IN GUT CONTENTS

The holothurian feeds on the organic detritus available in the natural bed. The information on the biochemical constitutents and their assimilation efficiency from different regions of the digestive tract in *H. (M.) scabra* is lacking. So, an attempt has been made to analyse the organic nutrients such as total organic carbon, carbohydrate, protein and the inorganic nutrient - nitrogen from the oesophagus, stomach and intestine of the digestice tract as well as from the sediments where they live. The percentage of assimilation efficiency from sediment to faeces and oesophagus to faeces are discussed.

5.1 Results

5.1.1 Total organic carbon

The total organic carbon analysed from the sediments of the different regions of the digestive tract *viz.* oesophagus, stomach and intestine were 1.32 $\pm$ 0.07, 1.45 $\pm$ 0.07 and 1.10 $\pm$ 0.04% respectively while the sediments collected from the natural bed contained 1.58%. The organic matter examined from the digestive tracts were 2.63 $\pm$ 0.13 in oesophagus, 2.90 $\pm$ 0.14 in stomach and 2.20 $\pm$ 0.06% in intestine and 2.38% in the sediments. A

comparison of the total organic carbon and organic matter assimilated from the sediment to the faecal pellets was 30.38% and 7.56% while the assimilation efficiency from oesophagus to faeces was 16.29%.

5.1.2 Carbohydrate

The carbohydrate available in the sediments was 0.340 µg/mg. The carbohydrate content in different regions of the digestive tract was found to be 0.340 µg/mg in oesophagus, 0.297 µg/mg in stomach and 0.277 µg/mg in intestine. The assimilation efficiency of carbohydrate from sediment to faeces was 26.53% and oesophagus to faeces was 18.35%.

5.1.3 Nitrogen

The total nitrogen estimated in the sediments of the oesophagus, stomach and intestine was 2.09 ± 0.06, 2.08 ± 0.06 and 1.41 ± 0.21 % respectively, and the protein 13.04 ± 0.37, 13.0 ± 0.38 and 8.84 ± 1.33% respectively. The nitrogen content of the sediment was 1.81% while protein was 11.30%. The assimilation efficiency for nitrogen from the sediment to faeces was 21.75% and for protein 21.77%, from oesophagus to faeces 32.41% efficiency was recorded.

5.2 Discussion

H. (M.) scabra was found to utilize 16.29% of organic carbon and 7.56% of organic matter present in bottom sediments. Yingst (1976) reported an assimilation efficiency of 22% for organic carbon utilized by *Parastichopus parvimensis* while *Stichopus tremulus* assimilated 6-51% of organic carbon from sediments, with a mean of 27% (Hauksson, 1979). An assimilation efficiency of 40 $\pm$ 15 % for the utilization of organic matter by *H. difficilis* and 50% assimilation efficiency for organic carbon and nitrogen have been recorded (Bakus 1968, 1973). Hammond (1981) showed an average of 39% efficiency in three holothuroid species which was in agreement with the value of Bakus (1973). Glynn (1965) recorded that *Astichopus multifidus* consumes sediments containing only 0.7% organic matter. Choe (1963) reported 51-57% of organic carbon digested by *Stichopus japonicus*. Moriarty (1982) pointed out that on an average, organic carbon levels 16-34% more in the foregut than in the sediment and suggested 10% of the carbon requirements in *H. atra*.

The comparative analysis of total organic matter, total nitrogen and total organic carbon in the surrounding sediment and in the sediment of the foregut of some holothurians, pointed out that concentrations were higher in the foregut (Tanaka, 1958a; Webb *et al.*, 1977 and Moriarty, 1978).

The assimilation efficiency of nitrogen and protein utilised by *H. (M.) scabra* from the sediments were 21.75% and 21.77% respectively. Khripounoff and Sibuet (1980) observed 22% efficiency in holothurians. Massin (1979) noted 27% efficiency of intestinal absorption in *Holothuria tubulosa*. Tanaka (1958a) reported nitrogen assimilation to be approximately 50% while Moriarty (1982) reported a value of 40%. For carbohydrate, 26.53% efficiency was observed from sediments and 18.53% from oesophagus to faeces.

From the above, it is clear that the concentration of organic carbon and nitrogen was generally higher in the foregut contents than in the sediments or hindgut contents. Also, the same was confirmed by Moriarty (1982). The differences in efficiencies between the holothurians, may have been due to variation in the fractions of organic matter available in the environment as well as the particle sizes ingested by the holothurians.

To conclude, holothurians absorb only limited quantity of organic nutrients and eliminate the rest as semidigested faecal pellets. The findings of the present study on *H. (M.) scabra* also relate well with the findings of Massin (1979).

CHAPTER 6

LENGTH - WEIGHT RELATIONSHIP

The length-weight relationship of holothurian is calculated primarily with a two fold aim. Firstly, to determine the mathematical relationship between the two variables, length and weight, so that if one is known the other can be computed. Secondly, to measure the variations from the expected weight for length of individual holothurians. Moreover, it also helps in establishing the yield. Very few investigators have attempted work on holothurians (Conand, 1981, 1982, 1986, 1990; Choe, 1963; Lawrence, 1979; Tyler *et al.*,1987). So, in view of practical utility, an attempt has been made to determine the length-weight relationship of *H. (M.) scabra* and the details are presented below.

Numerous inaccuracies occur while measuring a holothurian. Total length (TL) is difficult to determine because of the contraction and expansion of the body wall while, total weight (TW) varies depending on the amount of coelomic fluid and of sediment in the digestive tract. The gutted weight (GW) is taken in grams for each specimen.

For the present study, a total of 272 holothurians in

indeterminate stage were collected during March 1988 to February 1990. During March 1988 to February 1989, 149 females (16-33 cm) and 114 males (15-33 cm) were collected. Apart from this 136 females (21-33 cm) and 113 males (17-31 cm) collected during March 1989 to February 1990, from Tuticorin were also utilized.

It is known that with increase in length of holothurians, there is a concomitant increase in weight, thereby showing that the weight of holothurians is a function of power of length. Since length is a linear measure and the weight, a measure of volume, it was generally found that, for holothurians, the relation between length and weight could be expressed the hypothetical law $W = aL^b$, where 'W' represents weight of holothurians, 'L' its length, 'a' is a constant and 'b' exponent.

On linear transformation the above equation becomes

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

$$i.e. Y = a + b X$$

where $a = \log a$; $x = \log L$; $Y = \log W$ and 'b' represents the slope of the line and it is an estimate of the rate of increase in weight and 'log a' is the origin of the fitted lines, which is a linear relation between 'Y' and 'X'. This linear equation was fitted separately for indeterminate, males and females using the data collected during the above mentioned period. The estimate

of the parameters 'a' and 'b' for each case obtained by the method of least squares.

6.1 Results and Discussion

As there was no significant variation between the years the entire data was pooled both sex-wise as well as for the indeterminate individuals for both the years. The observed relationships are:

Indeterminate $W = 11.83080926\ L^{1.0527}$ ($r = 0.79$);

Male $W = 0.212819556\ L^{2.3648}$ ($r = 0.86$);

Female $W = 0.1652021463\ L^{2.4460}$ ($r = 0.89$).

No significant relationship was found between total length, total weight and gutted weight. It can be seen from the table 5, that there was significant relation between the sexes and so the data for the two sexes was pooled. The pooled relationship between length and weight is given below. It was found to be $W = 0.1877987698\ L^{2.4049}$ ($r = 0.88$) (Fig. 6).

It was found that the exponent in length-weight relationship significantly different from 3 for both the sexes and also for the pooled relationship indicating allometric growth.

Table 5. Comparison of regression lines for males and females of *H. (M.) scabra*

Within	df	Σx^2	Σxy	Σy^2	Reg.	Deviation from regression df	SS	MS	F
Male	262	4.012237895	9.488084074	30.31329295	2.36478	261	7.876004397	0.03017626206	
Female	248	3.798730081	9.291618778	28.70675027	2.4459	247	5.979634188	0.0242090453	
						508	13.85563859	0.02727487911	(b)
Pooled	510	7.810967976	18.77970285	59.02004322	--	509	13.8680244	0.0272465668	(a)
		Difference in slope				1	0.01286385	0.01286385	(c) 0.472 NS (c/b)
Male + Female	511	7.82256472	18.81257913	59.11323543	--	510	13.87063966		
		Difference in means				1	0.00213722	0.00213722	(d) 0.166 NS (d/a)

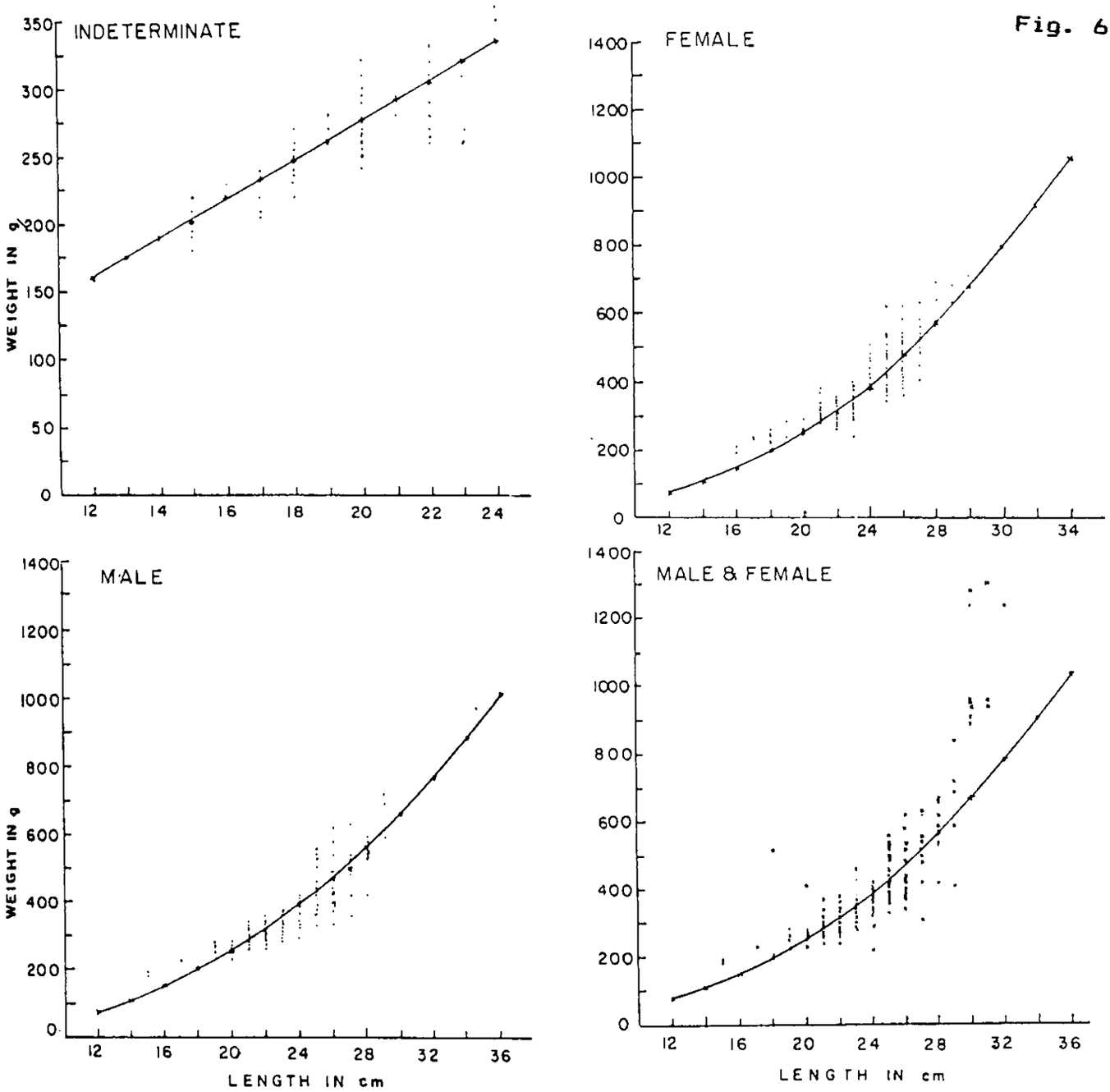


Fig. 6. Length-Weight relationship of *H. (M.) scabra*

CHAPTER 7

REPRODUCTIVE BIOLOGY

The reproductive cycle plays a major role in understanding the life history of an individual and helps to arrive at the annual regeneration of their stocks. Reproductive parameters such as size at first maturity, spawning frequency, fecundity and recruitment are of significant value in fishery predictions and formulation of management measures. Therefore, an attempt has been made to study the sexual cycle of *H. (M.) scabra* in detail, to provide first hand information regarding this species.

7.1 Reproductive system

The gonads of *H. (M.) scabra* are white in immature and yellow in mature stage, composed of a single tuft of tubules and each tubule is generally divided into three branches, attached to the left side of the dorsal mesentery and hangs freely in the coelom. The gonadial tubules are long and open into the hollow gonadial base. From the gonadial base, the gonoduct proceeds anteriorly along the mesentery and opens externally on the mid dorsal line.

Sexes are separate and no hermaphrodite individuals or any sign of asexual reproduction were noticed.

7.2 Results

7.2.1 Maturity

In order to study the maturity and ascertain the spawning season, 249 females and 263 males were examined and depending on the macroscopic and the microscopic examination of the ovary and testis, five maturity stages were recognised for the species, namely, immature, maturing, early mature, late mature and spent which were denoted as stage I, II, III, IV & V respectively.

The characteristic features of the maturity stages of *H. (H.) scabra* are as follows.

Macroscopic observations

Indeterminate stage

Immature and Maturing

Single tuft of 20-25 tubules, tubules short 1-4 cm in length without branching, partly yellow in colour (Plate II,a & b).

Male

Early mature

Gonadial tubules are elongated, 4-10 cm in length, tubules branched having small saccules increasing in size and number, yellow in colour (Plate II, c & f).

Late mature

Gonadial tubules are 10-13 cm in length, tubules with 2-3 ancillary branches, pale yellow in colour. Saccules are more elongated (Plate II, d).

Spent

Number of tubules decreased and the size reduced. Pale yellow in colour (Plate II, e).

Female

Early mature

Gonadial tubules 5-10 cm in length, yellowish red, branched with round saccules (Plate III a & d).

Late mature

Gonadial tubules with 10-12 cm in length, pale red, elongated with swollen round saccules with 2 to 3 ancillary branches (Plate III, b).

Spent

Gonadial tubules shorter and wider, pale yellow in colour (Plate III, c).

Plate II. Photographs showing the macroscopic features of different stages of gonads of *H. (M.) scabra*.

(a) Immature stage

(b) Maturing stage

(c) Male : Early mature stage

(d) Male : Late mature stage

(e) Male : Spent stage

Gt- Gonadial tubule

Go- Gonopore

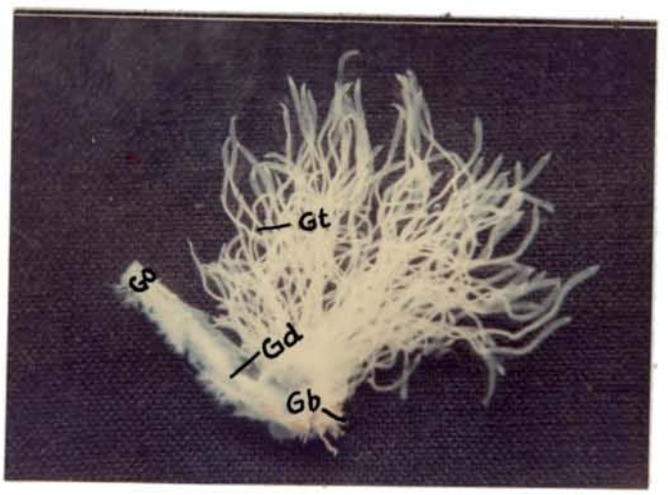
Gd- Gonoduct

Gb- Gonadial base

Sc- Saccules

(f) Male: Branching of gonadial tubule

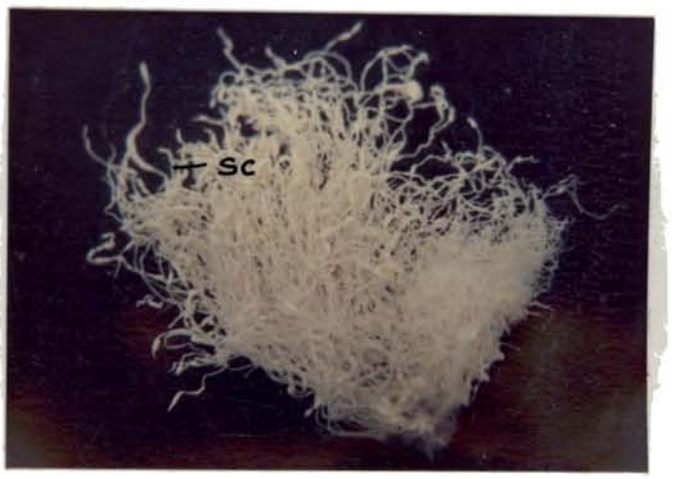
PLATE II



a

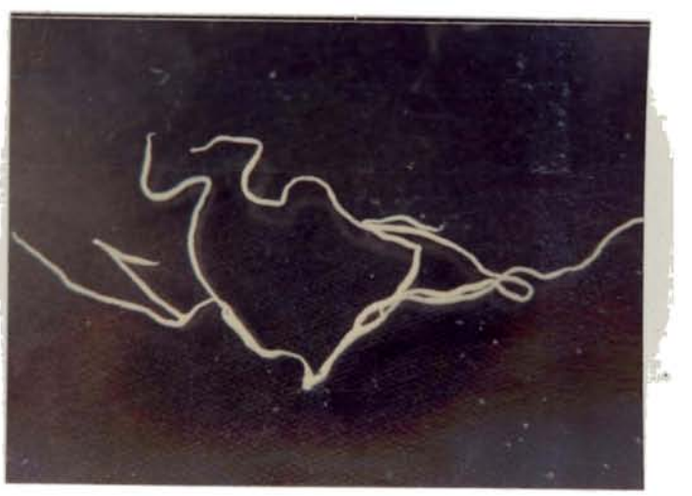
d

b



e

c



f

Plate III. Photographs showing the macroscopic features different stages of gonads of *H. (M.) scabra*.

(a) Female : Early mature stage

(b) Female : Late mature stage

(c) Female : Spent stage

(d) Female : Branching of gonadial tubule

E- Eggs

PLATE III

a

c

b

d

Microscopic observations

Indeterminate stage

Immature and Maturing

Sex indistinguished, germinal cells having the diameter of 40 μ (Plate IV, a & b).

Male

Early mature

Some spermatozoa can be seen from a portion of the tubules (Plate IV, c & d).

Late mature

Numerous spermatozoa are round, yellow in colour (Plate IV, e & f).

Spent

Yellow coloured spermatozoa are found near the margin of the gonadal wall (Plate V, a,b & c).

Female

Early mature

Oocytes are growing with box in size without modal size. The diameter of the oocyte range from 30-130 μ (Plate V, d).

Plate IV. Photographs showing the microscopic features of gonads of *H. (M.) scabra*.

(a) Immature stage

(b) Maturing stage

(c&d) Male : Early mature stage and a portion of gonadial tubule enlarged

(e&f) Male : Late mature stage and a portion of the gonadial tubule enlarged

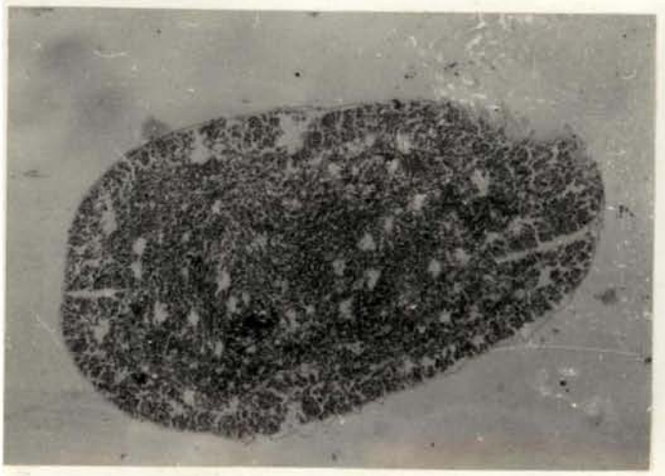
EW - Epithelial wall

S - Spermatozoa

PLATE IV

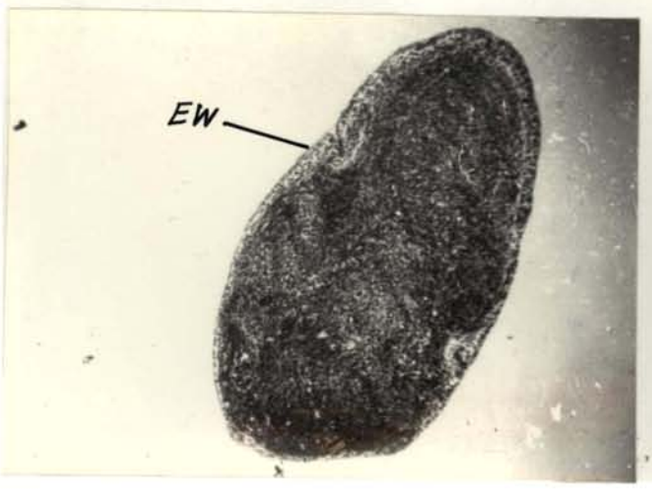
a

b



c

d



e

f

Plate V. Photographs showing the microscopic features of gonads of *H. (N.) scabra*.

(a&b) Male : Spent stage and a portion of gonadial tubule enlarged

(c) Group of male sex cells

(d) Female : Early mature stage

(e) Female : Late mature stage

(f) Female : Spent stage

N - Nucleus

O - Oocyte

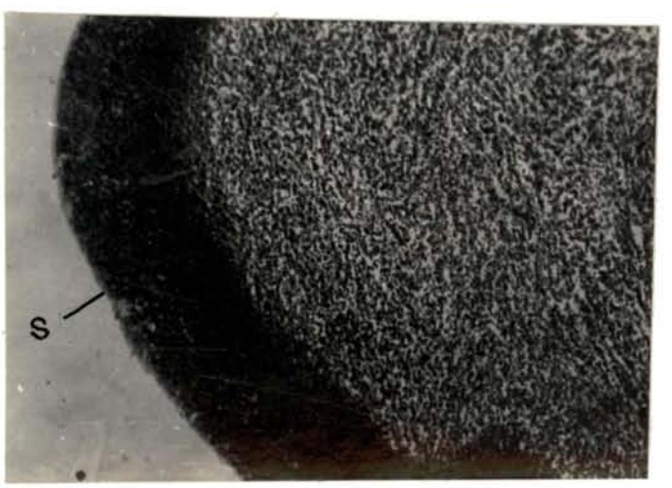
Ew- Epithelial wall

S - Spermatozoa

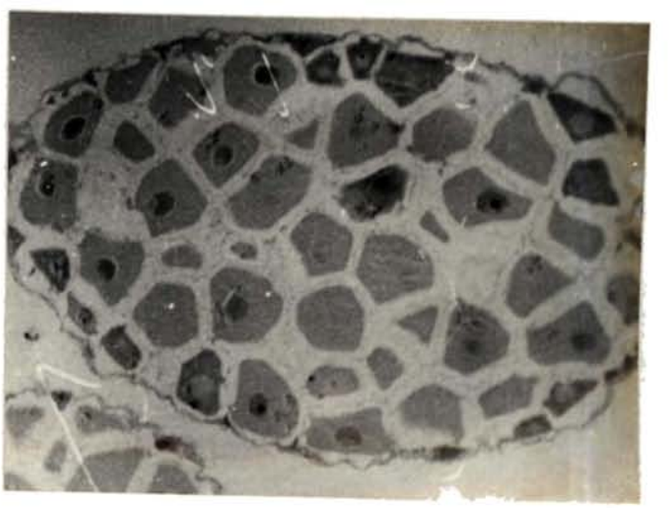
PLATE V

a

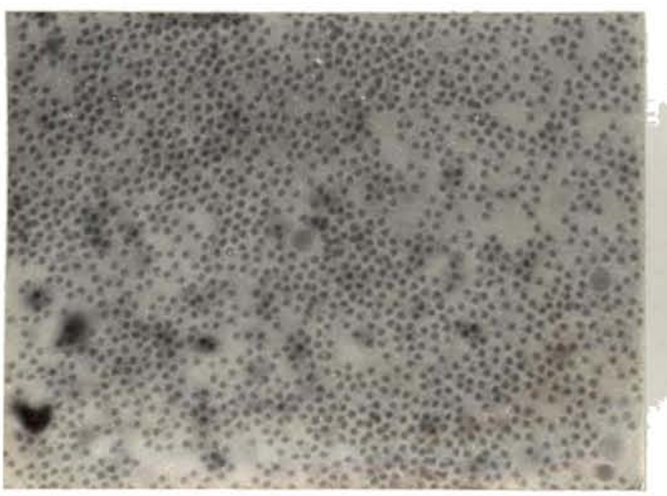
d



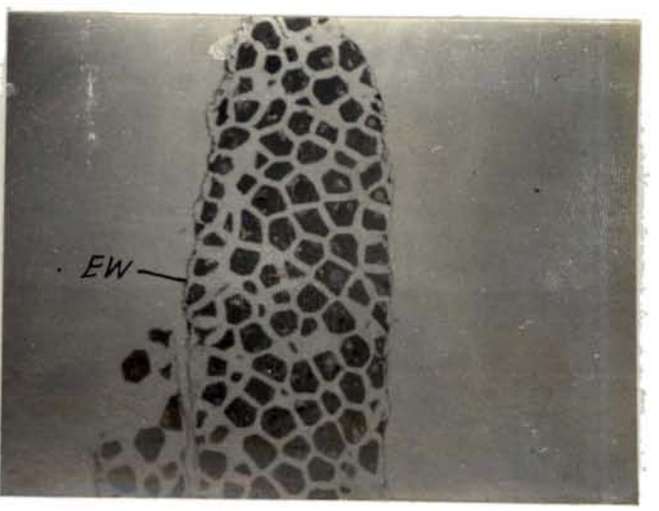
b



e



c



f

Late mature

Oocytes are polymodal in shape with 120-197 μ diameter (Plate V, e).

Spent

Few oocytes of dark yellow coloured cells, 30-100 μ in diameter (Plate V, f).

7.2.2 Ova Diameter

Ova diameter measurements of as many as 20 ovaries in the different stages of maturity were studied. Based on the characteristic macroscopic appearance correlated with microscopic study of the ova, five stages of maturity were defined as stated earlier.

All the five stages of the ovary were selected for the ova diameter frequency polygons. At stage I, majority of the ova were in the size range of 1-15 μ. At stage II, the size of the ova ranged from 15-55 μ with a mode at 20 μ. At stage III, majority of the ova were in the size range of 30-130 μ with a mode at 60 μ and 80 μ. At stage IV, the size of the ova ranged from 120-197 μ with a peak at 167 μ and at stage V, majority of the ova were in the size range of 30-100 μ with a peak of 60 μ.

The smaller eggs encounted in stage V indicate the new batch of eggs added to the gonad.

7.2.3 Spawning

A total of 381 holothurians during March 1988 to February 1989 and 404 holothurians during March 1989 to February 1990, were examined to study the percentage occurrence of gonads in different stages of maturity. The details are presented in Tables 6 & 7 and Fig. 7.

In March 1988, stages I to IV were present, stage III being the most dominant (Fig. 7). In April, all stages were present, stage II & III being dominant. In May and June, almost the same picture as in April was noted but here the percentage of stage I was more. Stage V was absent in July to September, and stage II was maximum in July and September while stage I was maximum in August. During October, stages I to V were present, while stage II was dominant. In November, stage I was absent and stage IV and V were dominant. During December, stage II and III were maximum among the five stages. During January 1989, stages I to III were recorded maximum while in February 1989 stages III to V were dominant with stage III at its peak.

During the following year March 1989 to February 1990, (Tables 6 & 7 and Fig. 7) the following observations were made

Table 6. Percentage occurrence of males of *H. (M.) scabra* in different stages of maturity (March 1988-February 1990)

Month	Number of holothurians	Stages of maturity I	II	III	IV	V
March'88	12	8.33	16.70	41.70	33.30	--
April	21	9.52	33.30	28.60	19.10	9.50
May	22	27.30	31.80	27.30	9.10	4.50
June	23	21.80	47.80	21.80	4.30	4.30
July	24	29.20	50.00	16.70	4.10	--
August	26	61.50	15.40	23.10	--	--
September	32	15.62	59.37	21.88	3.13	--
October	23	17.39	34.79	21.74	13.04	13.04
November	18	--	11.11	16.67	27.78	44.44
December	21	19.05	38.10	9.52	19.04	14.29
January'89	27	29.63	37.04	25.93	3.70	3.70
February	19	21.05	10.53	31.58	15.79	21.05
March	16	6.25	6.25	25.00	31.25	31.25
April	17	11.76	--	41.18	17.65	29.41
May	23	21.74	30.44	21.74	13.04	13.04
June	25	28.00	24.00	28.00	16.00	4.00
July	25	24.00	28.00	32.00	12.00	4.00
August	26	19.23	30.77	30.77	15.38	3.85
September	24	29.17	25.00	33.33	8.33	4.17
October	25	28.00	28.00	8.00	24.00	12.00
November	19	15.78	10.53	26.32	10.53	36.84
December	13	13.04	26.09	21.74	26.09	13.04
January'90	24	20.83	37.50	25.00	8.33	8.34
February	22	31.82	13.64	18.18	13.64	22.72

Table 7. Percentage occurrence of females of *H. (M.) scabra* in different stages of maturity (March 1988-February 1990)

Month	Number of holothurians	Stages of maturity				
		I	II	III	IV	V
March '88	14	7.10	14.30	50.00	28.60	--
April	20	10.00	35.00	15.00	20.00	20.00
May	18	33.30	38.90	5.60	11.10	11.10
June	23	21.80	47.80	13.00	13.00	4.40
July	27	25.90	44.40	18.60	11.10	--
August	25	64.00	16.00	16.00	4.00	--
September	30	16.67	63.33	16.67	3.33	--
October	24	16.67	33.33	20.83	16.67	12.50
November	20	--	10.00	25.00	25.00	40.00
December	26	15.38	30.77	26.93	19.23	7.69
January '89	23	34.78	43.48	8.70	8.70	4.34
February	17	23.53	11.76	17.65	23.53	23.53
March	18	5.56	5.56	33.34	27.77	27.77
April	15	13.34	--	20.00	33.33	33.33
May	22	22.72	31.82	22.73	18.18	4.55
June	22	31.82	27.27	18.18	18.18	4.55
July	22	27.27	31.82	27.27	9.09	4.55
August	23	21.74	34.78	21.74	17.39	4.35
September	21	33.33	28.57	14.29	19.05	4.76
October	25	28.00	28.00	16.00	16.00	12.00
November	21	14.30	9.52	9.52	33.33	33.33
December	20	15.00	30.00	25.00	20.00	10.00
January '90	25	20.00	36.00	20.00	16.00	8.00
February	21	33.33	14.29	19.06	14.26	19.06

Fig. 7.

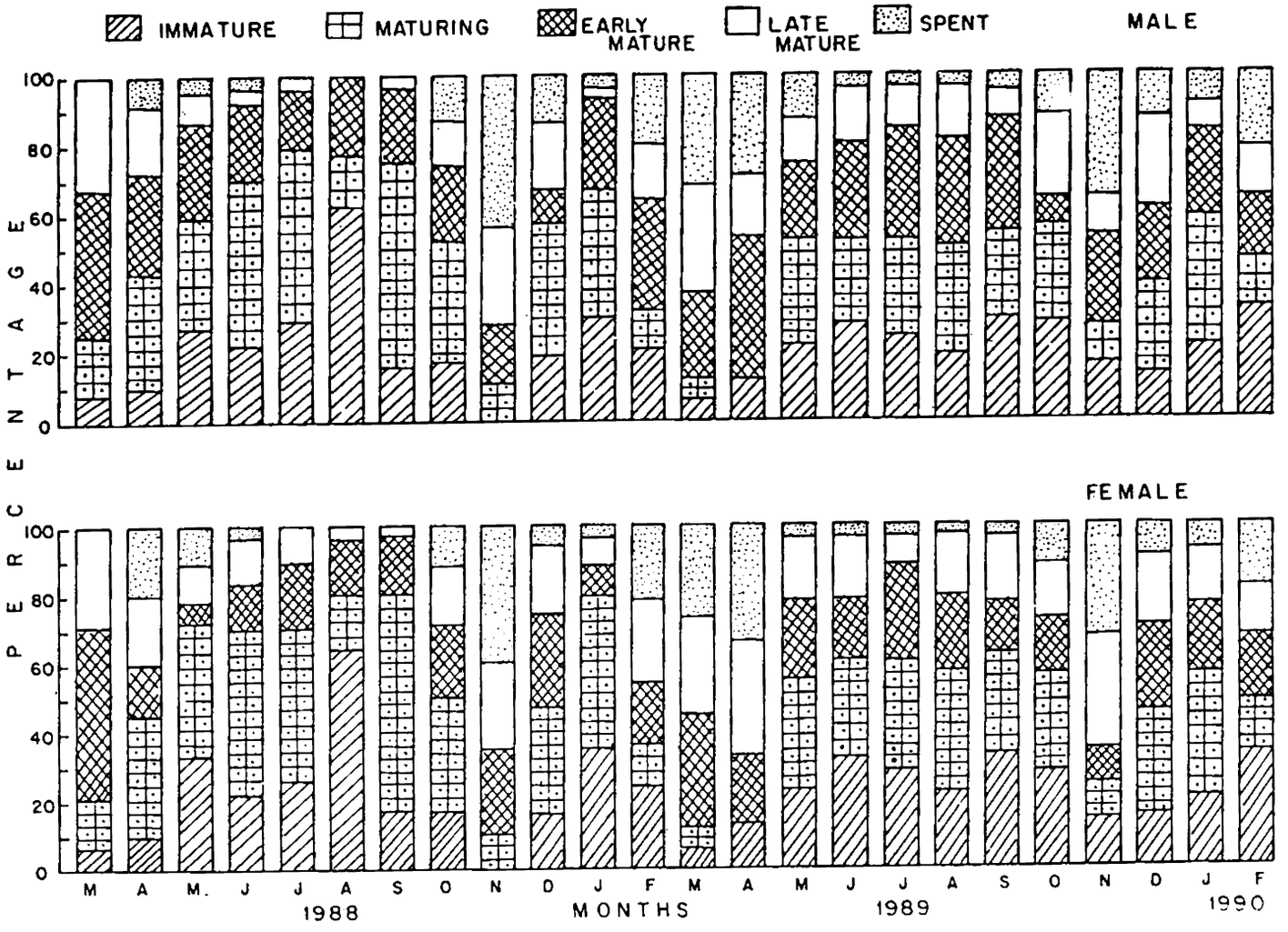


Fig. 7. Percentage occurrence of males and females of *H. (H.) scabra* in different stages of maturity (March 1988 to February 1990)

based on the occurrence of maturity stages. In March, holothurians of all stages from I to V were recorded and the stages III to V were dominant. In April, stage II was absent and though both stages III and V showed a maximum, the former was at a peak. During May, stages I to III were maximum. The same condition was noticed in June, July and August. In September, stage III was dominant and in October, stages I, II and IV were maximum. During November, stages IV and V were more and in December, stages II, III and IV were dominant. In January 1990, stages II and III and in February, stages I and V were dominant.

A comparison of the above data on the maturity of *H. (H.) scabra* over two successive years indicates that holothurians of various maturity stages may be present in any month of the year. For instance, the maturity stages I, II and III were present throughout the year, excepting during November 1988 and April 1989 when both stages I and II were absent. Similarly, the holothurian with late maturity (stage IV) may be seen throughout the year. The spent individuals were recorded in April to June 1988 and from October 1988 to February 1990. This indicated that the mature individuals were occurring in all the months, with a peak of spawning in certain months in a year.

The percentage occurrence of mature holothurians (stages

III, IV and V) are shown in Figs. 8 a & b. As can be seen from the figure that mature holothurian occur almost throughout the year with peaks in March, May to September and December during 1988 and January, April, June to September, October and November during the year 1989 and January 1990. This, however, does not prove that spawning occurs round the year, because the duration of time the holothurians remain at these stages before spawning, is difficult to ascertain. In this respect the occurrence of late mature individuals may provide a clue for spawning. The holothurians in late mature condition (stage IV) showed a peak in March to May and October to December in 1988. The same was observed in 1989 also with an indication of bimodal spawning.

The young ones of this species measuring 3-5 cm in size were collected at Pamban (Gulf of Mannar) in March 1989. From the size of these individuals and the month of collection, it may be inferred that recruitment would have taken place three or four months before. James (1976) recorded 30 mm long *H. (M.) scabra* in April, 70 mm from Mandapam (Palk Bay). In February, 1978 James (1983) collected juveniles ranging in length from 65-160 mm from Sesostris Bay at Port Blair. It takes 4 to 5 months to reach 45 mm length in the hatchery. The reason was that the larvae of *H. (M.) scabra* take three weeks to reach the juvenile stage (0.5 mm) as reported by James *et al.* (1988, 1989) who pointed out that

Fig. 8. (a) Percentage occurrence of early mature, late mature and spent stages of males of *H. (M.) scabra* (March 1988 to February 1990)

(b) Percentage occurrence of early mature, late mature and spent stages of females of *H. (M.) scabra* (March 1988 to February 1990)

(c) Percentage occurrence of indeterminate, male and female of *H. (M.) scabra* (March 1988 to February 1990).

Fig. 9. (a) Seasonal changes in the gonad index of males of *H. (M.) scabra*, surface water temperature and salinity (March 1988 to February 1990).

(b) Seasonal changes in the gonad index of females of *H. (M.) scabra*, surface water temperature and salinity (March 1988 to February 1990).

Fig. 8.

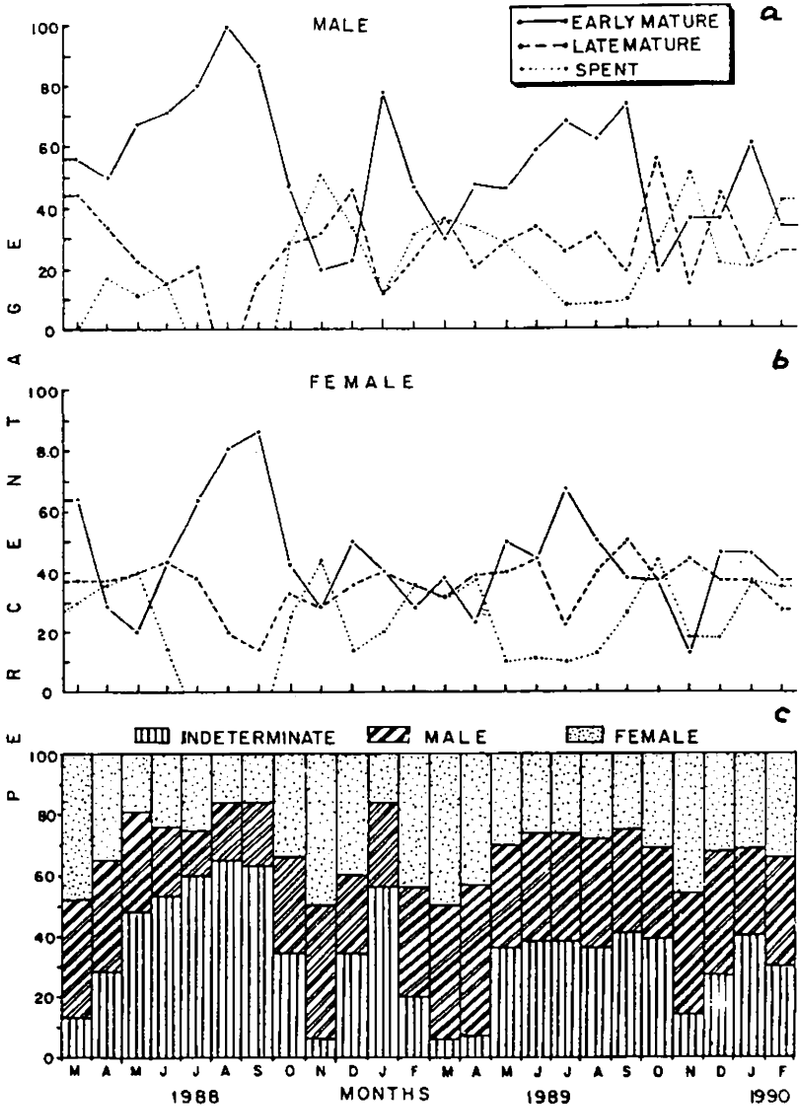
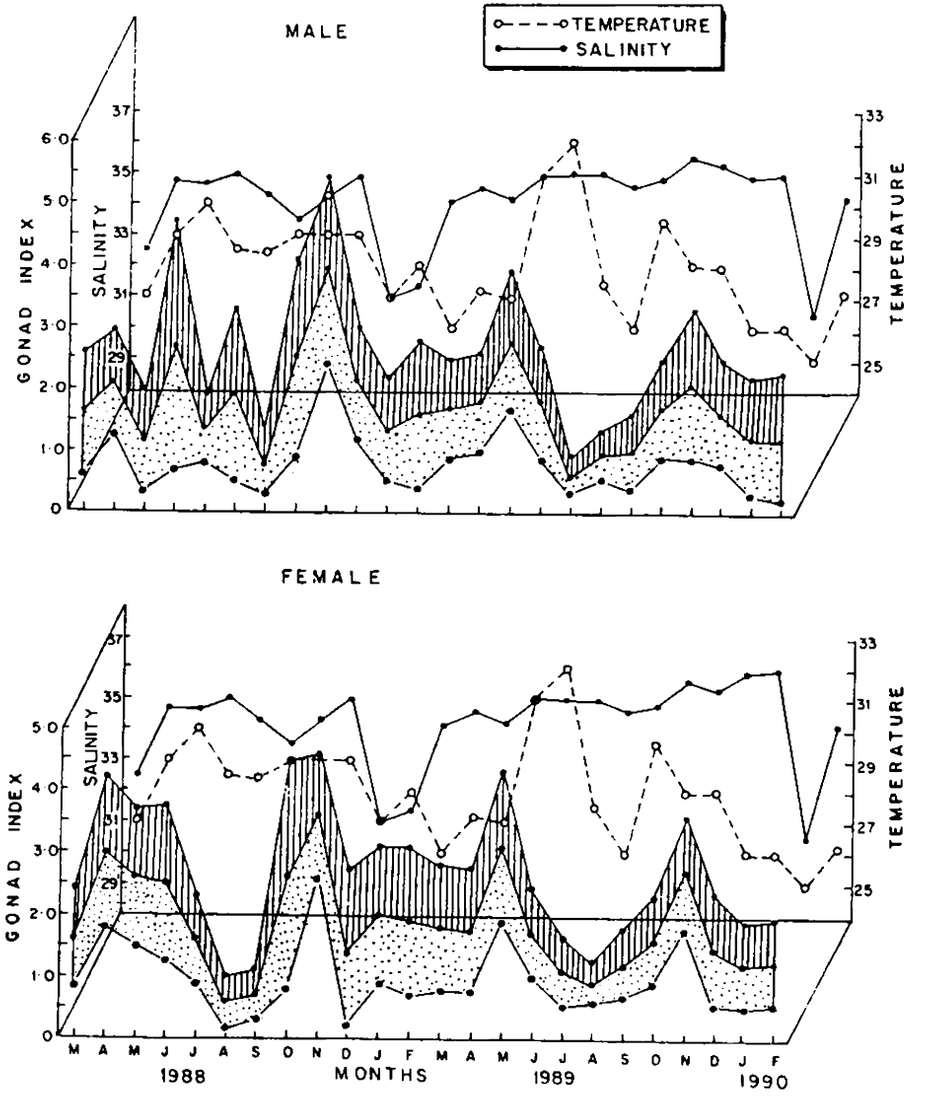

a
MALE
EARLY MATURE
LATE MATURE
SPENT
b
FEMALE
c
INDETERMINATE
MALE
FEMALE
PERCENTAGE
MONTHS
1988
1989
1990

Fig. 9.


MALE
TEMPERATURE
SALINITY
GONAD INDEX
SALINITY
TEMPERATURE
FEMALE
MONTHS
1988
1989
1990

the juveniles grow faster than the adult. It is therefore, possible that the young ones recorded in March 1989 would have been recruited some time in October to December 1988.

7.2.4 Gonad Index

The gonad index is used to indicate the maturity and intensity of spawning in *H. (M.) scabra*. The gonad index was calculated separately for male and female holothurians collected from Tuticorin during March 1988 to February 1990 (Fig. 9).

Males : The GI showed an increase during April 1988 (2.09 $\pm$ 0.85), June (2.67 $\pm$ 2.01), October (2.5 $\pm$ 1.63) and November 1988 (3.96 $\pm$ 1.53). There was a decline in the gonad index during July (1.29 $\pm$ 0.51) to September 1988 (0.88 + 0.46), January 1989 (1.35 $\pm$ 0.81) and February 1989 (1.61 $\pm$ 1.21). The gonad index in males increased again in May 1989 (2.82 $\pm$ 1.13) and November (2.09 $\pm$ 1.21).

Females : The female gonad index values showed an increase in April 1988 (3.05 $\pm$ 1.15), November 1988 (3.63 $\pm$ 1.04), May 1989 (3.07 $\pm$ 1.16) and November 1989 (2.73 $\pm$ 0.91). During July 1988 (1.57 $\pm$ 0.72) to October 1988 (2.56 $\pm$ 1.83) and during June (1.75 $\pm$ 0.70) to October 1989 (1.64 $\pm$ 0.72) a decrease in the gonad index was observed.

The variations in GI values were high in June and November 1988 and May and November 1989 in males while in females during April and November 1988 and May and November 1989. This indicates a high variation in the gonads at various stages of holothurian maturity. The decline in gonad index from July to September and January to February suggest that the individuals have attained spent or maturing stage.

7.2.5 Relationship between gonad index, temperature and salinity

During the study period March 1988 to February 1989, water temperature ranged between 26-30^{o}C. The maximum temperature was recorded in May 1988 (30^{o}C) and minimum temperature was noted in January 1989 (26^{o}C). The salinity values ranged from 31 to 35%. The maximum salinity was recorded during June and October 1988 (34.99%.) and minimum was observed during November 1988 (31.03%.).

During March 1989 to February 1990, the minimum temperature and salinity were observed in January 1990 (25^{o}C and 30.5%. respectively). A maximum temperature of 32^{o}C was recorded in May 1989 and a maximum salinity of 35.5%. was recorded during September 1989. The variation in temperature and salinity may have been due to the inflow of rain water during the northeast monsoon season.

The estimated correlation coefficient of gonad index with

salinity and temperature were -0.278 and 0.009 respectively. Both these correlates were statistically non significant. However, there was an inverse relationship between salinity and gonad index indicating possible reduction in gonad indices at higher levels of salinity. In nature spawning is not influenced by higher temperature since one spawning peak appears in March to May when temperature is high and another spawning peak is during October to December when the temperature is low.

7.2.6 Relationship between total length, total weight, gutted weight, gonad weight and maturity stage

Multiple regression analysis was carried out to study

1. The effect of total weight (TW) and maturity stage (MS) on gonad weight (G).

2. The effect of gutted weight (GW) and maturity stage (MS) on gonad weight (G).

3. The effect of total length (TL) and maturity stage (MS) on gonad weight (G).

The following relationships were studied (no. of observations = 378)

(a) $G = -6.89096 + 0.00173\ TW + 3.027885\ MS$ ($r^2 = 72.7\%$)

(+0.00055) (+0.126)

(b) G = -7.35590 + 0.00483 GW + 3.127884 MS (r^2 = 72.3%)

(+0.0024) (+0.122)

(c) G = -8.26280 + 0.008596 TL + 3.032599 MS (r^2 = 72.3%)

(+0.0042) (+0.150)

Figures in paranthesis are the standard errors of the estimates. All the afore mentioned empirical relationships explain that about 72% of the variation in gonad weight indicates that the above relationships are reasonably good fits to the data.

7.2.7 Size at first maturity

To determine the minimum size of *H. (M.) scabra*, 113 females and 114 males during March 1988 to February 1989 and 136 females and 149 males during March 1989 to February 1990 were examined.

Relationship between size and maturity of holothurians

Holothurians were grouped sex wise into one centimeter size classes and the percentage occurrence of holothurians of various maturity stages in the class was calculated. For the purpose of calculating the size at first maturity, holothurians belonging to stages III, IV and V were grouped under mature holothurians and

the details are presented in Figs. 10 to 12 and Tables 8 to 11.

From table 8, it can be seen that during March 1988 to February 1989, upto 14 cm, all the holothurian were in the immature stage. From 14.1 to 25 cm, they passed into maturing stage and a few of them (15.38%) were found to be matured. The early mature male individuals were found in the size of 12.1-26 cm with 14.29% were found mature. The late mature individuals were observed from 18.1-26 cm with 14.29% in the late mature stage. The spent individuals were recorded for the first time in 21-22 cm (3.33%) class and also all specimens above 20 cm. In 23-24 cm class only a few holothurians (8.00%) were found to be in the maturing stage whereas 92% of them were matured at this stage. From this size onwards, the percentage of mature individuals gradually increased and all of them were practically matured at 27 cm.

As can be seen from Table 9 all the individuals upto 14 cm were immature and in 19-20 cm class (more than 50% of them) were in the maturing stage and the early mature female individuals were found in the size range of 15-28 cm, with a peak (42.11%) in the size range of 22-23 cm. The late mature holothurians were recorded in class 17-28 cm, with a peak in 23-25 cm (50%) and the spent individuals were observed from 23-33 cm, having 100% in the

Fig. 10. Size at first maturity of male and female *H. (M.) scabra* based on data for the period

(a) 1988-1989

(b) 1989-1990

(c) Pooled data of males for the period 1988-1990 and

(d) Pooled data of females for the period 1989-1990.

Fig. 11. Weight at first maturity of male and female *H. (M.) scabra* based on data for the period

(a) 1988-1989

(b) 1989-1990

(c) Pooled data of males for the period 1988-1990

(d) Pooled data of females for the period 1989-1990.

Fig. 10.

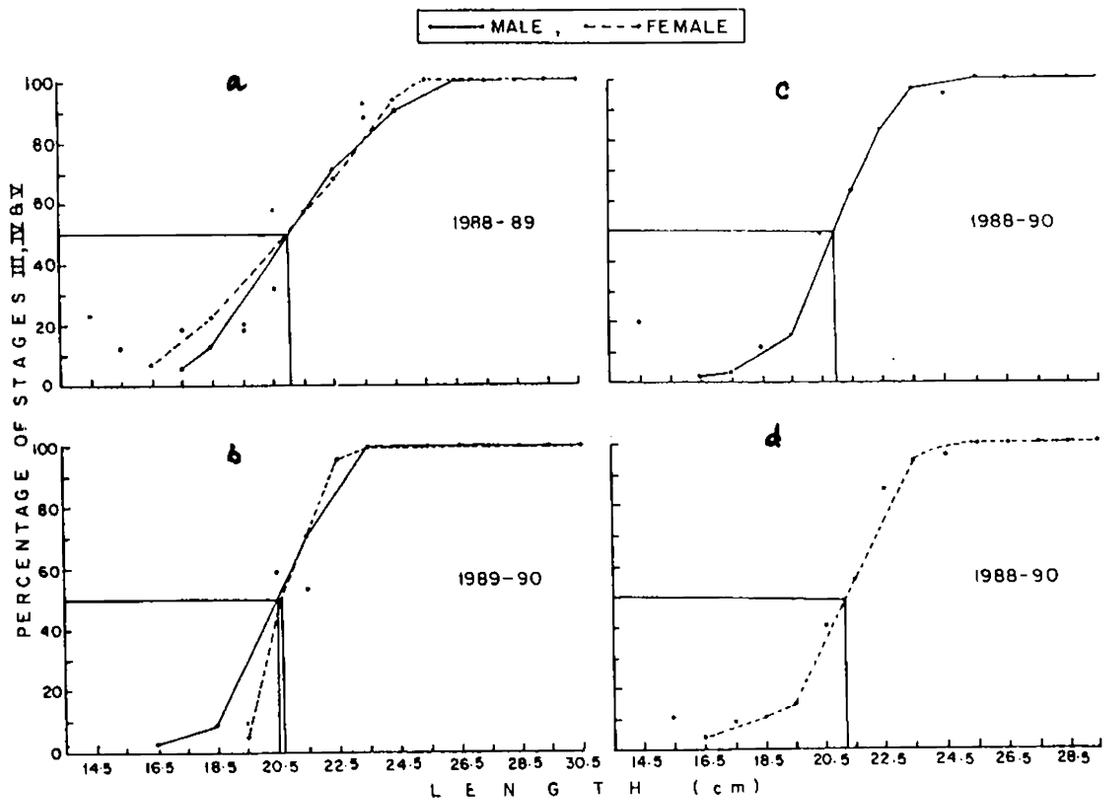

MALE , ----FEMALE
a
1988-89
c
1988-90
b
1989-90
d
1988-90
PERCENTAGE OF STAGES III, IV & V
LENGTH (cm)

Fig. 11.

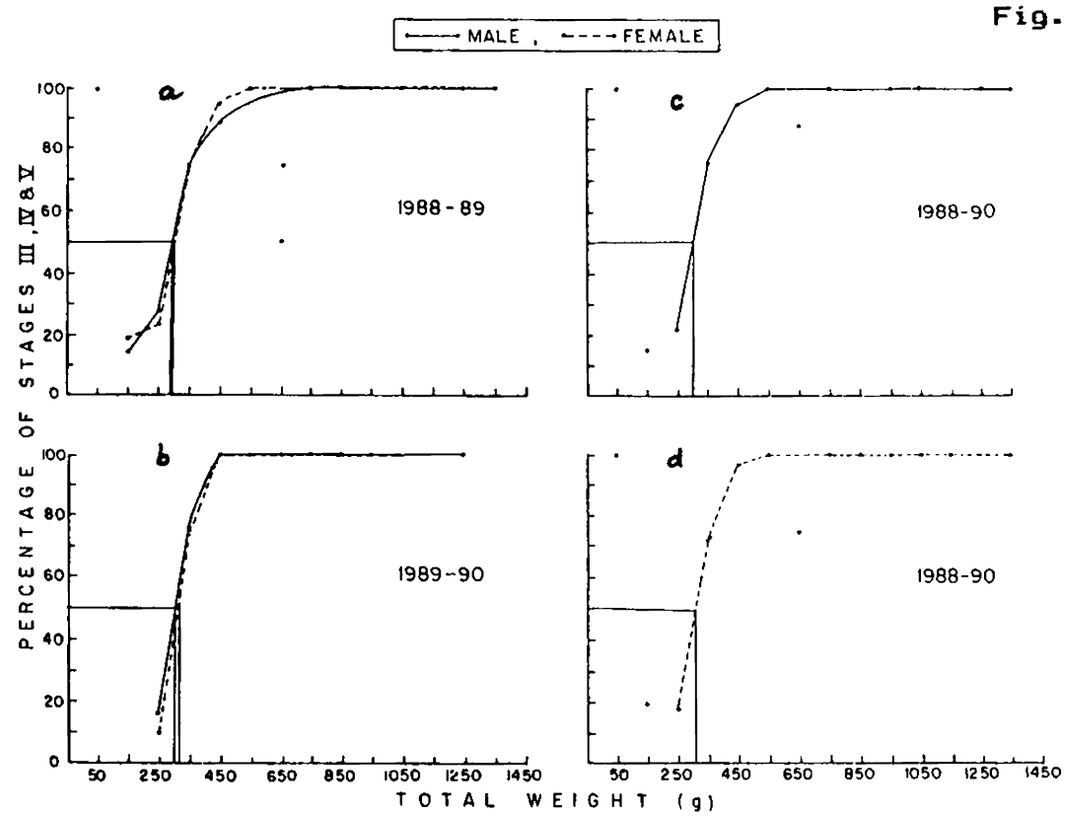

MALE , ----FEMALE
a
1988-89
c
1988-90
b
1989-90
d
1988-90
PERCENTAGE OF STAGES III, IV & V
TOTAL WEIGHT (g)

Fig. 12. Gutted weight of *H. (M.) scabra* at first maturity based on data for the period

(a) 1988-1989

(b) 1989-1990

(c) Pooled data for the period 1988-1990.

Fig. 12.

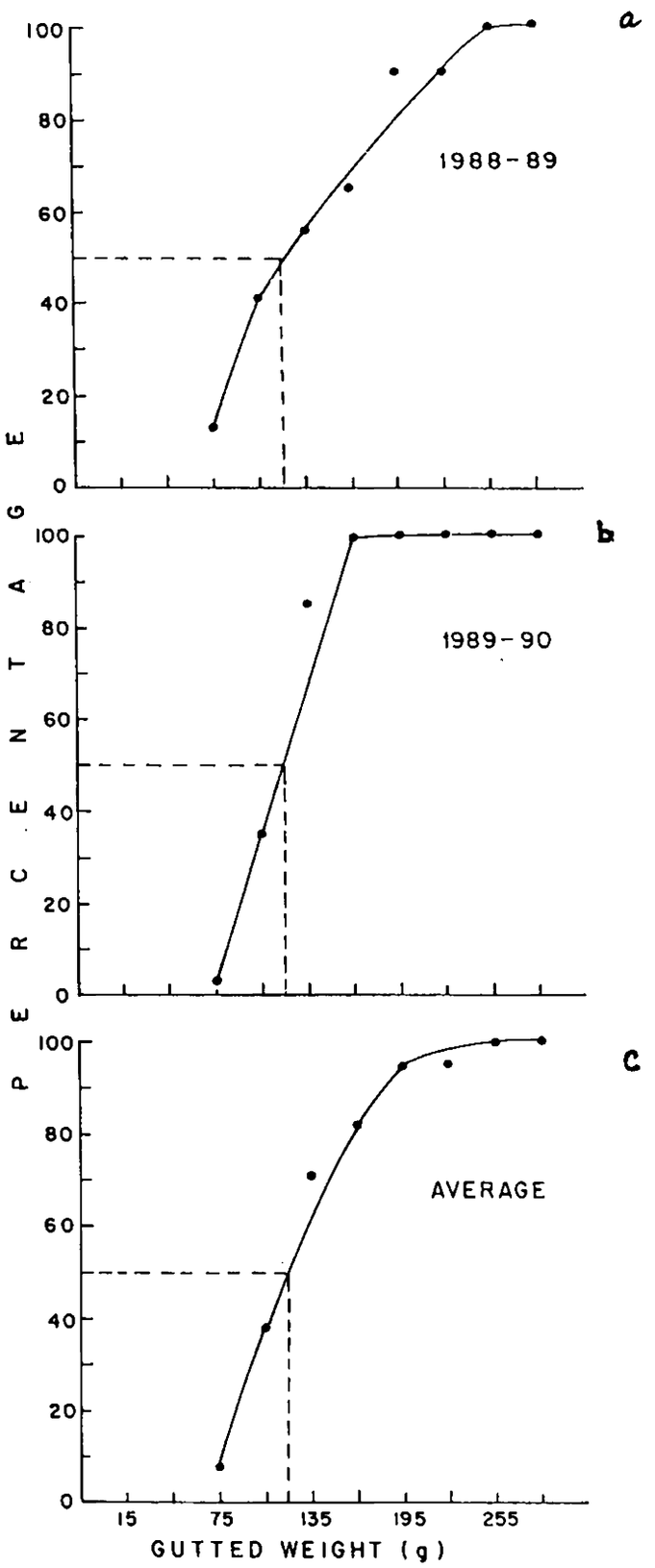

a
100
80
60
40
20
0
1988-89
b
100
80
60
40
20
0
1989-90
PERCENTAGE
c
100
80
60
40
20
0
AVERAGE
15
75
135
195
255
GUTTED WEIGHT (g)

Table 8. Percentage occurrence of males of *H. (M.) scabra* in different stages of maturity in various size groups (March 1988 - February 1989)

Size group (cm)	Number of holothurians	Stages of maturity				
		I	II	III	IV	V
12-13	1	100.00	--	--	--	--
13-14	1	100.00	--	--	--	--
14-15	13	53.85	23.08	15.38	7.69	--
15-16	15	80.00	20.00	--	--	--
16-17	14	78.57	21.43	--	--	--
17-18	35	51.43	41.86	5.71	--	--
18-19	16	37.50	50.00	6.25	6.25	--
19-20	39	2.56	79.50	15.38	2.56	--
20-21	26	3.85	38.46	46.15	11.54	--
21-22	30	10.00	33.33	46.67	6.67	3.33
22-23	21	4.76	23.81	61.90	9.52	--
23-24	25	--	8.00	40.00	44.00	8.00
24-25	10	--	10.00	30.00	40.00	20.00
25-26	7	--	--	14.29	14.29	71.43
26-27	4	--	--	--	--	100.00
27-28	4	--	--	--	--	100.00
28-29	3	--	--	--	--	100.00
29-30	1	--	--	--	--	100.00
30-31	2	--	--	--	100.00	--
31-32	1	--	--	--	--	100.00
32-33	1	--	--	--	--	100.00

Table 9. Percentage occurrence of females of *H. (M.) scabra* in different stages of maturity in various size groups (March 1988 - February 1989)

Size group (cm)	Number of holothurians	Stages of maturity				
		I	II	III	IV	V
12-13	1	100.00	--	--	--	--
13-14	1	--	--	--	--	--
14-15	10	70.00	30.00	--	--	--
15-16	17	70.59	17.65	11.76	--	--
16-17	15	73.33	20.00	6.67	--	--
17-18	40	45.00	37.50	12.50	5.00	--
18-19	18	33.33	44.44	16.67	5.56	--
19-20	40	2.50	77.50	20.00	--	--
20-21	16	6.25	62.50	18.75	12.50	--
21-22	30	10.00	33.33	36.67	20.00	--
22-23	19	5.26	26.32	42.11	26.32	--
23-24	16	--	12.50	12.50	50.00	25.00
24.25	16	--	6.25	18.75	50.00	25.00
25-26	15	--	--	6.67	26.67	66.66
26-27	5	--	--	20.00	20.00	60.00
27-28	3	--	--	33.33	66.67	--
28-29	1	--	--	--	--	100.00
29-30	1	--	--	--	--	100.00
30-31	--	--	-- --	--	--	--
31-32	--	--	-- --	--	--	--
32-33	2	--	--	--	--	100.00

Table 10. Percentage occurrence of males of *H. (M.) scabra* in different stages of maturity in various size groups (March 1989- February 1990).

Size group (cm)	Number of holothurians	Stages of maturity				
		I	II	III	IV	V
14-15	2	100.00	--	--	--	--
15-16	1	100.00	--	--	--	--
16-17	35	77.14	20.00	2.86	--	--
17-18	26	57.69	42.31	--	--	--
18-19	22	40.91	50.00	4.55	--	4.54
19-20	20	--	90.00	10.00	--	--
20-21	29	--	41.38	58.62	--	--
21-22	24	12.50	16.67	70.83	--	--
22-23	19	--	5.26	84.21	10.53	--
23-24	31	--	--	38.71	61.29	--
24-25	12	--	--	8.33	91.67	--
25-26	18	--	--	--	55.56	44.44
26-27	12	--	--	--	8.33	91.67
27-28	7	--	--	--	--	100.00
28-29	4	--	--	--	25.00	75.00
29-30	5	--	--	--	--	100.00
30-31	2	--	--	--	--	100.00

Table 11. Percentage occurrence of females of *H. (M.) scabra* in different stages of maturity in various size groups (March 1989 - February 1990)

Size group (cm)	Number of holothurians	Stages of maturity				
		I	II	III	IV	V
14-15	2	100.00	--	--	--	--
15-16	1	100.00	--	--	--	--
16-17	35	77.14	20.00	--	--	2.86
17-18	26	57.69	42.31	--	--	--
18-19	20	45.00	55.00	--	--	--
19-20	19	--	94.74	5.26	--	--
20-21	23	--	52.17	43.48	4.35	--
21-22	15	20.00	26.67	53.33	--	--
22-23	27	--	3.70	88.89	7.41	--
23-24	21	--	--	28.57	71.43	--
24-25	17	--	--	--	70.59	29.41
25-26	20	--	--	5.00	75.00	20.00
26-27	12	--	--	8.33	25.00	66.67
27-28	8	--	--	12.50	--	87.50
28-29	3	--	--	--	33.33	66.67
29-30	5	--	--	--	--	100.00
30-31	1	--	--	--	--	100.00

28-29 cm size group (Fig. 13).

Data on the condition of gonads of both sexes during March 1989 to February 1990 showed that upto 16 cm, all the holothurians were in the immature stage. From 16 to 23 cm, the individuals were in the maturing stage, and more than 90% were noted in the size group of 19-20 cm. The early mature individuals were recorded in the size range of 16-25 cm, with a peak of 84.21% in the 22-23 cm size group in males while in females, the individuals matured from 19-28 cm, with a peak (88.89%) in the 22-23 cm size range. The late mature holothurians were observed from 22-29 cm having maximum percentage of 91.67% in 24-25 cm in males and 75% of females in the size group of 25-26 cm. The spent individuals were recorded in the size group of 18-19 cm and also in 25-31 cm where 100% were recorded in 27-28 cm in males while in females, spent individuals were recorded in 16-17 cm and from 24-31 cm with 100% in the 29-30 cm size group (Tables 10 & 11 and Fig. 14).

Pooled data for the percentage occurrence of stages III, IV and V for each year as well the averages for two consecutive years were calculated (Tables 12 & 13). It can be seen from the tables that for males of 14-15 cm, 11.53% and for 16-17 cm size group, 1.43% of the holothurians were mature. In the following size group of 17-18 cm, 2.85% of holothurians were mature, and in

Fig. 13. (a) Percentage occurrence of males of *H. (M.) scabra* in different stages of maturity in various size groups (March 1988 to February 1989).

(b) Percentage occurrence of females of *H. (M.) scabra* in different stages of maturity in various size groups (March 1988 to February 1989).

Fig. 14. (a) Percentage occurrence of males of *H. (M.) scabra* in different stages of maturity in various size groups (March 1989 to February 1990).

(b) Percentage occurrence of females of *H. (M.) scabra* in different stages of maturity in various size groups (March 1989 to February 1990).

Fig. 13.

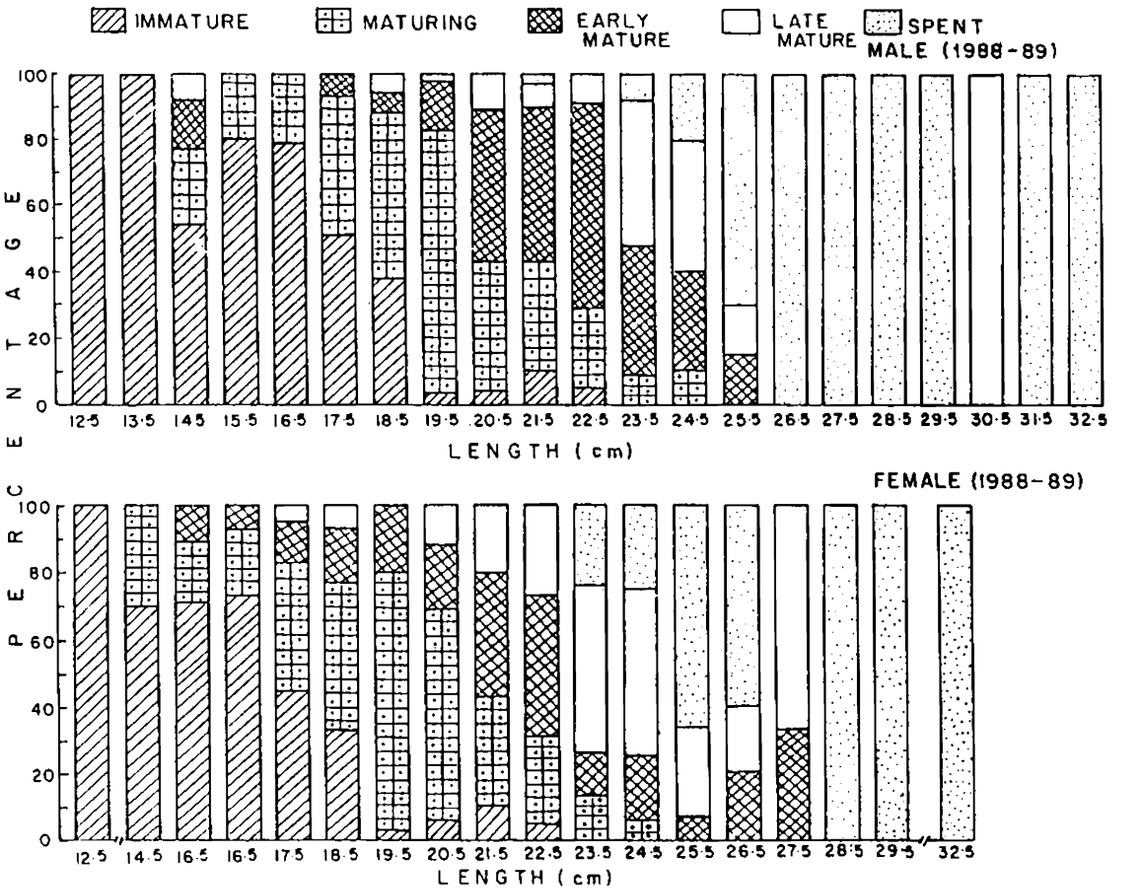

IMMATURE
MATURING
EARLY MATURE
LATE MATURE
SPENT
MALE (1988-89)
PERCENTAGE
LENGTH (cm)
FEMALE (1988-89)
PERCENTAGE
LENGTH (cm)

Fig. 14.

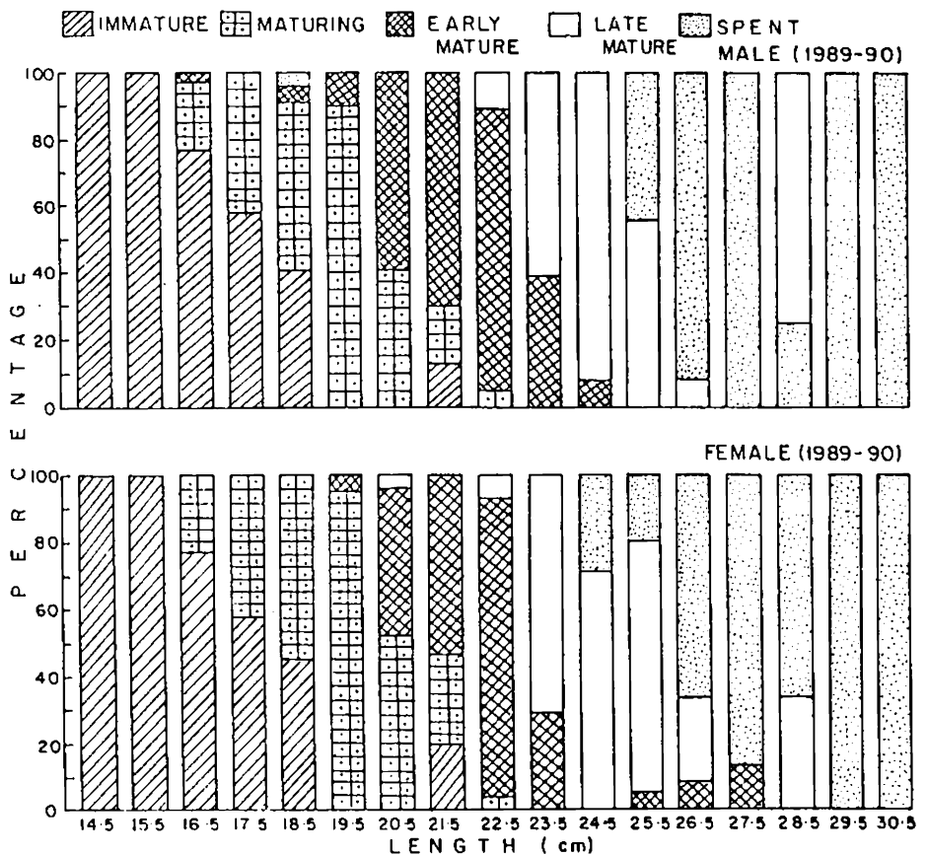

IMMATURE
MATURING
EARLY MATURE
LATE MATURE
SPENT
MALE (1989-90)
PERCENTAGE
FEMALE (1989-90)
PERCENTAGE
LENGTH (cm)

Table 12. Percentage occurrence of mature males of *H. (M.) scabra* in various size groups.

Size group (cm)	1988-89	1989-90	Average
14-15	23.07	--	11.53
15-16	--	--	--
16-17	--	2.86	1.43
17-18	5.71	--	2.85
18-19	12.50	9.09	10.79
19-20	17.94	10.00	13.97
20-21	57.69	58.52	58.15
21-22	56.67	70.83	63.75
22-23	71.42	94.74	83.08
23-24	92.00	100.00	96.00
24-25	90.00	100.00	95.00
25-26	100.00	100.00	100.00
26-27	100.00	100.00	100.00
27-28	100.00	100.00	100.00
28-29	100.00	100.00	100.00
29-30	100.00	100.00	100.00
30-31	100.00	100.00	100.00

Table 13. Percentage occurrence of mature females of *H. (M.) scabra* in various size groups

Size group (cm)	1988-89	1989-90	Average
15-16	11.75	--	5.88
16-17	6.67	2.86	4.76
17-18	17.50	--	8.75
18-19	22.23	--	11.11
19-20	20.00	5.26	12.63
20-21	31.25	47.83	39.54
21-22	56.67	53.33	55.00
22-23	68.43	96.30	82.36
23-24	87.50	100.00	93.75
24-25	93.75	100.00	96.87
25-26	100.00	100.00	100.00
26-27	100.00	100.00	100.00
27-28	100.00	100.00	100.00
28-29	100.00	100.00	100.00
29-30	100.00	100.00	100.00

18-19 cm, 10.79 of the males were mature. In the size class of 20-21 cm, 58.15% of holothurians were mature. The percentage of mature individuals increased steadily in the higher size groups and practically all the holothurians were mature at 25-26 cm.

In female, the holothurians mature in the 15-16 cm size class (5.88%) and 16-17 cm (4.76%). In the following size group *ie.* 17-18 cm, the percentage of mature individuals increased similarly as in males. Fifty percent of the individuals were mature in the size group of 20-21 cm and 21-22 cm in males and females respectively.

The size at which 50% of the holothurians mature was taken to be the size at first maturity. As per the data available, the males matured at 21.1 cm in 1988, 20.5 cm in 1989 and an average 21 cm (1988-1990). The females matured at 21.2 cm size in 1988, and 20.7 cm size in 1989 and 21.3 cm on an average (1988-90). The total average weight at maturity was 290 g in males and 310 g in females. The gutted weight at first maturity was 125 g (Figs. 10, 11 & 12).

The monthly percentage of indeterminate, male and female individuals was calculated and are denoted in Fig. 8 c. The indeterminate individuals were represented maximum from July to September in 1988 and January, June to October in 1989 and

January 1990. The males and females were recorded maximum during March, April 1988 and October to December 1988. The same was also observed in 1989 and February 1990. This confirms that the individuals spawn during March to April and November to December in a year and the young ones (immature individuals) were found in the subsequent months (June to October).

7.2.8 Fecundity

The ovary as a whole at stages III, IV and V was teased and total number of mature ova were counted. The maximum fecundity observed was 10,04,160 and the minimum observed was 1,04,688 mature ova in the holothurian. Fecundity was related to total length (TL), total weight (TW) and gonad weight (G) by logarithmic regression as follows:-

$Log_eF = 0.5993 + 2.2181\ log_eTL;\quad r^2 = 0.09$ NS

$Log_eF = 10.7015 + 0.3694\ log_eTW;\quad r^2 = 0.06$ NS

$Log_eF = 9.3892 + 1.6768\ log_e\ G;\quad r^2 = 0.82$ S

S - significant; NS - non significant.

From the above, it is clear that there was no significant relationship between fecundity and total length and total weight. However, a significant relationship was noted between fecundity and gonad weight.

7.2.9 Sex ratio

During the course of this study, individuals of *H. (M.) scabra* were examined in a wide range of size but it was not possible to differentiate the sex externally. The holothurian gonads were composed of tubules, a part of which was examined, opened and spread on a slide to reveal the sex. The percentage occurrence of sexes in different months is given in Fig. 15.

It can be seen from figure 15 that the percentage of males during April, May, August and September 1988 was higher when compared to other months during the year. Similarly, a high percentage occurrence of males was recorded in January, February, April to September and December 1989 and in February 1990. Significant chi-square values (significant at 5%) for males and females were observed during the months of May 1988 (1 : 0.55, X^2 = 8.168), July 1988 (1:1.6, X^2 = 5.326), December 1988 (1:1.6, X^2 = 4.726) and January 1989 (1:0.6, X^2 = 8.168) respectively.

The data was pooled for each year separately and the sex ratio was calculated. The ratio of males to females was found to be 1 : 0.95 in the first year and 1 : 0.92 during second year with an average of 1 : 0.89. From the above, it appears that in *H. (M.) scabra*, the male population is slightly more dominant than the female population.

Fig. 15.

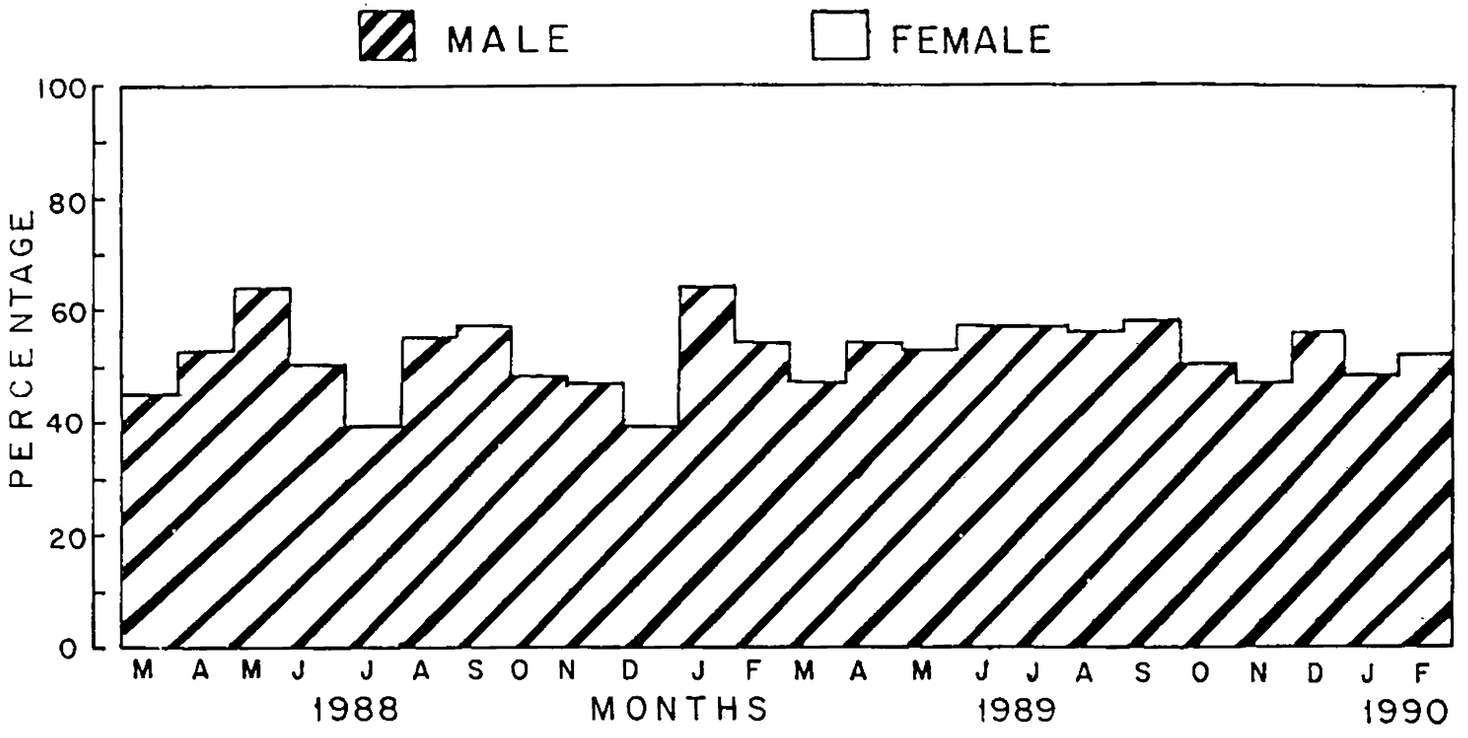


Fig. 15. Percentage of male and female *H. (M.) scabra* (March 1988 to February 1990).

7.3 Discussion

The maturity stages in *H. (M.) scabra* were classified by Krishnaswamy and Krishnan (1967) and they reported four stages of maturity *viz.* immature, mature, gravid and spent. But it was revised and divided into five stages of maturity *viz.* immature, maturing, early mature, late mature and spent, based on the macroscopical and microscopical observations of the gonad. Tanaka (1958b), Green (1978), Engstrom (1980), Conand (1981, 1990), Costello (1985) and Jayasree and Bhavanarayana (1989) also identified five maturity stages in different species of holothurians. The diameter of the ova measured was 197 μ and the egg was lecithotrophic containing little yolk.

Though no relationship could be established between gonad index and temperature, an inverse relationship was found between gonad index and salinity. The present findings are closely related with the observations made by Jayasree and Bhavanarayana (1989) in *Holothuria leucospilota* from Goa.

A linear relationship was made between the total length, total weight, gutted weight, gonad weight and maturity stages. In this context, it is clear from the results obtained that an increase in total length is directly proportional to an increase

in total weight, gonad weight, gutted weight and maturity stages. In a population, more than 72% of the individuals were observed to follow the same pattern.

Regarding the spawning of holothurian, two peak breeding seasons were observed, one in March to May and the next in October and November. Krishnaswamy and Krishnan (1967), however, reported that *Holothuria scabra* breeds throughout the year with peak intensities in July and October. This may be due to the fact that samples were collected from Tondi (Palk Bay) which is a different ecosystem. The breeding season of different species of holothurians have been dealt by different authors. *Stichopus japonicus* reproduce in June to August (Tanaka, 1958b) whereas Engstrom (1980) reported that *S. japonicus* breed between mid May and September. *Cucumaria lubrica* spawn in November and early January and *Holothuria floridana* spawn during late summer in Southern Florida (Engstrom, 1980, 1982). *Holothuria atra* breeds biannually with spawning in November and May (Harriott, 1982) and *H. impatiens* in late spring or summer (Harriott, 1985). *Actinopyga echinites* spawn in January and February, *Holothuria nobilis* breed in colder season, *H. (M.) scabra* reproduce in October to November in New Caledonia, *Thelenota ananas*, *H. fuscogilva* spawn in warm season (Conand, 1981, 1990). *Holothuria parvula* spawn during July to September (Emson and Mladenov,

1987).

The spawning behaviour of *H. (M.) scabra* was observed in the laboratory. The males allowed a characteristic position like a sigma and every time the anterior end is bent inwards, the sperms are released in the form of white thread. It spawns sometimes even two hours. The female raises the anterior end and releases the eggs in one or two powerful spurts. Costello (1985) also made similar observations in the holothurian *Aslia lefevrei*.

The male attained maturity at 21.0 cm and in female 21.3 cm; the mean total weight in male was 290 g and 310 g in female and the mean gutted weight observed was 125 g. Few investigators have attempted work on this aspect in different species of holothurian, notably, Choe (1963) reported that smallest matured *Stichopus japonicus* had a body wall weight of 39 g, but in general they weighed 58-60 g. Conand (1990) reported that *Holothuria nobilis* matured at 260 mm, *H. fuscogilva* reproduced at 320 mm, *H. (M.) scabra* spawned at 160 mm and *Actinopyga echinites* matured at 120 mm and their drained weights were 580, 900, 140 and 75 g respectively. *Holothuria mexicana* reproduced at 90 mm in males, 103 mm in females (Engstrom, 1980).

The fecundity observed in *H. (M.) scabra* was very high and recorded a maximum of 10,04,160 mature eggs. Conand (1990) in

her study mentioned that the fecundity of *H. (M.) scabra* recorded was 9-12 x 10^6. Whereas, Choe (1963) observed 1,83,000 to 2,63,000 eggs in 1 g of matured ovary of *Stichopus japonicus*. Harriott (1985) recorded 6600, 2800 and 800 mature eggs in *H. atra*, *H. edulis* and *H. impatiens* respectively. No relationship has been observed between fecundity and total length and total weight of *H. (M.) scabra*. The same was reported by Shelley (1981). A significant relationship was found between fecundity and gonad weight in *H. (M.) scabra*. The increase in fecundity was proportional to gonad weight.

The ratio of males to females, on an average was found to be 1 : 0.89 and significant chi-square values were obtained in the months of May, July, December 1988 and January 1989 ($P < 0.05$). It is clear that during breeding season, occurrence of males and females maintains more or less a 1 : 1 ratio, and the ratio influences the feeding, breeding and aggregation of sexes. Conand (1981, 1990) also has drawn similar ratio in *Holothuria nobilis* and *Actinopyga echinites*.

It is important to mention that the young ones of the *H. (M.) scabra* collected from Pamban on the Gulf of Mannar lie sticking to the roots of sea weeds or to the stems of the eel grass which hold fast on reefs, but are not found in places deeper than eel grass zone on muddy-sandy areas.

CHAPTER 8

AGE AND GROWTH

The growth schedule of the holothurian was determined using modal progression as followed by Ebert (1978) in *Holothuria atra*, Shelley (1985) in *Actinopyga echinites* and *Holothuria scabra*. The main problem in studying the growth of holothurians is the difficulty in taking the correct length of the specimens. Here, an attempt has been made to study the growth of *H. (M.) scabra*.

To estimate the growth of *H. (M.) scabra*, samples were collected at random from commercial catches landed at Tuticorin during March 1988 to February 1990 by skin diving and the holothurian individuals were measured. The method adopted to measure is mentioned in chapter 2. The data collected during the above period were grouped into 2 cm intervals. The numbers and percentage of frequencies were given in Tables 14 & 15. For modal progression analysis data from September 1988 to May 1989 was used.

8.1 Results and Discussion

Modal progression analysis

In September 1988, two modes could be seen at 19 and 27 cm

Table 14. Length frequency of *H. (N.) scabra* used for modal progression analysis.

Size group	1988			1989					
(cm)	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
6-8	--	--	--	--	--	--	--	1	--
8-10	--	--	--	--	--	--	--	1	--
10-12	--	--	--	--	2	--	1	7*	--
12-14	3	--	--	10	9*	2	3	5	1
14-16	15	13	13	27	6	11	12	10	2
16-18	49	40*	19*	44	20	18	12	20	26
18-20	64*	31	14	61*	32	26*	16	28*	28
20-22	50	38*	47*	40	45*	21	27	23	35
22-24	20	33	22	41*	40	34*	34*	14	45*
24-26	6	17	42*	15	24	21	29	26	33
26-28	7*	20*	23	16*	8	14	24	43*	11
28-30	3	13	8	2	2	5	12	6	2
30-32	1	16*	4	--	1	1	5	7*	--
32-34	--	1	--	--	1	--	1	7	--
TOTAL	218	222	192	256	190	153	176	198	183

* Mode points

Table 15. Percentage of length frequency of *H. (M.) scabra* used for modal progression analysis.

Size group	1988			1989					
(cm)	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
6-8	--	--	--	--	--	--	--	0.51	--
8-10	--	--	--	--	--	--	--	0.51	--
10-12	--	--	--	--	1.05	--	0.57	3.54	--
12-14	1.38	--	--	3.91	4.74	1.31	1.70	2.53	0.55
14-16	6.88	5.86	6.77	10.55	3.16	7.19	6.82	5.05	1.09
16-18	22.48	18.02	9.90	17.19	10.53	11.76	6.82	10.10	14.21
18-20	29.36	13.96	7.29	23.83	16.84	16.99	9.09	14.14	15.30
20-22	22.94	17.12	24.48	15.63	23.68	13.73	15.34	11.62	19.13
22-24	9.17	14.86	11.46	16.02	21.05	22.20	19.32	7.07	24.59
24-26	2.75	7.66	21.88	5.86	12.63	13.73	16.48	13.13	18.03
26-28	3.21	9.01	11.98	6.25	4.21	9.15	13.64	21.72	6.01
28-30	1.38	5.86	4.17	0.78	1.05	3.27	6.82	3.03	1.09
30-32	0.46	7.21	2.08	--	0.53	0.65	2.84	3.54	--
32-34	--	0.45	--	--	0.53	--	0.57	3.54	--

and during the next month, four modes were located at 17, 21, 27 and 31 cm. In November 1988, three modes were noted at 17, 21 and 25 cm and in December 1988, the modes were recorded at 19, 23 and 27 cm. In January 1989, two modes at 13 and 21 cm and in February 1989, two modes 19 and 21 cm were seen. In March 1989, one mode at 23 cm and in April 1989, four modes at 11, 19, 27 and 31 cm and in May 1989, one mode at 23 cm was observed. The modal lengths were plotted against months and the data was repeated for four years to facilitate modal progression. They are coded arbitrarily 1988, 1989, 1990 & 1991. The possible modal progressions are given in Table 16 and Fig. 16.

From the figure 16 it appears that there are two possible growth curves one in April and next in November. Table 16 explains that in April cohort, the holothurian of 11 cm had grown to 19 cm in 12 months (8 cm / 12 months) and from 19 cm in April 1989 became 23 cm in December (4 cm / 8 months). From 23 cm the animal had grown to 27 cm in September 1990 (4 cm / 9 months) and from September 1990 of 27 cm had grown to 31 cm in October 1991 (4 cm / 13 months).

The second cohort (November) showed that the individual had reached 11 cm in 14 months. This 11 cm of January 1990 had shifted to 19 cm in 11 months (8 cm / 11 months) and further has

Table 16. Modal Progression of *H. (M.) scabra*

Month (t_1)		Length (l_1) (cm)	Month (t_2)		Length (l_2) (cm)	Length ($l_1+l_2/2$) (cm)	$L=\Delta l/\Delta t$
April Cohort							
April	88	11	April	89	19	15	0.75
April	89	19	Dec.	89	23	21	0.50
December	89	23	Sep.	90	27	25	0.44
September	90	27	Oct.	91	31	29	0.31
November Cohort							
January	90	13	Dec.	90	19	16	0.667
December	90	19	Dec.	91	23	21	0.50
Cohort							
September	88	19	Jan	89	21	20	0.50
January	89	21	May	89	23	22	0.4*
May	89	23	Nov	89	25	24	0.33*
November	89	25	Apr.	90	27	26	0.40
April	90	27	Apr.	91	31	29	0.33

* Not considered.

Total of 9 points

$$\frac{\Delta l}{\Delta t} = a + b\,\bar{L}$$

$a = 1.870157$; $r = 0.946$

$b = -0.02726649215 = -K$ month

$L_\infty = a/-b = 40.37$ cm; K annual $= 0.327$

Fig. 16. Modal progression of *H. (M.) scabra*

Fig. 17. Modal points of *H. (M.) scabra*.

Fig. 18. Age and Growth of *H. (M.) scabra* by Elefan method.

● Not considered

Fig. 16.

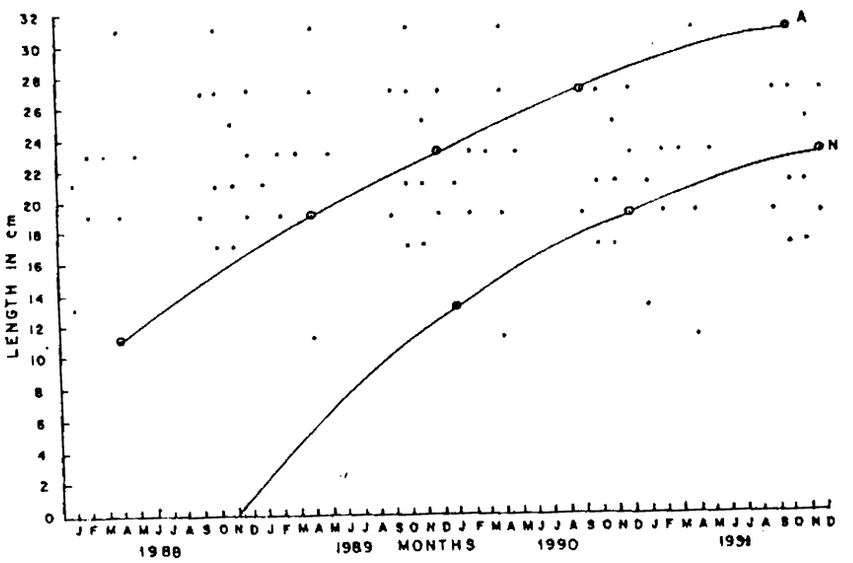


Fig. 17.

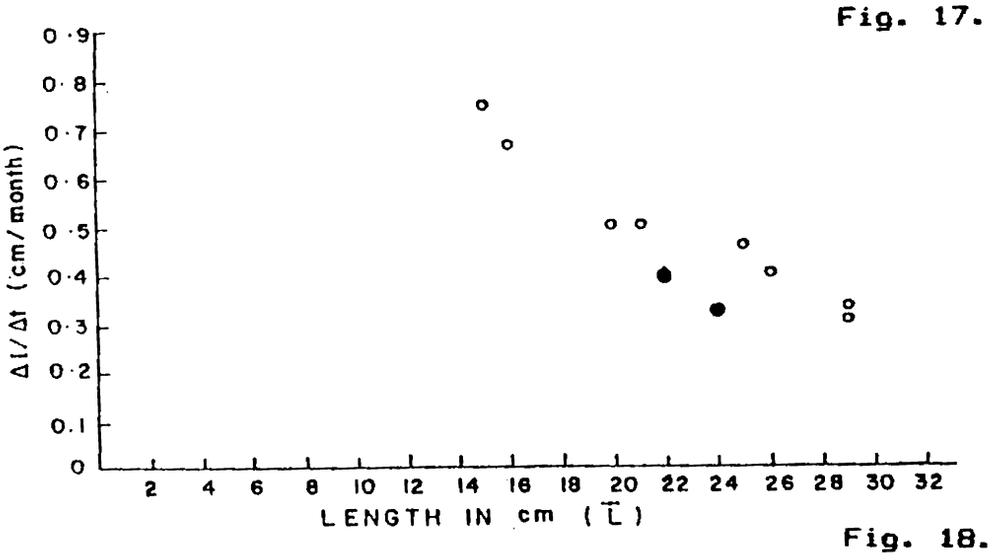
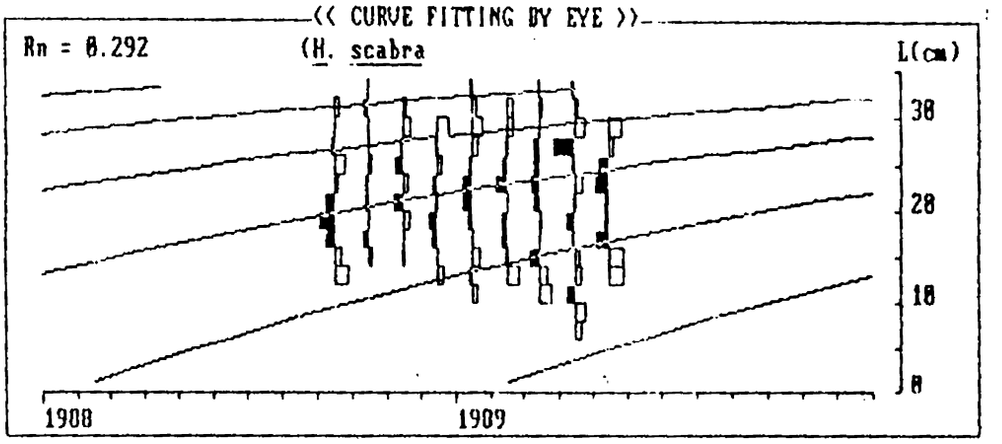


Fig. 18.



L∞	(asymptotic length)	[	39.59]
K	(growth constant)	[	0.420]
C	(amplitude)	[	0.000]
WP	(winter point)	[	0.000]
SS	(starting sample)	[	0]
SL	(starting length)	[	16.000]

moved from 19 cm to 23 cm in 12 months (4 cm / 12 months). Comparison of these two curves, that the holothurians had grown faster in November (cohort 11 cm / 14 months) than in April (cohort 8 cm / 12 months). The possible reason may be due to low saline conditions.

It was assumed that growth in length of *H. (M.) scabra* followed Von Bertalanffy Growth Formula (VBGF) as used by Shelley (1985) which is given as

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

where L_{∞} = length at infinity ;

k = growth coefficient ;

t_o = (arbitrary) origin of growth

From the modal progression data L_{∞} and k values were estimated using Gulland - Holt Plot method (1959) (Fig. 17). In the above figure, two points (22 - 0.4 ; 24 - 0.33) were not considered and the rest of the nine points were taken into consideration using the selected points the estimates were obtained which are L_{∞} = 40.37 cm and k = 0.327 (annual).

The same data were analysed using ELEFAN I (Fig. 18). The results obtained were L_{∞} = 39.6 cm and k = 0.42 (annual). It was seen that the growth parameters L_{∞} & k as obtained using

both the methods did not show much variation.

Both the methods used did not provide estimate of 't_o'. This parameter can be estimated, if age - length data are available. Since such data were not available for *H. (M.) scabra* 't_o' could not be estimated. However, lengths at relative ages could be estimated using the VBGF which are as follows:

For L_∞ = 40.37 cm ; k = 0.327

Relative age (year)	1	2	3	4	5	6	7	8	9	10
Length (cm)	11.3	19.4	25.2	29.5	32.5	34.7	36.3	37.4	38.3	38.8

For L_∞ = 39.6 cm ; k = 0.42

Relative age (year)	1	2	3	4	5	6	7	8	9	10
Length (cm)	13.6	22.5	28.4	32.2	34.8	36.4	37.5	38.2	38.7	39.0

Detailed reports on the growth of holothurians are obscure. The reason being the difficulty in taking accurate measurements of length due to the contraction and relaxation of the body wall.

Inspite of these difficulties, the present study was undertaken using VBGF to determine the growth of holothurian *H. (M.) scabra*. Based on the values estimated in two ways for L_{∞} & k, the relative age (in year) was computed. It is not certain whether VBGF will fit the growth schedule of *H. (M.) scabra*. However, it is assumed that the growth of *H. (M.) scabra* follows VBGF.

The life span of *Cucumaria elongata* was reported to be atleast 10 years (Fish, 1967). James (in press) recorded one specimen of *H. (M.) scabra* of 40 cm length from Tarmugli Island (Andaman) at a depth of 2 m. From the two years data on length parameters (modal progression) of *H. (M.) scabra*, a life span of 10 years has been projected with the animal reaching a length of 38.8 - 39.0 cm.

The growth rate decreased from 8 cm in the first year to 3 cm in the fifth year. From the sixth year onwards the growth was uniform with an average growth rate of 1 - 2 cm.

In the fishery the dominant age classes were between the second and third year groups. One year old specimens were recorded in the months of January, March and April (11.3-13.6 cm). Four year old specimens (29.5-32 cm) were observed in October and April .

PART- II.

ECOLOGY

CHAPTER 9

OBSERVATIONS ON BEHAVIOUR

Animal behavioural studies are of vital importance and in the case of holothurians their locomotion are very interesting. Parker (1921) studied the locomotion of the holothurian *Stichopus parvimensis*. Glynn (1965) studied the active movements in the holothurians *Astichopus* and *Leptosynapta*. The present chapter describes the observations regarding the burrowing behaviour and locomotion in *H. (M.) scabra*.

9.1 Results and Discussion

9.1.1 Mechanism of burrowing

At the time of introduction, individuals contracted initially and started crawling for one or two minutes. After contracting the body to the maximum extent, they slowly started feeding by digging the substratum with the help of oral tentacles, thereby a small pit was made and the individual began to burrow. This process took 20 to 30 minutes. In the next step, the individual moved further deep into the substratum and exposed the posterior end of the body. This condition was reached in 2 hours and referred as 'semi buried'. This process continues and the holothurians buried completely in the

substratum within 3-4 hours, leaving only the cloacal opening exposed for respiration.

It was observed that the individual, while burrowing fed continuously and each time eliminated 3 to 4 pellets of faecal matter, with an interval of 1 to 2 hours. It appears that *H. (M.) scabra* ingest sand while it burrows. Similar observations were made by Hyman (1955) in other burrowing species of holothurians.

9.1.2 Influence of light on burrowing

The 12 hour light and 12 hour dark experiment showed that nearly 45% were buried in the sand from 0900 to 1500 hours and more than 80% of the holothurians began to expose after 1500 hours. In the 24 hour dark experiment, nearly 70% of the holothurians had not buried themselves and in the 24 hour light experiment, 30% of the individuals buried from 0900 to 1500 hours (Table 17).

It may be seen that during day time between 0900 and 1500 hours, most of the holothurians buried in sand and exposed after 1800 hours. This shows that light is a vital and controlling factor in the burrowing habit of holothurians.

Table 17. Burrowing behaviour of *H. (M.) scabra* exposed to light

Time	Percentage								
	12 hr light & 12 hr dark			24 hr. dark			24 hr light		
(Hrs)	FE	FB	SB	FE	FB	SB	FE	FB	SB
0900	55.56	22.22	22.22	66.67	16.67	16.67	77.78	5.56	11.11
1200	61.12	27.78	11.11	94.45	5.55	--	72.23	22.22	5.55
1500	66.67	22.22	11.11	94.45	--	5.55	77.78	11.11	11.11
1800	100.00	--	--	100.00	--	--	88.89	11.11	--
2100	100.00	--	--	100.00	--	--	94.45	--	5.55
2400	94.45	5.55	--	100.00	--	--	100.00	--	--
0300	83.34	16.67	--	94.45	5.55	--	100.00	--	--
0600	83.34	16.67	--	83.34	5.55	11.11	100.00	--	--

FE=Fully exposed; FB=Fully buried; SB=Semi buried.

9.2 Locomotion

H. (M.) scabra lodges itself in sand by means of ambulacral tube-feet and creeps on the surface with the help of numerous podia present on the ventral side of the body.

The process of locomotion was accomplished by a muscular wave that originates at the posterior end of the animal and sweeps over to the anterior end. Before the locomotor wave begins the whole length of the body of the individual was attached to the substrate by its ambulacral tube feet (Fig. 19a). The tube-feet of the posterior portion were loosened from the substrate and the whole hind end was lifted well above the surface. The posterior portion of the animal then contracted vigorously on its length thus carrying the hind end forward to a new position (Fig. 19b). In this position, the posterior portion was then reapplied to the substrate to which its ambulacral tube-feet again became attached while the wave moved on to the middle of the animal (Fig. 19c). As this portion was attached, the muscular wave reached the anterior end, which was now projected forward (Fig. 19d) and finally attached to the substrate, when the condition characteristic of rest was resumed (Fig. 19e). The effect of the locomotor wave as it passed off at the anterior end of the animal was to carry this end as far forward as the posterior end was advanced and in this way *H. (M.) scabra* moved forward step by step over the substrate .

Fig. 19.

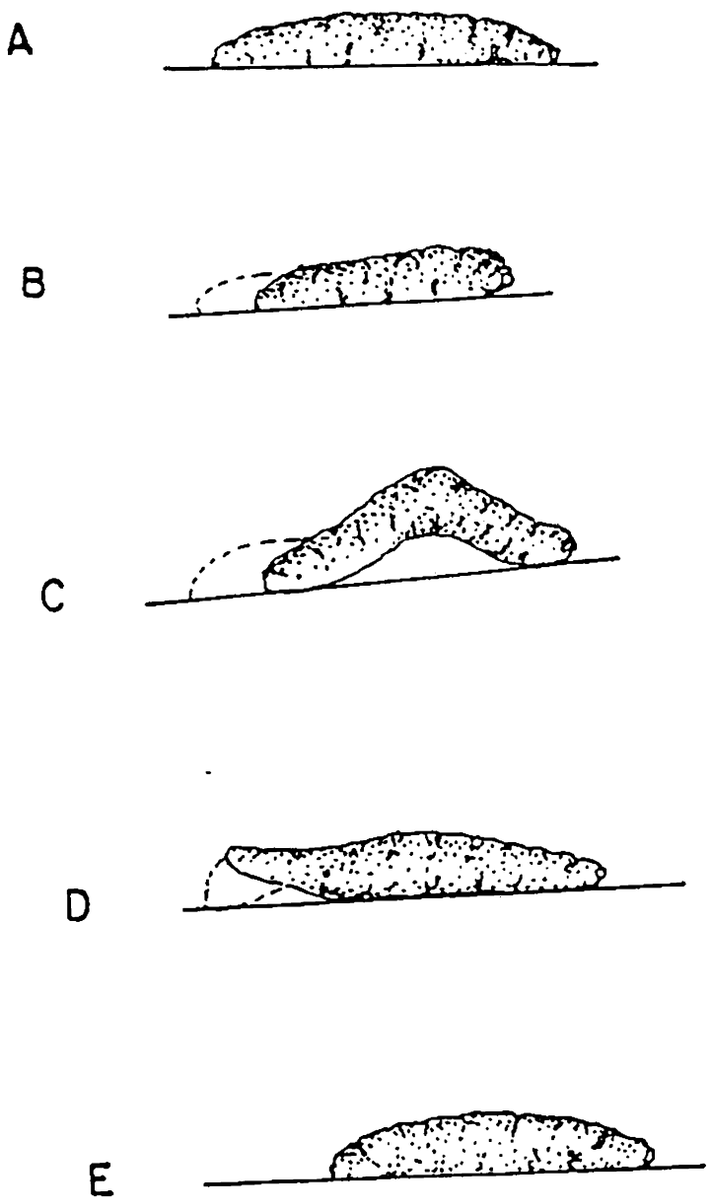


Fig. 19. Process of locomotion in *H. (H.) scabra*

(a) Resting position

(b) Initiation of wave at posterior end

(c) Muscular wave at the middle of body, posterior end returned to substrate.

(d) Muscular wave passing off at the anterior end.

(e) New resting position.

PART_III.

FISHERY

CHAPTER 10

PRESENT STATUS OF THE HOLOTHURIAN FISHERY

The processing of *beche-de-mer* is an age old industry introduced by the Chinese in India. Hornell (1917) gave history and revival of the industry at that time. Later, Krishnamoorthi (1957), Chari (1964), James (1973, 1991a) studied the holothurian resources from India. Jacob (1973), Shenoy, (1977), Durairaj (1982) and Durairaj *et al.* (1984) reported about the processing of *beche-de-mer*. In olden times, *beche-de-mer* and pearls were sent in exchange for porcelain, silks and sweet meats. In olden days the divers collected the holothurians without the aid of masks or fins. In early sixties, masks were locally fabricated and used extensively to collect the material. This facilitated clear visibility under water. The divers still could not afford to use rubber flippers because of the prohibitive cost. In late seventies, ordinary aluminium plates were used as flippers to increase the efficiency and manurability under water. This naturally resulted in better catches. It can be seen from the above statements that the industry has undergone vast changes over the years.

10.1 Species contributing to the fishery

The commercially important holothurians occur in Palk Bay

and the Gulf of Mannar of the southeast coast of India, of which *H. (M.) scabra* is the most important species, *H. spinifera* occurs in lesser numbers while *Bohadschia marmorata* is available occasionally at Kilakarai centre in the Gulf of Mannar. Recently, James and Bahrudeen (1990) reported on the fishery of *Actinopyga echinites* from the Gulf of Mannar. Small quantities of *H. atra* are also collected for processing nowadays.

The species *H. (M.) scabra* called **Vella attai** in Tamil, grows to a length of 40 cm and the body wall is 1 cm in thickness. The *H. spinifera* is sold separately with good price in the international market. It is locally called **Raja attai**. *B. marmorata* is known as **Nool attai**, grows to 40 cm length. The *A. echinites* is the deep-water red fish grows to 26 cm and weighs upto 430 g. During the year 1990, 26.5 tonnes of *A. echinites* was collected for processing.

10.2 Fishing methods

Holothurians were caught by skin divers, tallu valai and bottom trawlers.

10.2.1 Skin diving

Holothurians were fished by skin divers during low tide in the intertidal region. Usually, the divers go for fishing by

0700 hours and come back between 1500 to 1700 hours, using a boat. Nearly, 8-14 fishermen go in a boat. The number of persons depend on the size of the boat. On board, the fishermen form into two groups, one group goes for fishing, till then the other group waits in the boat and vice versa. Fishing was done approximately for 3 to 4 hours at a depth of 4-20 m (Plate VI,1).

For fishing, skin divers used aluminium plate as improvised flippers, mask and nylon bag of 20 mm mesh size, to keep the fished holothurians. Most of the catches are made by skin diving (Plate VI, 2,3 & 4).

10.2.2 Trawl net

The trawl is a very effective gear for capturing benthic organisms. These are conical bags which narrow at the cod end attached to moving boats, and while moving, their mouths are kept open. The trawlers are operated for fishing prawns and fish while holothurians are caught as bycatch in bottom trawl nets.

10.2.3 Tallu valai

Till now no special net is deviced for the capture of holothurians exclusively. The tallu valai units were operated at Tuticorin and Vedalai of the Gulf of Mannar, in the shallow waters of 3-6 m depth. The net used in these boats was

Plate VI Fishing and processing of *Beche-de-mer*

1. Fishing of holothurians by skin divers using mask.
2. Skin divers using round aluminium flippers and nylon net at their hip to store the fished holothurians.
3. Transportation of holothurians from coast to sea shore.
4. A basket with holothurians
5. Heap of holothurians on the beach
6. Degutting of holothurians

PLATEVI

1

4

2

5

6

called **madi valai** and was operated by three persons during March to September. The boat used for this was Tuticorin type boat **Catamarans** (James, 1967). The tallu valai units were used mainly for prawn fishing and holothurians were also caught accidentally.

The net called **madi valai** (bag net) consists of a bag like portion with side wings. The bag is about 9 m long and 1.8 m wide at the mouth. The cod end measured about 60 cm and had a mesh of 0.5 cm. The bag is preceeded by the hemp wings which measure 46 m on either side and are in turn followed by the warps of the same length. At the junction of the hemp wing and the warp a single float is attached to the head rope and a sinker to the foot rope.

10.3 Fishing season and areas along southeast coast

10.3.1 Fishing season

The Northeast monsoon commences in October-November and lasts upto March-April. During this period, the sea is relatively calm and fishing is carried out chiefly in the Gulf of Mannar as during this time the Palk Bay becomes rough. The Southwest monsoon commences in March-April and lasts till October-November when the Gulf of Mannar becomes rough and all fishing operations have to be suspended. During this period

intense fishing was done on Palk Bay.

10.3.2 Fishing areas

Gulf of Mannar

At Tuticorin, the holothurian fishery was conducted round the year by skin divers and tallu valai. The divers collect the holothurians mainly from the islands, especially from the Kaswar theevu and Van theevu at 4-12 m depth which is nearly 5 km away from the shore. The tallu valai units were operated in shallow waters between March and September. The species *H. (M.) scabra* constituted the major catch and *H.spinifera* occurred very rarely.

At Kilakarai, fishing was done mainly by skin divers. The holothurians were fished mainly from Nalla Thanni theevu, Yana Par theevu, Pallyamunai theevu, Pursumpatty theevu, Edamurrai theevu, Theedal theevu, Kilinjan Par theevu, Appa theevu and Vala theevu, at 2-16 m depth, the **theevu** meaning **Island.** The distance from the coast to the fishing islands was approximately 20 km and the gap between the islands was nearly 1 to 2 km. The species landed at Kilakarai were *H. (M.) scabra, H. spinifera, Bohadschia marmorata.* Of these, *H. (M.) scabra* predominates in the commercial catch.

At Vedalai, the holothurian fishery depends on divers and tallu valai, and fishing was done mainly from Manali theevu and

Musal theevu which is nearly 5 km away from the coast. Though both *H. (M.) scabra* and *H. spinifera* were collected, *H. (M.) scabra* formed a major fishery.

Palk Bay

At Rameswaram, the holothurians were collected by skin divers and trawlers as bycatch. The divers fished the holothurians mainly from Dhanuskodi at a depth of 4-16 m, which was about 15-20 km away from the coast. At Rameswaram, *H. (M.) scabra* and *H. spinifera* were recorded. The trawlers were operated at 10-20 m and the important species fished by trawl nets were *H. (M.) scabra* and *H. spinifera* with a greater occurrence of *H. (M.) scabra*.

Tirupalakudi is one of the major centres on the Palk Bay side where fishery is going on for the last few decades. Fishery depends on the skin divers and the fishing activity was carried out from Panaikulam and Attankarai of the Palk Bay coast, which is nearly 20 km away from the coast. The important species available were *H. (M.) scabra* and *H. spinifera*.

Based on the above observations, it was found that in the Gulf of Mannar, the season for holothurian fishing was from October to March, with peak intensities in December and January,

whereas at Palk Bay, the season began from March and ended in October, with a peak in April and May. At some places, season may advance due to monsoon.

10.4 Particulars of catch

The details of holothurian landings and their species composition from the Gulf of Mannar and Palk Bay of southeast coast of India, during 1988-1990 are presented in Tables 18-21 and Figs 20-24.

10.4.1 Species composition

From table 18, it appears that at Tuticorin, 100% of holothurians caught were *H. (M.) scabra* during 1988-1990, with a total catch of 33.35 tonnes. At Kilakarai, the species were *H. (M.) scabra*, *H. spinifera* and *B. marmorata* which constituted 69.79%, 30.18% and 0.03% during 1988-1989, and 91.43%, 8.43% and 0.14% in 1989-1990 respectively. The total catch recorded from this centre was 31.15 tonnes. At Vedalai, the holothurians fished were *H. (M.) scabra* and *H. spinifera* having 98.92% and 1.08% in 1988-1989, 99.2% and 0.8% during 1989-1990 with a total production of 12.66 tonnes.

At Rameswaram, the annual percentage occurrence of *H. (M.) scabra* and *H. spinifera* constituted 52.08% and 47.92%

Table 18. Species wise catch composition of holothurian landings from different centres during 1988-1990.

Centres	1988-89				1989-90				Average (1988-90)			
	H.sc	H.sp	B.m	Total (in tonnes)	H.sc	H.sp	B.m	Total	H.sc	H.sp	B.m	Overall total (in tonnes)
Tuticorin	100.00	--	--	12.45	100.00	--	--	20.90	100.00	--	--	33.35
Kilakarai	69.79	30.18	0.03	27.40	91.43	8.43	0.14	3.75	72.40	27.56	0.04	31.15
Vedalai	98.92	1.08	--	2.93	99.20	0.80	--	9.73	99.13	0.87	--	12.66
Rameswaram	52.08	47.92	--	10.00	97.79	2.21	--	5.26	67.84	32.16	--	15.26
Tirupalakudi	87.11	12.89	--	93.80	93.41	6.59	--	40.44	89.01	10.99	--	134.24

H.sc= *H. (M.) scabra*; H.sp= *H.spinifera*; B.m =*B. marmorata*

Table 19. Gear wise catch composition of holothurian landings from different centres during 1988-1990.

Centre	1988-89			1989-90			Average (1988-90)			Overall total (in kg)
	Diving	Tallu valai	Trawl	Diving	Tallu valai	Trawl	Diving	Tallu valai	Trawl	
Tuticorin	94.17	5.83	--	98.51	1.49	--	96.89	3.11	--	33328.68
Kilakarai	100.00	--	--	100.00	--	--	100.00	--	--	31179.34
Vedalai	21.31	78.69	--	64.71	35.29	--	54.66	45.34	--	12652.17
Rameswaram	74.21	--	25.79	--	--	100.00	48.63	--	51.37	15262.75
Tirupalakudi	100.00	--	--	100.00	--	--	100.00	--	--	134223.05

Table 20. Total landings (in tonnes) of holothurians in Gulf of Mannar and the Palk Bay coast.

Centre	1988-89	1989-90	1988-90
Gulf of Mannar			
Tuticorin	12.45	20.90	33.35
Kilakarai	27.40	3.75	31.15
Vedalai	2.93	9.73	12.66
Total	42.78	34.38	77.16
Palk Bay			
Rameswaram	10.00	5.26	15.26
Tirupalakudi	93.80	40.44	134.24
Total	103.80	45.70	149.50
Total % of catch in 1988-90			74.40%

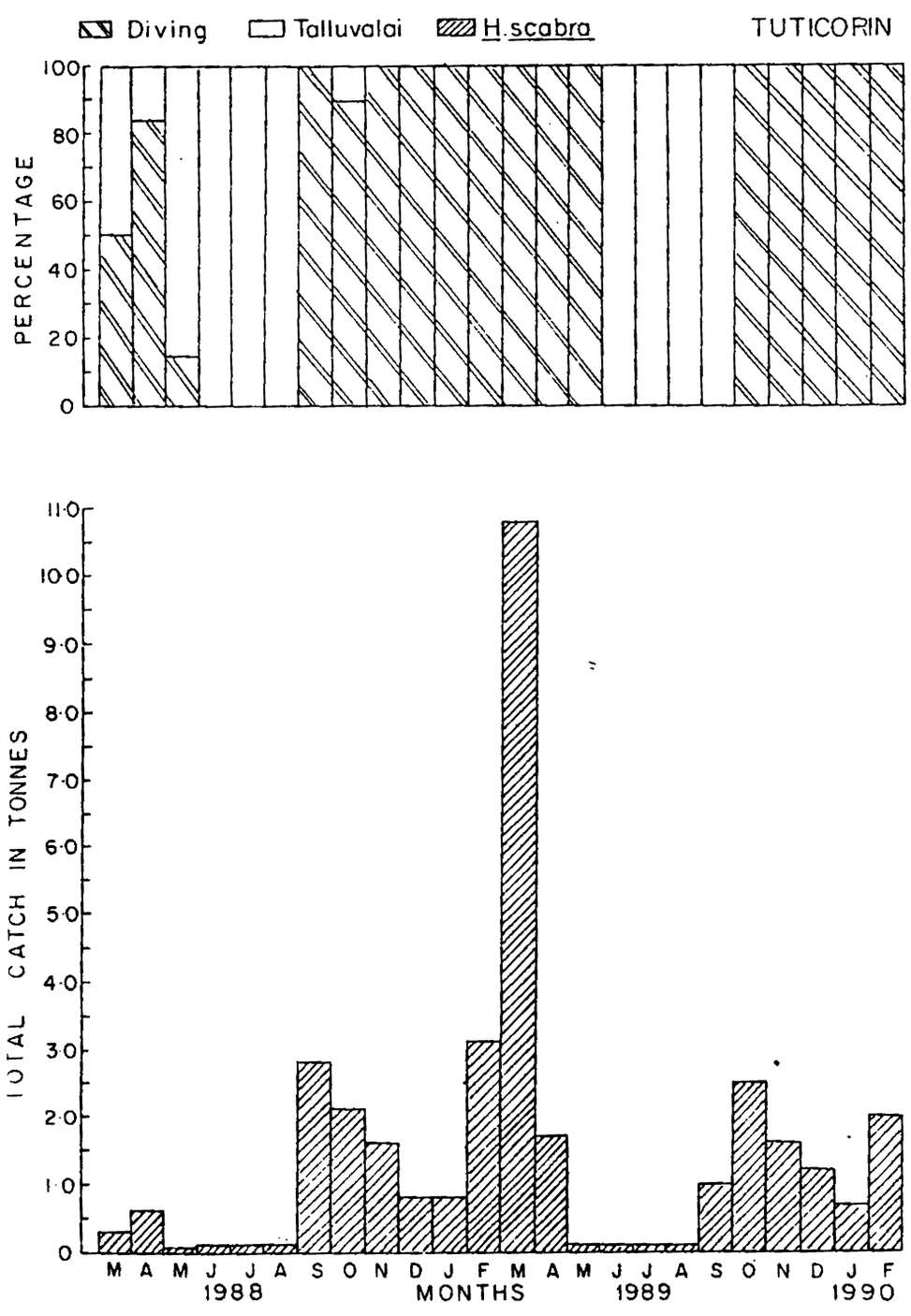
respectively in 1988-1989, 97.79% and 2.21% in 1989-1990 having a total catch of 15.26 tonnes. At Tirupalakudi, the main species were *H. (M.) scabra* and *H. spinifera*. Of these, *H. (M.) scabra* was dominant. The percentage occurrence of the two species was 87.11% and 12.89% during 1988-1989, 93.41% and 6.59% in 1989-1990. The total catch recorded in this centre was 134.24 tonnes.

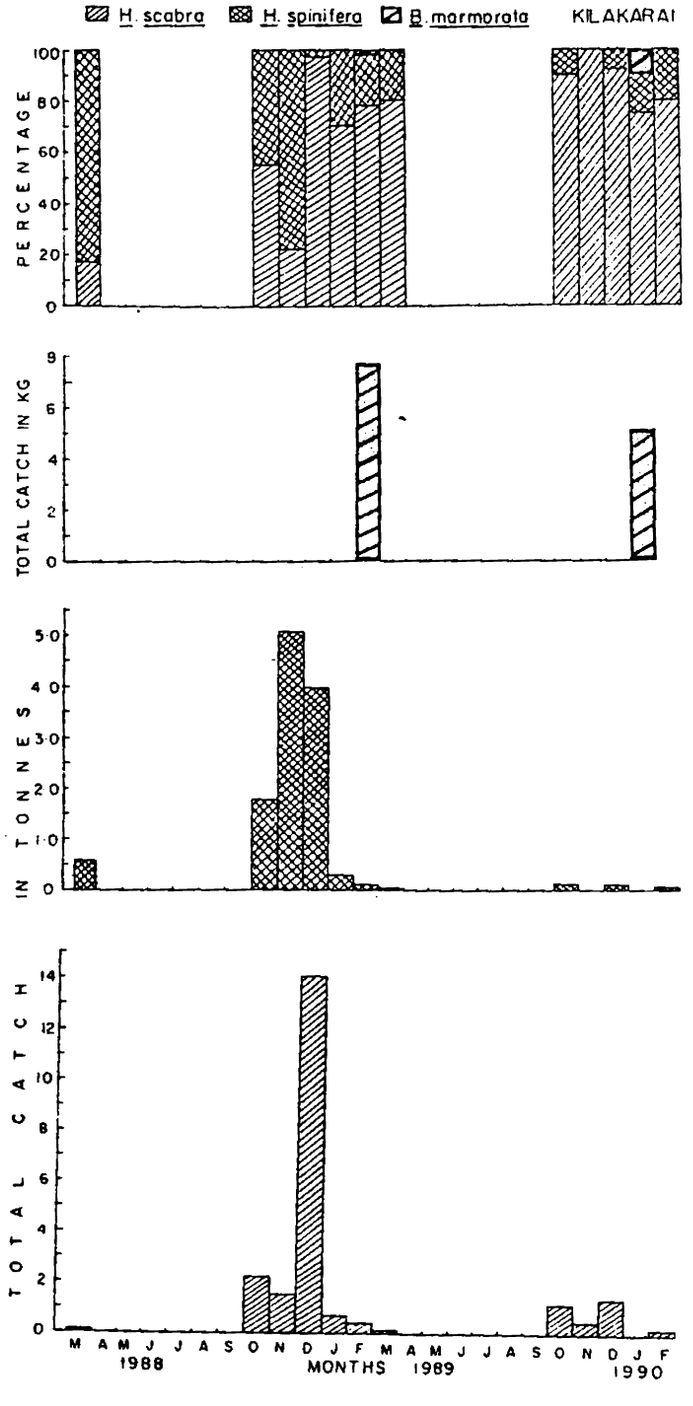
Figure 20 depicts the monthly catches of holothurians landed at Tuticorin. In March 1989, 11.0 tonnes of *H. (M.) scabra* were caught. The gear wise percentage occurrence of holothurians indicated that diving was done from March 1988 to May 1988, September 1988 to May 1989 and October 1989 to February 1990. The tallu valai was operated during March 1988 to August 1988 and June 1989 to September 1989. It was found that 100% catches were recorded by diving in the month of September 1988, November 1988 to May 1989, October 1989 to February 1990. 100% catch was recorded by tallu valai which is similar to the results obtained by skin diving during the month of June to August 1988 and June to September 1989.

Figure 21 indicates that in Kilakarai, the fishing of holothurians was seasonal from March to October during the years of study. The maximum catch (13.6 tonnes) of *H. (M.) scabra* was recorded in December 1989 and 5.0 tonnes of *H. spinifera* was

Fig. 20. Monthly landing of holothurians and their percentage occurrence, using skin diving and tallu valai from Tuticorin (March 1988-February 1990).

Fig. 21. Monthly landing of different species of holothurians by skin diving and their percentage occurrence from Kilakarai (March 1988- February 1990).


Diving
Talluvalai
H.scabra
TUTICORIN
PERCENTAGE
TOTAL CATCH IN TONNES
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990


H. scabra
H. spinifera
B. marmorata
KILAKARAI
PERCENTAGE
TOTAL CATCH IN KG
IN TONNES
TOTAL CATCH
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990

landed in November 1988. The species *Bohadschia marmorata* was landed rarely with 7.8 kg. and 5.0 kg. during the month of February 1989 and 1990.

At Vedalai, gear wise catch was recorded. In tallu valai, *H. (M.) scabra* was fished in all the months during 1988-1990, with a maximum catch of 1.6 tonnes in November 1989. *H. spinifera* was recorded in August and October 1988, January and December 1989 and January 1990, with a dominant catch of 20 kg. in January 1990. Diving was performed in the month of October in both the years. Maximum catches of *H. (M.) scabra* and *H. spinifera* recorded in October 1989 were 6.0 tonnes and 50 kg respectively (Fig. 22).

At Rameswaram (Fig. 23) the catches recorded by skin diving were maximum in July 1988 (13 tonnes) and in March 1988 (4 tonnes). In trawlers, *H. (M.) scabra* was collected more during March 1989 (1.4 tonnes) and *H. spinifera* was fished more in September 1988 (46 kg). The total catch of holothurians landed at this centre was 4.75 tonnes during March 1988.

At Tirupalakudi (Fig. 24) the holothurians were caught from July 1988 to October 1989 except in the months of November and December 1988. The peak landings of the holothurian *H. (M.) scabra* were found in February 1989 (39.5 tonnes) while those of

Fig. 22.

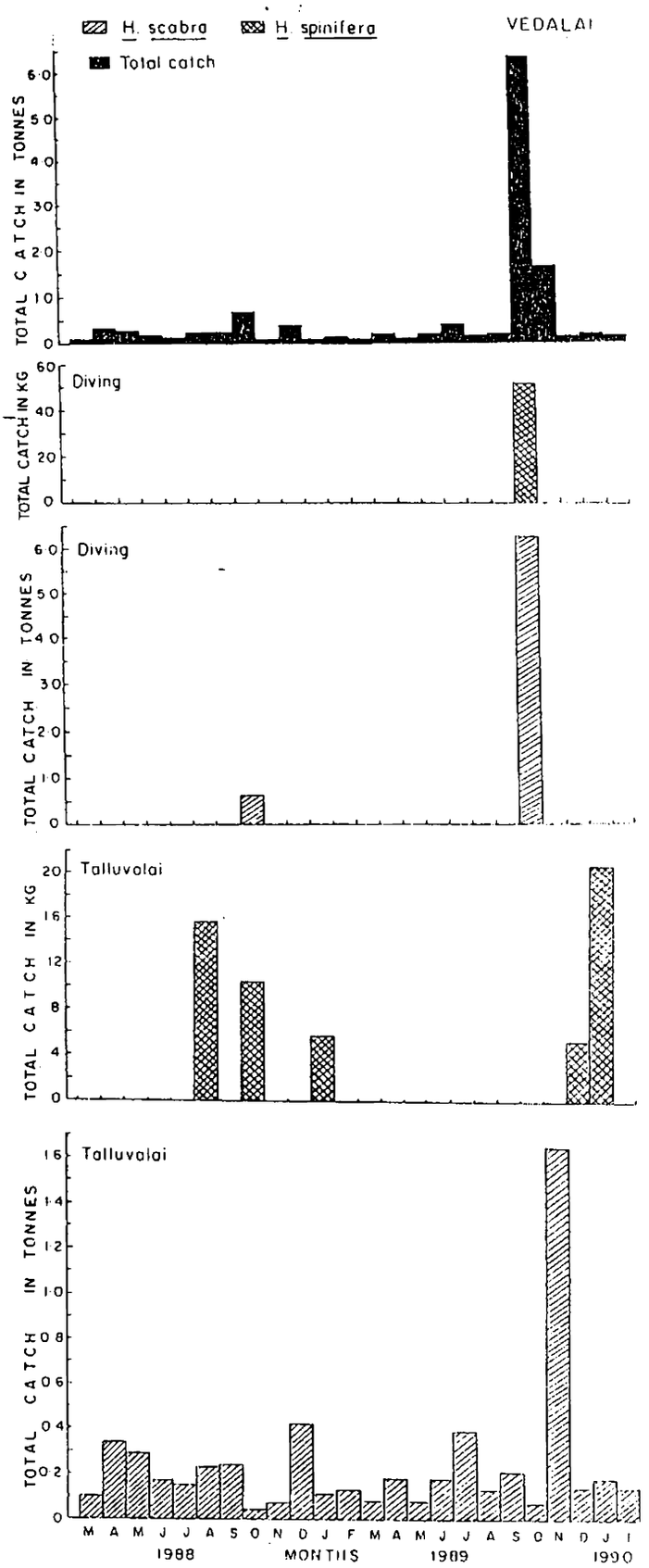
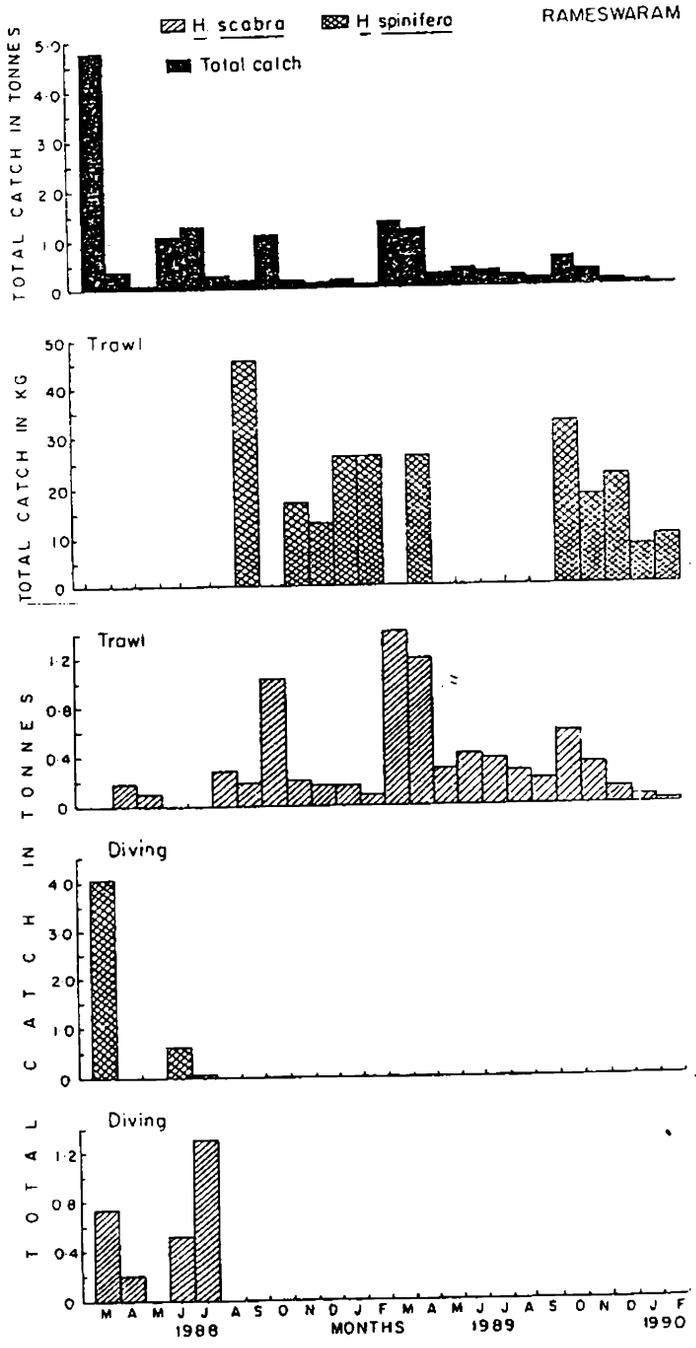
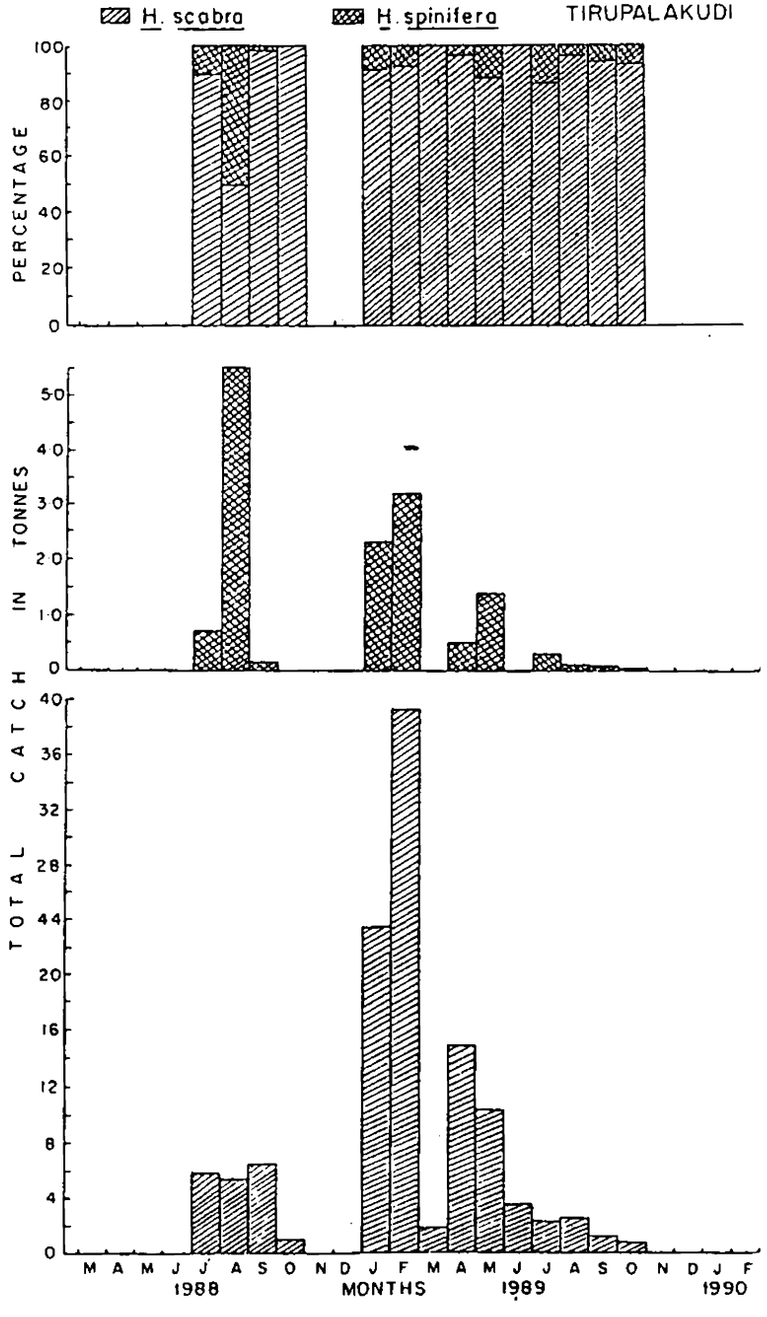


Fig. 22. Total catches of holothurians using skin diving and tallu valai from Vedalai (March 1988- February 1990).

Fig. 23. Total catches of holothurians by trawlers and skin diving from Rameswaram (March 1988- February 1990).

Fig. 24. Total landings (in tonnes) of holothurians by skin diving and their percentage occurrence from Tirupalakudi (March 1988- February 1990).


H. scabra
H. spinifera
Total catch
RAMESWARAM
TOTAL CATCH IN TONNES
Trawl
TOTAL CATCH IN KG
Trawl
TOTAL CATCH IN TONNES
Diving
TOTAL CATCH IN TONNES
Diving
TOTAL CATCH IN TONNES
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990


H. scabra
H. spinifera
TIRUPALAKUDI
PERCENTAGE
TOTAL CATCH IN TONNES
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990

H. spinifera in August 1988 (6.0 tonnes) respectively. The percentage composition of different species of holothurians showed that *H. (M.) scabra* recorded was 100% in October 1988, March and June 1989.

It is clear from the above that *H. (M.) scabra* recorded maximum catch in all the fishing centres on the Gulf of Mannar and Palk Bay which constituted 90.51% and 78.43% respectively, during 1988-1990. This indicated that *H. (M.) scabra* was exploited maximum along the southeast coast, whereas *H. spinifera* and *B. marmorata* together constituted 9.49% in the Gulf of Mannar and 14.38% in Palk Bay. There was a vast resource of other holothurians along the southeast coast. At some places notably Tirupalakudi, *H. (M.) scabra* was exploited heavily (89%). To diversify the fishing intensity of the above species and to develop the *beche-de-mer* industry, other commercially important species of holothurians should be exploited. Thereby the resources of *H. (M.) scabra* can be conserved and managed in a better way, and ecological balance can also be maintained.

10.4.2 Gearwise catch composition

The catch composition of holothurians using different gears such as skin diving, tallu valai and trawls, collected from different centres of the southeast coast of India are presented

in Table 19 and Figs. 20-24.

Table 19 shows that at Tuticorin, diving and tallu valai were used having a percentage of 96.89 and 3.11% respectively, with a total catch of 33328.68 kg during 1988-1990. At Kilakarai, 100% of the holothurians were caught by skin diving and recorded a total landing of 31179.34 kg in 1988-1990. At Vedalai, the main catch was by skin diving and tallu valai, the percentages of catch estimated being 54.66% and 45.34% respectively, with a net production of 12652.17 kg in 1988-1990.

At Rameswaram, holothurians are fished by diving (48.63%) and trawlers (51.37%), the total catch estimated being 15262.75 kg during 1988-1990. At Tirupalakudi, the holothurians were collected mainly by divers (100%) with a total landing of 134223.05 kg during the year 1988-1990.

It is evident that fishing of holothurians by skin divers was common at all the centres. Tallu valai was operated at Tuticorin and Vedalai on the Gulf of Mannar and trawl was used at Rameswaram. In this context, it is important to mention that the percentage occurrence of holothurians caught by skin divers was 83.85% in Gulf of Mannar and 74.32% in Palk Bay and by tallu valai 16.15% in the Gulf of Mannar and by trawl 25.69% in Palk Bay.

An overall view shows that the percentage of holothurians caught by skin divers, tallu valai and trawlers were 80.05%, 9.69% and 10.27% respectively. This confirms the view that holothurian resources are exploited more by skin divers.

Table 20 shows that the holothurians landed from the Gulf of Mannar were 25.72 tonnes and from Palk Bay 74.75 tonnes, during 1988-1990, which constituted 25.6% and 74.4% respectively. In this context, it is important to state that the Palk Bay coast is productive and the resources are heavily exploited.

The estimated total landings for the Gulf of Mannar were 154.32 tonnes and for Palk Bay coast they were 897.00 tonnes during 1988-1990. Thus, the estimated total catch of holothurians along the southeast coast was 1051.32 tonnes in 1988-1990, and on conversion to, *beche-de-mer* (dried product), it was roughly estimated at 88.10 tonnes, based on the report made by Basker and James (1989) (Table 21).

10.5 Catch per Unit Effort (CPUE)

The Catch Per Unit Effort (CPUE) was estimated from five different centres during March 1988 to February 1989 and March 1989 to February 1990 and are given in Fig. 25.

At Tuticorin, the fishing effort was recorded maximum by

Table 21. Estimated total landings of holothurians and production of *beche-de-mer* along southeast coast (1988-90)

Coast	Average catch per centre (in tonnes)	No. of centre	Total catch in the coast (in tonnes)	*Beche-de-mer* production (in tonnes)
Gulf of Mannar	25.72	6	154.32	12.93
Palk Bay	74.75	12	897.00	75.17
Net total production			1051.32	88.10

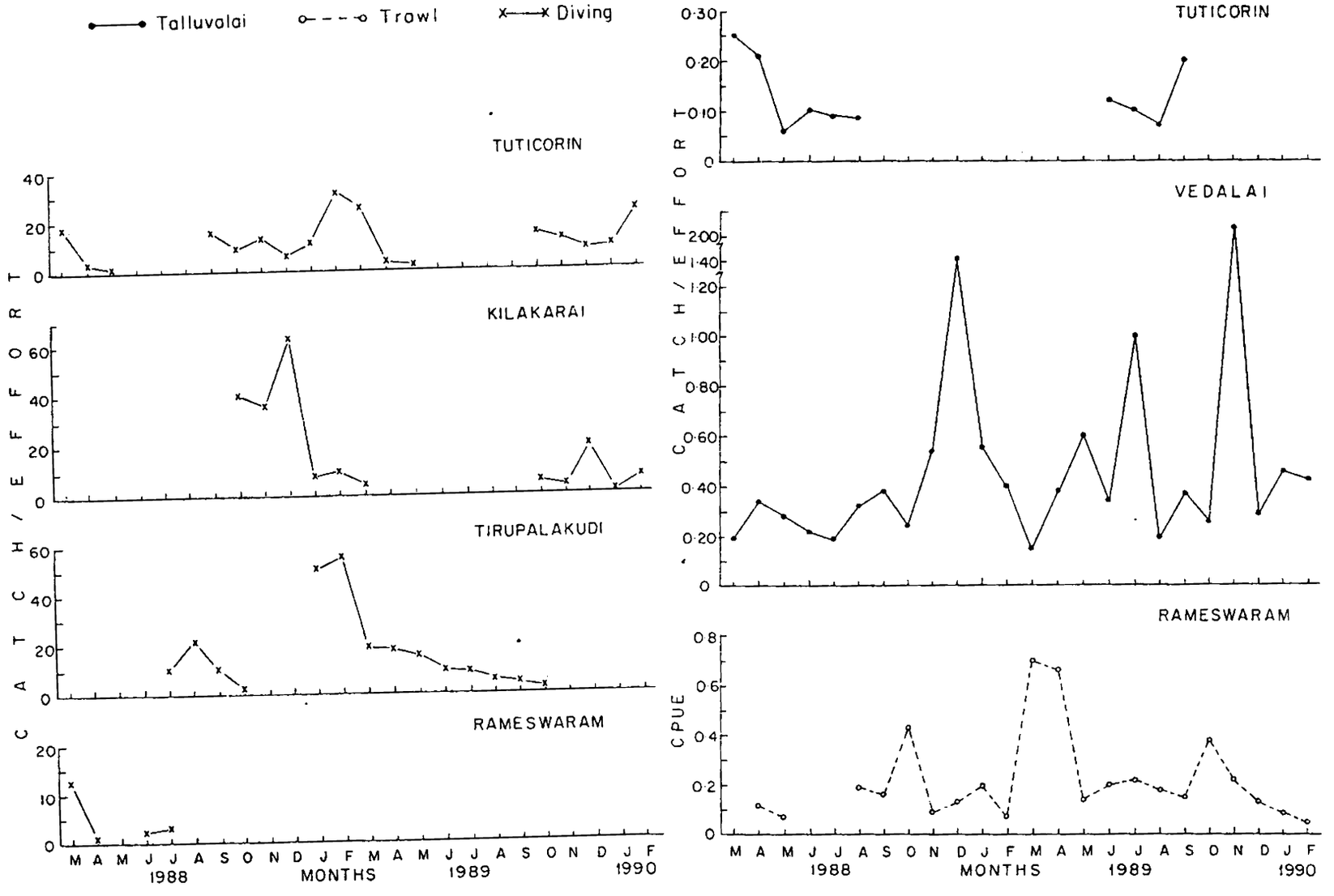
Table 22. Export figures of *beche-de-mer* from India during 1978-1989.

Year	Weight of *beche-de-mer* (in Kg)	Value of *beche-de-mer* (in Rs)
1978	24537	1076560
1979	31231	1522941
1980	34013	1872314
1981	47841	2628757
1982	37143	1723558
1983	71853	3696765
1984	20715	1797948
1985	11993	1168213
1986	32864	3803858
1987	53755	7937977
1988	22682	4994371
1989	51572	12302933

Source : James (1989).

Fig. 25. The Catch Per Unit Effort of holothurian landings using skin diving, trawlers and tallu valai (March 1988-February 1990).

Fig. 25.


Talluvalai
Trawl
Diving
TUTICORIN
KILAKARAI
TIRUPALAKUDI
RAMESWARAM
CATCH/EFFORT
TUTICORIN
VEDALAI
RAMESWARAM
CPUE
MONTHS
1988
1989
1990

skin divers during February 1989 (30.08 kg) and March 1989 (24.51 kg) and at Kilakarai, December 1988 and December 1989, the intensity of fishing was dominant with 62.74 kg and 19.43 kg respectively. At Vedalai in the Gulf of Mannar coast, the fishing effort was found more in October 1989 (20.17 kg). While in the Palk Bay coast, particularly at Tirupalakudi the intensity was recorded in February 1989 (54.6 kg) and March 1989 (18.00 kg) and at Rameswaram, 12.44 kg was found during March 1988.

In tallu valai, fishing effort was more in October 1988 (0.27 kg) September 1989 (0.20 kg) at Tuticorin, while at Vedalai, it was 1.45 kg during December 1988 and 2.03 kg during November 1989. In trawls the fishing effort was more during October 1988 (0.43 kg) and March 1989 (0.70 kg) at Rameshwaram.

10.6 Export

During the year 1981, 48 tonnes of *beche-de-mer* worth Rs. 26.69 lakh, while in 1983, 71.85 tonnes of *beche-de-mer* worth Rs. 36.97 lakhs was exported. Due to the ban imposed in 1982 on the export of *beche-de-mer* below 3 inches size (75 mm), the trade dwindled to a certain extent, and value fluctuated to 17.98 and 11.68 lakhs during 1984 & 1985 respectively. Whereas again in 1987 and 1989, 82.34 and 123.03 lakhs worth of *beche-de-mer* was exported from India. (Table 22). *Beche-de-mer* (Plate VII, e & f)

is mainly exported to Singapore, Hongkong and other Southeast Asian countries.

10.7 *Beche-de-mer* processing

Degutting : The sea cucumbers were brought to the shore and were heaped. A slit of 20-30 mm was made at the posterior end of each animal with a sharp knife. The intestine, respiratory tree and the gonads were removed by bending the individual after which it was cleaned in sea water (Plate VI, 5 & 6).

Boiling : Boiling is an important step in processing the holothurians and the quality depends on the shape of the vessel used and the stirring done (Plate VII, b). The fishermen used oil drums (Tin) of 200 litre capacity and aluminium vessels for boiling. The usage depends on the availability of the material on hand. Initially, sea water was boiled then the degutted sea cucumbers were put slowly. Boiling was done roughly for 30-45 minutes the exact boiling time depending upon animal size. *Beche-de-mer* shrinks slightly and gradually become hard. Hardness is the best way to judge the quality. Constant stirring of holothurians using a wooden

spatula improves the rolling of *beche-de-mer*. The entire sample is then burried in a pit near the beach for 12 hours, after which the lot is taken out. The chalky white patches deposited on the ventral side are cleaned, washed and boiled in sea water once again for 30 minutes with constant stirring. While boiling, it is important to see that the boiling pan should get constant heat on all the sides as this ensures good quality of the product. Coconut husks, coconut shells, mangrove wood and some other hard woods were being used as fire material.

Drying: The boiled specimens were spread on the palmarh mat or coirmat and dried in sunlight for 3-4 days (Plate VII, c).

Smoking: During rainy season, the boiled specimens were smoked by placing them on top of the iron wire mesh placed on top of fire source. The heat on the iron net absorbs the moisture content of the specimens. While smoking, the specimens were turned up and down uniformly.

Odour: The product should be free from bad odour. When it comes in contact with water it has an offensive odour.

Colour: Dark colour is generally preferred. The chalky white ventral surface of sandfish *H. (M.) scabra* should be avoided (Plate VII, d).

Moisture content:

Beche-de-mer stored in a humid atmosphere tends to absorb moisture and becomes soft. 20 to 30 percent moisture content by weight may be allowed. A hard dry product is preferred to a soft, moisture laden one.

Spoilage: Products should be free from bacterial and chemical spoilage.

Packing and storing:

The graded product is packed in polythene bags arranged and kept on a palmarh woven basket and stitched with gunny bags before shipment. The packed product awaiting shipment should be stored in a dry place. When the product is to be stored for a long time in humid conditions, re-drying is generally necessary.

Plate VII Processing of *Beche-de-mer*

a. Involvement of women in degutting of holothurians

b. Boiling of the degutted holothurians

c. *Beche-de-mer* dried on Palmarh

d. Uncleaned *beche-de-mer*

e. Different sizes of *beche-de-mer*

   (a) 1.5 inch

   (b) 2.5 inch

   (c) 3 inch

   (d) above 3 inch

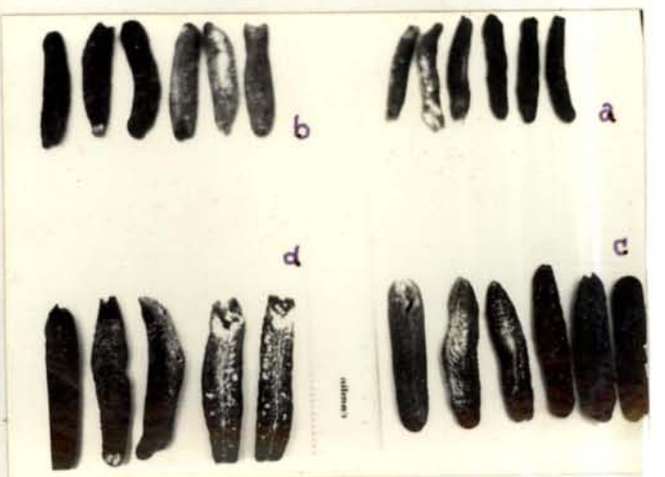
f. Export size of *beche-de-mer* (3 inch)

PLATE VII

a

d

b



e

CHAPTER 11

SUMMARY

The results of the present study are summarised as follows:

1. The distribution of the holothurian *H. (M.) scabra* indicated its availability all along coastal areas on Palk Bay from Rameswaram to Mallipattinam and along the Gulf of Mannar coast from Pamban to Ervadi and Tuticorin, at 4-20 m depth.

2. The major fishing for holothurians was done by skin diving at all the centres. The tallu valai was operated at Tuticorin and Vedalai and trawlers were operated at Rameswaram .

3. The food of *H. (M.) scabra* consists of organic matter which contains mud, sand, shell debris, bivalves and algae. Observations indicated the species seems to be a non-selective feeder.

4. Quantitatively, H. (M.) scabra prefered the particles of 500 μ size which constituted 62.15% of the gut content. This confirmed that the above species prefers the muddy-sandy substratum.

5. There is no significant difference between the size of individual and size of the particles in the gut contents of *H. (M.) scabra*. Also, there is no relationship between total length, total weight and gutted weight of the animal with the total length and total wet weight of the digestive tract.

6. It was observed that *H. (M.) scabra* feeds actively during breeding seasons *viz.* March - April and November - December.

7. The analysis of the biochemical constituents *viz.* organic carbon, organic matter, carbohydrate, nitrogen and protein from the sediments where the individual lives as well as from the digestive tract showed that the assimilation efficiencies from oesophagus to faeces to be 16.29% of organic carbon and organic matter, 18.53% of carbohydrate and 32.41% of nitrogen and protein. From the sediment to faeces the assimilation efficiencies was found to be 7.56% of organic matter, 30.38% of organic carbon, 26.53% of carbohydrate, 21.75% of nitrogen and 21.77% of protein .

8. The assimilation efficiency from sediment to faeces indicated that the faecal pellets of *H. (M.) scabra* are semidigested .

9. The length and weight relationship was found to be: for indeterminate $W = 1.047887\ L^{1.0527}$ ($r = 0.79$); Male $W = 0.0091878\ L^{2.3648}$ ($r = 0.86$); Female $W = 0.000591583\ L^{2.4460}$ ($r = 0.89$); and for (pooled) Male and Female $W = 0.0007392524\ L^{2.4049}$ ($r = 0.88$). The exponent value was significantly different from 3. This indicated that the length and weight relationship corresponds to allometric growth.

10. The reproductive cycle of the present species showed five stages of maturity *viz.* immature, maturing, early mature, late mature and spent, based on the macroscopical and microscopical observations of the gonads.

11. The gonad index (GI) values were found maximum in males during the months of April-June and October-November while in females during April-May and in the month of November. This indicated a high gonadial maturity in these months. A negative correlation was found between gonad index and salinity, and no relationship was noted between gonad index and temperature.

12. The size at first maturity of the species indicated that the male attains maturity at 21.0 cm and the females at

21.3 cm. The mean total weight (TW) recorded in male was 290 g and in female 310 g, and the mean gutted weight observed was 125 g for the pooled data.

13. Two spawning seasons were observed in *H. (M.) scabra* one in March-April and next in November-December. Juveniles (3-5 cm) was recorded in March 1989 from Pamban (Chinnapalayam) along the Gulf of Mannar coast which would have been recruited some time in November - December of the earlier year.

14. Young ones of *H. (M.) scabra* prefer algal ground to bury themselves into the muddy-sandy substratum.

15. The fecundity observed in *H. (M.) scabra* was ranged from 1,04,688 to 10,04,160 ova. A significant relationship was noted between the fecundity and gonad weight by logarithmic regression ($\log_e F = 9.3892 + 1.6768 \log_e G$; $r^2 = 0.82$).

16. A multiple relationship was fitted between total length, total weight, gutted weight, gonad weight and maturity stages were found significant.

17. The ratio of males to females, on an average was found to be 1:0.89 and during the breeding season ratio was

found to be 1:1. Significant chi square values were obtained during the months of May, July, December 1988 and January 1989 ($P < 0.05$).

18. Results on age and growth indicated L_{∞} = 40.37 cm and k = 0.327 (annual) and L_{∞} = 39.6 cm and k = 0.42 (annual) respectively . The maximum length recorded was 40 cm . The growth parameters L_{∞} and k as obtained in both the methods did not show much variation. Based on these, a life span of 10 years is indicated for the species. The growth rate was 8 cm in the first year which decreased to 3 cm in the fifth year. From the sixth year onwards the growth was uniform with an average growth rate of 1-2 cm.

19. The burrowing behaviour and locomotion of *H. (M.) scabra* was observed in the laboratory. The experimental work showed that light plays a vital and controlling role in burrowing habit of holothurians.

20. The fishing season for holothurians commences from October to March along Gulf of Mannar coast and from March to October along Palk Bay coast.

21. The species fished in the southeast coast include *Holothuria scabra, H. spinifera, H. atra* and

Bohadschia marmorata. Of these, *H. (M.) scabra* was dominant.

22. The total catches recorded from Tuticorin, Kilakarai, Vedalai, Rameswaram and Tirupalakudi centres were 33.35, 31.15, 12.66, 15.26 and 134.24 tonnes respectively. Of the five centres, Tirupalakudi forms the major centre for holothurian fishing.

23. The percentage of catches recorded by skin diving, trawlers and tallu valai were 80.04%, 10.27% and 9.69% respectively. Skin diving contributes to maximum catch.

24. Of the total catch, 83.85% of the catches by skin diving comes from Gulf of Mannar and 74.32% from Palk Bay. Tallu valai contributes to 16.15% from the Gulf of Mannar. Trawlers contribute to 25.69% from Palk Bay.

25. The holothurians landed all along the Gulf of Mannar and Palk Bay coasts constitute 25.6% and 74.4% respectively. This showed that Palk Bay coast is more productive.

REFERENCES

01*. AKHMET' EVA, E.A., B.A SMIRNOV and O.K. BORDOVSKIJ, 1982. On some peculiarities of organic matter composition in the intestine contents of the bottom detritus feeding holothurians. *Oceanologiya* 22(6): 1021-1024.

02. ATWOOD, D.G. and F.S. CHIA, 1974. Fine structure of an unusual spermatozoan of a brooding sea cucumber, *Cucumaria lubrica*. *Can. J. Zool.*, 52(4):519-532.

03. BAKUS, G.J., 1968. Defensive mechanisms and ecology of some tropical holothurians. *Mar. Biol.*, 2:23-32.

04. BAKUS, G.J, 1973. The biology and ecology of tropical holothurians. In: **Biology and Geology of Coral reefs.** vol.2.Edited by O.A.Jones and R. Endean. Academic Press, New York. p 325-367.

05. BAL, D.V., and K.V. RAO, 1990. **Marine Fisheries.** Tata McGraw-Hill publishing company limited, New Delhi.

06. BASKAR, B.K., and P.S.B.R.JAMES, 1989. Size and weight reduction in *Holothuria scabra* processed as *beche-de-mer*. *Mar. Fish. Infor. Serv. T&E ser.* No. 100:13-16.

07*. BELL, F.J., 1887. The Echinoderm fauna of the Island of Ceylon. Scient. Trans. R. Publ. Soc. (2) 3 (14): 643 - 658.

08. CAMERON, J.L. and P.V. FANKBONER, 1984. Tentacle structure and feeding processes in life stages of the commercial sea cucumber *Parastichopus californicus* (Stimpson). *J. Exp. Mar. Biol. Ecol.*, 81:193-209.

09. CAMERON, J.L. and P.V. FANKBONER, 1986. Reproductive biology of the commercial sea cucumber *Parastichopus californicus* (Stimpson) (Echinodermata: Holothuroidea) I. Reproductive periodicity and spawning behaviour. *Can. J. Zool.*, 64(1): 168-175.

10. CAMERON, J.L. and P.V.FANKBONER, 1989. Reproductive biology of the commercial sea cucumber *Parastichopus californicus* (Stimpson) (Echinodermata: Holothuroidea) II. Observations on the ecology of development, recruitment and the juvenile life stage. *J.Exp. Mar. Biol. Ecol.*, 127:43-67.

11. CHARI, S.T., 1964. The Indian *beche-de-mer* industry. *Indian Sea foods*, 1(4):11-13.

12*. CHOE, S., 1963. **Biology of the Japanese common sea cucumber** *Stichopus japonicus* (Selenka). Ph.D. Thesis, National University. pp. 226.

13. CLARK, G.L., 1954. **Elements of Ecology.** Philladelphia, Saunders. 534p.

14. CLARK, A.M., and F.W.E.ROWE, 1971. **Monograph of Shallow-water Indo-West Pacific echinoderms.** *British Museum (Natural History)* London. pp 238.

15. CLARK, G., 1981. **Staining Procedures.** Williams and Wilkins, U.S.A. pp 473.

16. COATES, M., H.F. CHAPMAN and D.W.CONNELL, 1984. Effects of grazing by deposit feeders on biogenic hydrocarbons in coral-reef surface sediments. *Mar. Biol.*, 81(1):87-95.

17. COLWIN, L.H., 1948. Note on the spawning of the holothurian *Thyone briareus* (Lesseur). *Biol. Bull.*, 95(3):296-306.

18. CONAND, C., 1981. sexual cycle of three commercially

important holothurian species (Echinodermata : Holothuroidea) from the lagoon of New Caledonia. *Bull. Mar. Sci.*, 31(3): 523-543.

19. CONAND, C., 1982. Reproductive cycle and biometric relations in a population of *Actinopyga echinites* (Echinodermata: Holothuroidea) from the lagoon of New Caledonia, Western Tropical Pacific. In : **Echinoderms.** Proceedings of the International conference, Tampa Bay, Ed. by. J.M. Lawrence, Rotterdam, Balkema. pp:437-442.

20. CONAND, C., 1983. Methods of studying growth in holothurian (*Beche-de-mer*), and preliminary result from a *beche-de-mer* tagging experiment in New Caledonia. *SPC Fish Newslet.*, No. 26:31-38.

21. CONAND, C., 1986. Les ressources lalieutiques des pays insulaires du pacipique. Les holothuries. *FAO DOC. Tech. peches*, (272.2):108

22. CONAND, C., 1988. *Beche-de-mer* in New Caledonia: Biology and Fishing. *SPC/Inshore Fish Res./WP.5.P*: 1-12.

23. CONAND, C., 1990. The fishery resources of Pacific island countries. Part 2. Holothurians. **FAO Fisheries**

Technical Paper, No. 272.2. Rome, FAO. 143p.

24. COSTELLOE, J., 1985. The annual reproductive cycle of the holothurian *Aslia lefevrei* (Dendrochirota: Echinodermata). *Mar. Biol.*, 88: 155-165.

25. DANIEL, A. and B.P.HALDAR, 1974. Holothuroidea of the Indian Ocean with remarks on their distribution. J. mar. biol. Ass. India. 16(2): 412-436.

26. DURAIRAJ, S., 1982. Evolving quality standards for *beche-de-mer*. *Seafood Export J.* 14(3): 19-22.

27. DURAIRAJ, S. M. MOHAMED NAINAR, M. KINGSLEY LAINE, R. SUDHAKARAN and S.INBARAJ, 1984. Study on the quality of the *beche-de-mer* in trade and Shrinkage of specimens during processing. *Fishery Techn.*, 21(1): 19-24.

28. EBERT, T.A., 1978. Growth and size of the tropical sea cucumber *Holothuria (Halodeima) atra* (Jaeger) at Enewetak Atoll, Marshall Islands. *Paci. Sci.*, 32: 183-191.

29*. ELANGANAYAGAM, P., 1983. **Studies on Ecology and some aspects of the biology of Srilankan holothurians. (Echinodermata: Holothuroidea)**. M.Phil thesis,

Univ. of Jaffna.

ELANGANAYAGAM, P., V.K. GANESHLINGAM and K. SACHITHANANTHAN, 1988. Studies on taxonomy and ecology of holothurians in the Jaffna lagoon. *Proc. Srilanka Aes. Advt. Sci.*, 37(1) : 44.

EMSON, R.H. and P.V.MLADENOV, 1987. Studies of the fissiparous holothurian *Holothuria parvula* (Selenka) (Echinodermata: Holothuroidea). *J. Exp. Mar. Biol. Ecol.*, 111(3): 195-212.

ENGSTROM, N.A., 1980. Reproductive cycles of *Holothuria (Halodeima) floridana, H. (H) mexicana* and their hybrids (Echinodermata: Holothuroidea) in Southern Florida, USA. *Int. J. Invertebrate Reprod.*, 2: 237-244.

ENGSTROM, N.A., 1982. Brooding behaviour and reproductive biology of a sub-tidal puget sound sea cucumber, Cucumaria lubrica (Clark, 1901) (Echinodermata: Holothuroidea) In. Proceedings of the International Conference on Echinoderms, Tampa Bay. Ed. by. J.M. Lawrence and A.A. Rotterdam, Balkema. pp:447-450.

34. FANKBONER, P.V., 1978. Suspension-feeding mechanisms of the armoured sea cucumber *Psolus chitinoides* (Clark). *J. Exp. Mar. Biol.*, 31: 11-25.

35. FANKBONER, P.V., 1981. A re-examination of mucus feeding by the sea cucumber *Leptopentacta (= Cucumaria) elongata*. *J. Mar. Biol. Ass. UK.* 61: 679-623.

36*. FERGUSON, J.C. 1973. Feeding, digestion and nutrition in Echinodermata. In:Florkin, K., Scheer B.T(eds) **Chemical Zoology** Vol.3. Academic Press, New York, pp.71-100.

37. FISH, J.D., 1967. The biology of *Cucumaria elongata* (Echinodermata: Holothuroidea). *J. Mar. Biol. Assoc. UK.*, 47: 129-143.

38. FONTAINE, A.R. and P.LAMBERT, 1976. The fine structure of the sperm of a holothurian and an ophiuroid. *J. Morph.*, 148(2):209-226.

39*. FRANKLIN, S.E., 1980. The **reproductive biology and some aspects of the population ecology of the holothurian** *Holothuria leucospilota* (Brandt) and *Stichopus chloronotus* (Brandt). Ph.D Thesis, Univ. of Sydney. 253 p.

40. GLYNN, P.W., 1965. Active movements and other aspects of the biology of *Astichopus* and *Leptosynapta* (Holothuroidea). *Biol. Bull.*, 129: 106-127.

41. GOPALKRISHNAN, P., 1969. On the Holothuroidea (Echinodermata) of the Gulf of Kutch. *J. Bombay. Nat. Hist. Soc.*, 66(2): 399-400.

42*. GRAVELY, F.H., 1927. The littoral fauna of Krusadai Island in the Gulf of Mannar: Echinodermata. *Bull. Madras Govt. Mus. (Nat. Hist)*. 1(1): 1-11.

43. GREEN, J.D., 1978. The annual reproductive cycle of an apodous holothurian *Leptosynapta tenuis*, a bimodal breeding season. *Biol. Bull.*, 154: 68-78.

44*. GULLAND, J.A., and S.J.HOLT, 1959. Estimation of growth parameters for the data of unequal time intrevals. *J. cons. CIEM.* 25(1):47-49.

45*. HAMMOND, L.S., 1979. *The feeding ecology and substrate relations of sediment ingesting holothurians and echinoids. (Echinodermata) from a shallow reef lagoon, Discovery Bay, Jamaica*, unpublished Ph.D. Thesis. Univ. of West Indies. pp. 182.

46. HAMMOND, L.S., 1981. An analysis of grain size modification in biogenic carbonate sediments by deposit feeding holothurians and echinoids (Echinodermata). *Limnol. Oceanogr.*, 26(5): 898-906.

47. HAMMOND, L.S., 1982a. Analysis of grain-size selection by deposit feeding holothurians and echinoids (Echinodermata) from a shallow reef lagoon, Discovery Bay, Jamaica. *Mar. Ecol. Prog. Ser.*, 8: 25-36.

48. HAMMOND, L.S., 1982b. Patterns of feeding and activity in deposit feeding holothurians and echinoids (Echinodermata) from a shallow back reef lagoon, Discovery Bay, Jamaica. *Bull. Mar. Sci.*, 32(2) : 549-571.

49. HAMMOND, L.S., 1983. Nutrition of deposit feeding holothuroids and echinoids from a shallow reef lagoon, Discovery Bay, Jamaica. *Mar. Ecol. Prog. Ser.*, 10: 297-305.

50*. HARGRAVE, B., 1970. The utilization of benthic microflora by *Hyalella azeca* (Amphipoda). *J. Anim. Ecol.*, 39: 427-432.

51*. HARRIOTT, V.J., 1982. Sexual and asexual reproduction of *Holothuria atra* Jaeger at Heron Island Reef, Great Barrier Reef. *Australian Mus. Mem.* No. 16: 53-66.

52. HARRIOTT, V.J., 1985. Reproductive biology of three congeneric sea cucumber species *Holothuria atra, H. impatiens* and *H. edulis* at Heron Reef, Great Barrier Reef. *Aust. J. Mar. Freshw. Res.* 36: 51-57.

53. HAUKSSON, E., 1979. Feeding biology of *Stichopus tremulus*, a deposit feeding holothurian. *Sarsia* 64: 155-160.

54. HORNELL, J. 1917. The Indian beche-de-mer industry, its history and recent revival. *Madras Fish. Bull.*, 11(4): 119-150.

55*. HUNT, O.D., 1925. The food of the bottom fauna of the plymouth fishing ground. *J. Mar. Biol. Assoc. UK.* 13(3): 569-570.

56. HYMAN, L.H. 1955. **The Invertebrates: Echinodermata.** Vol. IV. Mc Graw-Hill, New York, pp 763.

57. JACOB, P.G., 1973. Sea cucumbers. *Seafood Export J.*,

5(11): 21-24.

58. JAMES, D.B., 1969. Catalogue of Echinoderms in the reference collections of the CMFRI. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 7: 51-62.

59. JAMES, P.S.B.R., 1967. **The ribbon fishes of the family Trichiuridae of India.** (memoris) In: Marine Biological Association of India, Mandapam Camp, India. pp. 226.

60. JAMES, D.B., 1973. *Seche-de-mer* resources of India. *Proc. symp. Living resources of Seas around India* : 706-711.

61. JAMES, D.B., 1976. Studies on Indian Echinoderm-6. Redescription of two little known holothurians with a note on an early juvenile of *Holothuria scabra* (Jaeger) from Indian seas. *J. mar. biol. Ass.* India. 18: 55-61.

62. JAMES, D.B., 1983. Sea cucumber and Sea urchin resources. *Bull. cent. Mar. Fish. Res. Inst.* No. 34 : 85-93.

63. JAMES, D.B., 1986a. The holothurian resources R&D series for Marine Fishery Resource Management. No.10 :1-4.

63. JAMES, D.B, 1986. Quality improvement in Beche-de-mer. Seafood Export J. 18(3):5-10.

64. JAMES, D.B., 1986b. **Zoogeography of shallow water echinoderms of Indian Seas.** In. **Recent advances in Marine Biology.** ed. P.S.B.R. James, Today and Tomorrow's Printers and Publishers, New Delhi. p: 569-591.

65. JAMES, D.B., 1986c. The studies on Indian Echinoderm-13. *Phyrella fargilis* (Oshima) (Echinodermata : Phyllophoridae), a new record from the Indian Ocean with notes on its habits. *J. Andaman Sci. Ass.*, 2(1): 37-38.

66. JAMES, D.B., 1986d. Quality improvement in *Beche-de-mer*. *Seafood Export J.* 18(3):5-10.

67. JAMES, D.B., 1987. **Prospects and problems of *beche-de-mer* industry in Andaman and Nicobar Islands.** In: Proceedings of the symposium on Management of Coastal Ecosystems and Oceanic resources of the Andamans. P: 110-113.

68. JAMES, D.B., 1988. A review of the holothurian resources

of India : their exploitation and utilisation. **Symposium on Tropical Marine Living Resources.** Marine Biological Association of India. p.8.

69. JAMES, D.B., M.E. RAJAPANDIAN, B.K. BASKAR and C.P.GOPINATHAN, 1988. Successful induced spawning and rearing of the holothurian *Holothuria (Metriatyla) scabra* (Jaeger) at Tuticorin. *Mar. Fish. Serv. T&E ser.* No. 87:30-33.

70. JAMES, D.B., M.E.RAJAPANDIAN, C.P. GOPINATHAN and B.K.BASKAR, 1989. Breakthrough in induced breeding and rearing of the larvae and juvenile of *Holothuria (Metriatyla) scabra* (Jaeger) at Tuticorin. Abstract No. 15. **National Workshop on *Beche-de-mer***, Mandapam Camp. P:11.

71. JAMES, D.B., 1989a. *Beche-de-mer* : Its resources, fishery and industry. *Mar. Fish. Infor. Serv., T&E Ser.* No. 92:PP35.

72. JAMES, D.B., 1989b. *Beche-de-mer* resources of Lakshadweep. *Bull. Cent. mar. Fish. Res. Inst.*, 43:97-144.

73. JAMES, D.B. and M. BAHRUDEEN, 1990. A new and valuable

resource for the Indian beche-de-mer industry. CMFRI Newsletter No. 49: 2-3.

74. JAMES, D.B., 1991a. Research, conservation and management of edible holothurians and their impact on the *beche-de-mer* industry. *Bull. Cent. mar. Fish. Res. Inst.*, pt 3 :648-661.

75. JAMES, D.B., 1991b. On some echinoderms from the marine national park at Wandoor near Port Blair. *J. Andaman Sci. Ass.* (in Press).

76. JAYASREE, V., and P.V.BHAVANARAYANA, 1989. Reproduction in *Holothuria (Mertensiothuria) leucospilota* (Brandt) from Anjuna, Goa. Abstract No. 12. **National workshop on *Beche-de-mer***, Mandapam Camp. P:9.

77. JONES, S. and S. MAHADEVAN, 1966. Notes on animal association 5. The Pea crab *Pinnotherus decanensis* (Chopra) inside the respiratory tree of the sea cucumber *Holothuria scabra* (Jaeger). *J. mar. biol. Ass. India.* 7(2): 377-380.

78. JORGENSEN, C.B., 1966. **Biology of suspension feeding.** Pergamon, Oxford.

79. KHRIPOUNOFF, A., and M. SIBUET, 1980. La nutrition d' echinoderms abyssaux. I. Alimentation des holothuries. *Mar. Biol.*, 60: 17-26.

80*. KINOSITA, T. and TANAKA, S. 1939. The food of *Stichopus japonicus* in Hokkaido. *Suisan Kenkyushi* 34(1): 32-35(in Japanese)

81. KRISHNAMOORTHI, B. 1957. Fishery resources of the Rameswaram Island. *Indian J. Fish.*, 4(2) : 229-253.

82. KRISHNAN, S., 1967. Biochemical and cytochemical observations of the nucleic acids in the gonads of *Holothuria scabra* (Jaeger). *Acta Biol. med. Gda'nsk.*, 11: 307-313.

83. KRISHNAN, S. 1968. Histochemical studies on reproductive and nutritional cycles of the holothurian *Holothuria scabra*. *Mar. Biol.*, 2: 54-65.

84*. KRISHNAN, S., 1970. **Studies on the reproductive and nutritional cycles of *Holothuria scabra*** (Jaeger). Ph.D. Thesis, University of Madras. pp 96.

85. KRISHNASWAMY, S. and S.KRISHNAN, 1967. A report on the reproductive cycle of the holothurian *Holothuria scabra* (Jaeger). *Curr. Sci.*, 36: 155-156.

86. LAWRENCE, J.M., 1972. Carbohydrate and lipid levels in the intestine of *Holothuria atra* (Echinodermata: Holothuroidea). *Paci. Sci.*, 26: 114-116.

87. LAWRENCE, J.M., 1979. Numbers and biomass of the common holothuroids on the windward reef flat at Enewetak atoll, Marshall Islands. **In. Echinoderms: Present and past**, ed. M. Jangoux. Publ. by. A.A. Balkema, Rotterdam. P:201-204.

88*. LEVIN, V.S., 1979. A composition of feeding particles of aspidochirote holothurians from the upper sublittoral zone of Indo-West Pacific. *Biol. Morya.* No. 6: 20-27.

89*. LUDWIG, H., 1887. List of the species of holothurians collected at Ceylon. *S.B. Akad. Berlins.* p: 1217-1229.

90*. MARSHALL, N., A.G.DURBIN, R.GERBER and G.TELEK, 1975. Observations on particulate and dissolved organic matter in coral reef areas. *Int. Revue. ges. Hydrobiol.* 60: 335-345.

91. MARY BAI, M., 1971. Regeneration in holothurian *Holothuria scabra* (Jaeger). *Indian. J. Exp. Biol.*,

9:467-471.

92. MARY BAI, M., 1978. The anatomy and histology of the digestive system of *Holothuria scabra* (Jaeger). *J. mar. biol. Ass. India.* 20(1&2):22-31.

93. MARY BAI, M., 1980. Monograph on *Holothuria (Metriatyla) scabra* (Jaeger). *Mem. Zool. Surv. India.* 16(2):pp 75.

94. MARY BAI, M., 1989. Studies on regeneration in the holothurian *Holothuria (Metriatyla) scabra* (Jaeger). Abstract No. 10. **National workshop on beche-de-mer**, Mandapam camp. P:8.

95. MASSIN, C., and M. JANGOUX, 1976. Ecological observations on *Holothuria tubulosa, H. poli* and *H. forskali* (Echinodermata: Holothuroidea) and feeding behaviour of *H. tubulosa. Cah. Biol. Mar.* 17(1): 45-59.

96*. MASSIN, C., 1982. Food and Feeding mechanisms: Holothuroidea. **In : Echinoderms nutrition**, eds. M. Jangoux and J.M. Lawrence. A.A. Balkema, Rotterdam. PP: 43-55.

97. MASSIN, C., and C. DOUMEN, 1986. Distribution and feeding of epibenthic holothuroids on the reef flat of Lawig Island. (Papua New Guinea). *Mar. Ecol. Prog. Ser.*, 31(2): 185-195.

98. Mc EUEN, F.S., 1988. Spawning behaviours of Northeast Pacific sea cucumbers (Holothuroidea: Echinodermata). *Mar. Biol.*, 98: 565-585.

99. MOORE, H.B. and N.N. LOPEZ, 1972. Factors controlling variation in the seasonal spawning pattern of *Lytechinus variegatus*. *Mar. Biol.*, 14: 275-280.

100*. MONDY, E.O and H.E. COWAN, 1980. Observations on the behaviour and symbiotic relationship of the Pearl fish *Encheliophis vermicularis* (Osteichthys : Carapidae) *Kaliksan* 9(223): 309-312.

101. MORIARTY, D.J.W., 1978. Bacterial biomass in coral reef sediments ingested by holothurians. *Echinoderm Conf.* Sydney (Abstract).

102. MORIARTY, D.J.W., 1982. Feeding of *Holothuria atra* and *Stichopus chloronotus* on bacteria, organic carbon and organic nitrogen in sediments of the great barrier reef. *Aust. J. Mar. Freshw. Res.*, 33:255 - 262.

103. MORIARTY, D.J.W., P.C.POLLARD, W.G.HUNT, C.M.MORIARTY and T.J.WASSENBERG, 1985. Productivity of bacteria and microalgae and the effect of grazing by holothurians in sediments on a coral reef flat. *Mar. Biol.*, 85(3): 293-300.

104. MOSHER, C., 1980. Distribution of *Holothuria arenicola* (Semper) in the Bahamas with observations on habitat, behaviour and feeding activity. *Bull. Mar. Sci.* 30(1) : 1-12.

105*. MOSHER, C., 1982. Spawning behaviour of the aspidochirote holothurian *Holothuria mexicana* (Ludwig). **In: Proceedings of the International conference on echinoderms, Tampa Bay.** Ed. by. J.M.Lawrence, Publ. by. A.A. Balkema, rotterdam. pp. 467-469.

106. NEWELL, R.C., 1965. The role of detritus in the nutrition of two marine deposit feeders, the prosobranch *Hydrobia ulvae* and the bivalve *Macoma barthica*. *Proc. Zool. Soc. Lond.* 144:25-45.

107*. ORGCHE, R.G., and E.D.GOMEZ, 1985. Reproductive periodicity of *Holothuria scabra* (Jaeger) at Calatagen Batazas. Phillippines. *Asian Mar. Biol.*, 2: 21-29.

108. PARKER, G.H., 1921. The locomotion of the holothurian *Stichopus parvimensis* (Clark). *J. Exp. Zool.*, 33: 205-208.

109. PARULEKAR, A.H., 1981. Marine Fauna of Malvan, Central West Coast of India. *Mahasagar* 14: 33-34.

110*. PAVILLON, J.F., 1981. Ecological importance of the Dissolved Organic Matter (DOM) for marine invertebrate larvae. *Oceanis (DOC. Oceanogr).* 7(1): 79-96.

111*. PEARSON, J., 1913. Notes on the Holothuroidea of the Indian Ocean. Spolia Zylan 9(34) : 49-101.

112. PEARSE, J.S., 1968. Patterns of reproductive periodicities in four species of Indo-Pacific echinoderms. *Proc. Indian Acad. Sci. B* (67): 247-279.

113*. POWELL, E.N., 1977. Particle size selection and sediment reworking in a funnel feeder *Leptosynapta tenuis* (Holothuroidea: Synaptidae). *Int. Revue. Ges. Hydiobiol.*, 62: 385-408.

114. ROBERTS, D., 1979. Deposit-feeding mechanisms and resource partitioning in tropical holothurians. *J.*

Exp. Mar. Biol. Ecol., 37(1) : 43-56.

115. ROBERTS, D., and C. BRYCE, 1982. Further observations on tentacular feeding mechanisms in holothurians. *J. Exp. Mar. Biol. Ecol.*, 59(2&3): 151-163.

116. ROE, J.H., 1955. The determination of sugar in blood and spinal fluid with Anthrone reagent. *J. Biol. Chem.*, 153:373-380.

117. ROWE, F.W.E., 1969. A review of the family Holothuriidae (Holothuroidea : Aspidochirota). *Bull. Br. mus. nat. Hist. (Zool)*. 18(4): 119-170.

118. RUTHERFORD, J.C., 1973. Reproduction, growth and mortality of the holothurian *Cucumaria pseudocurata*. *Mar. Biol.* 22(2): 167-176.

119. SACHITHANANTHAN, K., 1972. South Pacific Islands *beche-de-mer* fishery: A report prepared for the South Pacific Islands Development Agency. Rome. FAO, FI; DP/RAS/69/102/11.

120. SAMBRAND, A., H. DIAZ and J.E.CONDE, 1990. Caracterisation de la ingesta en *Isostichopus badionotus* (Selenka), *Holothuria mexicana*

(Ludwig) (Echinodermata: Holothuroidea). *Caribbean Journal of Science*. 26(1-2):45-51.

121. SATYAMURTI, S.T., 1976. The Echinodermata in the collection of the Madras Government Museum. *Bull. Madras Govt. Mus. nat. Hist. New Series* 7(3): 1-284.

122*. SHELLEY, C.C., 1981. **Aspects on the distribution, reproduction, growth and fishery potential of holothurian (*beche-de-mer*) in the Papuan coastal lagoon.** M.S. Thesis, University of Papua, New Guinea p. 165.

123. SHELLEY, C.C., 1985. Growth of *Actinopyga echinites* and *Holothuria scabra* (Holothuroidea : Echinodermata) and their fisheries potential (as *beche-de-mer*) in Papua New Guinea. **In: proceedings of the fifth international coral reef symposium, Tahati.** Ed. by. B. Delesalle *et al*. Moorea, Antenne Museum/EPHE. P. 297-302.

124. SHENOY, A.S., 1977. Holothurians and its commercial utility. *Seafood Export J.*, 9(12) : 17-20.

125. SLOAN, N.A. and B.VON BODUNGEN, 1980. Distribution and feeding of the sea cucumber *Isostichopus badionotus* in relation to shelter and sediment criteria of the Bermuda platform. *Mar. Ecol. Prog. Ser.*, 2(3):257-264.

126. SMITH, T.B., 1983. Tentacular ultrastructure and feeding behaviour of *Neopentadactyla mixta* (Holothuroidea : Dendrochirota). *J. Mar. Biol. Assoc. U.K.*, 63(2):301-311.

127. SNEDECOR, G.W., and W.G.COCHRAN, 1967. Statistical Methods. Oxford & IBH publishing Co. 6th Edn. pp 593.

128. SOOTA, J.D., S.K. MUKHOPADHYAY and T.K. SAMANTA, 1983. On some holothurians from the Andaman and Nicobar Islands. *Rec. Zool. Surv. India.* 80: 507-524.

129. SOUTHWARD, A.J. and E.C.SOUTHWARD, 1972. Observations on the role of dissolved organic compounds in the nutrition of benthic invertebrates III. Uptake in relation to organic content of the habitat. *Sarsia.* 50: 29-46.

130*. SOUTHWARD, A.J. and E.C.SOUTHWARD, 1982. The role of dissolved organic matter in the nutrition of deep sea benthos. *Am. Zool.*, 22: 647-659.

131. SUMMERS, R.G., L.H. COLWIN, A.L.COLWIN and R.TURNER, 1971. Fine structure of the acrosomal region in spermatozoa of two echinoderms, *Ctenodiscus* (Starfish) and *Thyone* (Holothurian). *Biol. Bull.* 141:404.

132. TAGHON, G.L., R.F.L. SELF, and P.A.JUMARS, 1978. Predicting particle selection by deposit feeders: a model and its implications. *Limnol. Oceanogr.*, 23: 752-759.

133*. TAGHON, G.C., 1982. Optimal foraging by deposit-feeding invertebrates: roles of particle size and organic coating. *Oecologia.* 52: 295-304.

134. TANAKA, Y., 1958a. Feeding and digestive processes of *Stichopus japonicus. Bull. Fac. Fish. Hokkaido Univ.*, 9(1): 14-28.

135. TANAKA,Y., 1958b. Seasonal changes occurring in the gonad of *Stichopus japonicus. Bull. Fac. Fish. Hokkaido Univ.*, 9(1): 29-36.

136. TIKADAR, B.K. and A.K. DAS, 1985. Cruises of Animal life of Andaman and Nicobar Islands. *Zoological Survey of India*. pp. 170.

137*. TOKUHISA, S., 1915. On *Stichopus japonicus* in Nanao Bay. *Suisan Kenkyushi*. 10(2): 33-37.

138*. TOWNSLEY, S.J., and M.P.TOWNSLEY, 1973. A preliminary investigation on the biology and ecology of the holothurians at Fanning Island. In Fanning Island Expedition, July and August, 1972. *Hawaii Institute of Geophysics Rcpt.*, HIG. p 173-186.

139. TYLER, P.A., D.S.M.BILLETT and J.D.GAGE, 1987. The ecology and reproductive biology of *Cherbonniera utriculus* and *Molpadia blakei* from the N.E. Atlantic. *J. Mar. Biol. Assoc. U.K.*, 67(2): 385-397.

140. WALKELY, A., and T.A.BLACK, 1934. Determination of organic carbon. *Soil. Sci.*, 37:29.

141. WEBB,K.L., W.D.DUPAUL and C.F.D'ELIA, 1977. Biomass and nutrient flux measurements on *Holothuria atra* populations at Enewetak, Marshall Islands. *Proc. Third Int. Symp. Coral*, 2: 409-416.

142*. YAMANOUCHI, T., 1939. Ecological and physiological studies on the holothurians in the coral reef of Palao Islands. *Palao. Trop. Biol. St. Stud.*, 4: 605-635.

143*. YAMANOUCHI, T., 1942. Food habits of *Stichopus japonicus*. *Jap. Jour. Zool.*, 54(9): 344-346.

144. YINGST, J.Y., 1976. The utilization of organic matter in shallow marine sediments by an epibenthic deposit-feeding holothurian. *J. Exp. Mar. Biol. Ecol.*, 23: 55-69.

145. YINGST, J.Y., 1982. Factors influencing rates of sediment ingestion by *Parastichopus parvimensis* (Clark) an epibenthic deposit-feeding holothurian. *Estuarine Coastal and Shelf Science*, 14: 119-134.

* Not referred to Original

APPENDIX

JAMES, D.B., M.E.RAJAPANDIAN, B.K.BASKAR, and C.P.GOPINATHAN, 1988
Successful Induced Spawning and Rearing of the
Holothurian Holothuria(Metriatyla)scabra Jaeger
at Tuticorin. Mar.Fish.Infor.Serv.,T & E Ser.,No.87
p: 30-33.

SUCCESSFUL INDUCED SPAWNING AND REARING OF THE HOLOTHURIAN *HOLOTHURIA (METRIATYLA) SCABRA* JAEGER AT TUTICORIN*

In India holothurians are exploited exclusively for export purpose. From holothurians a product commercially known as *beche-de-mer* is prepared. India at present is earning a foreign exchange equal to Rs. 20 lakhs per annum. Presently the markets in Hong Kong and Singapore offer US $ 20 per kg of *beche-de-mer*. Although the price offered by the importers is very attractive and the process involved in the preparation of the product is very simple and inexpensive, the major constraint for the development of the industry is the shortage of raw materials. .On the mainland of India the holothurians are restricted to the Gulf of Mannar and Palk Bay region. At present two species of holothurians viz., *Holothuria (Metriatyla) scabra* and *Holothuria (Theelothuria) spinifera* are exploited commercially and there are evidences of over exploitation of these species. This situation forced the Government of India to impose a ban in 1982 on the export of the processed holothurians of less than 8 cm in size

* Prepared by D. B. James, M. E. Rajapandian, B. K. Baskar and C. P. Gopinathan, Tuticorin Research Centre of CMFRI, Tuticorin.

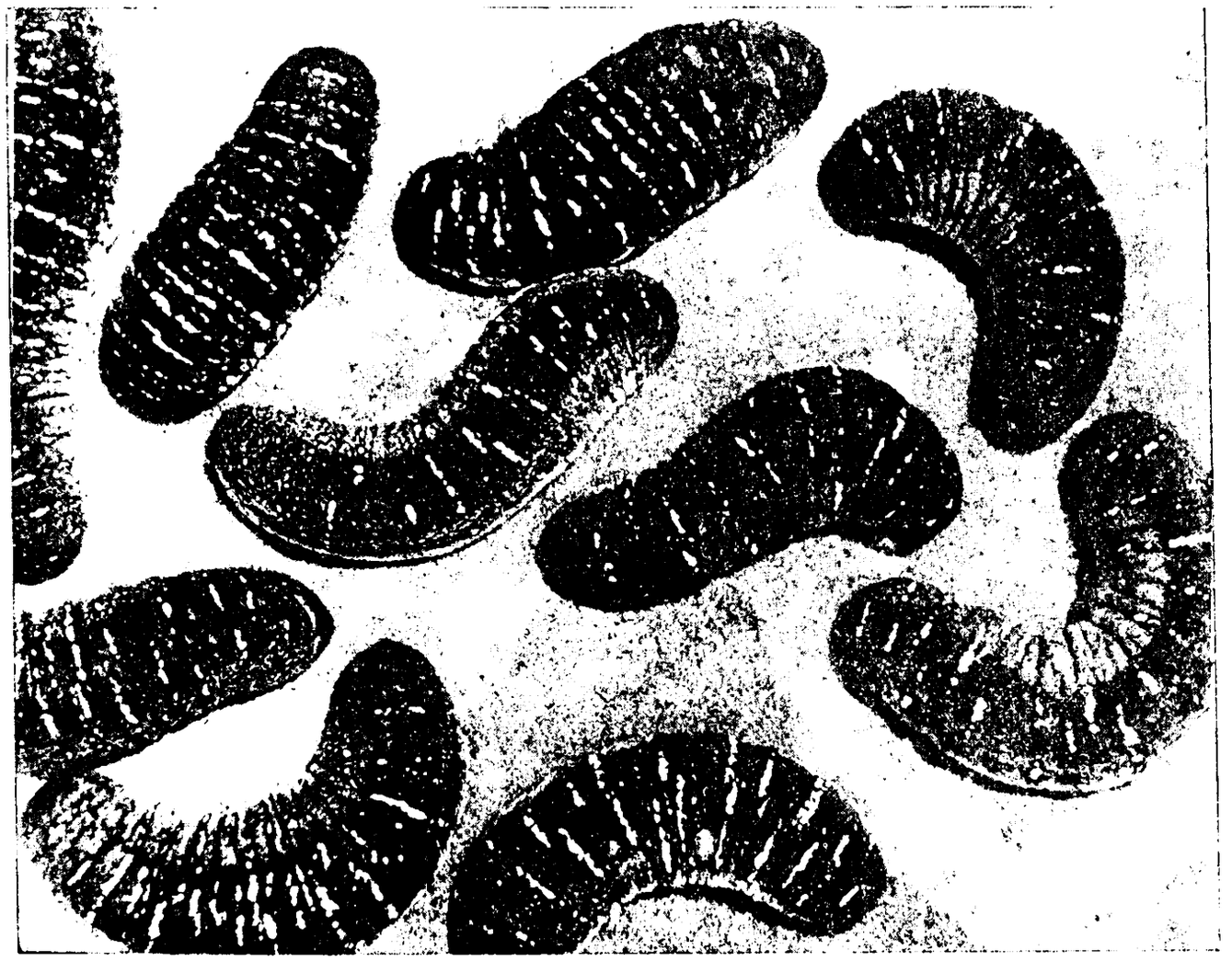


Fig. 1. A group of adult *Holothuria (Metriatyla) scabra.* (*Photo:* Mr. M. Kathirvel)

as a measure of conservation. As a result of this ban the *beche-de-mer* industry is facing a crisis in this country.

At this juncture the Central Marine Fisheries Research Institute, ventured upon a programme on the artificial breeding and production of seed for culture and propagation of the commercially valuable holothurian species. The Institute's success on the above aspects under controlled conditions is significant which may eventually solve the problems presently faced by the *beche-de-mer* industry in India. This is the first time that such work is carried out in India.

Large specimens of *Holothuria (Metriatyla) scabra* (300–350 mm/ 500–600 g) were brought to the laboratory in the last week of January, '88 and they were acclimatised to the laboratory conditions (Fig. 1). Various attempts were made to induce them to spawn in the laboratory such as subjecting them to mild electric shocks, manupulating the salinity and giving injections of radial nerve extracts of the star fish *Pentaceraster regulus.* Finally success was achieved by thermal stimulation.

On 6-2-'88 at 1030 hrs five specimens of *Holothuria (Metriatyla) scabra* were introduced into 70 litres of sea water at 32°C. The normal temperature of sea water in the laboratory was 27°C under which 10 specimens were maintained as control. Another lot of five specimens were put in sea water at 37°C. After ninety minutes one male in the first lot liberated the sperms in the form of white threads which later got mixed with the sea water. This male was immediately removed and placed in normal sea water to allow it to continue spawning. Simultaneously another male

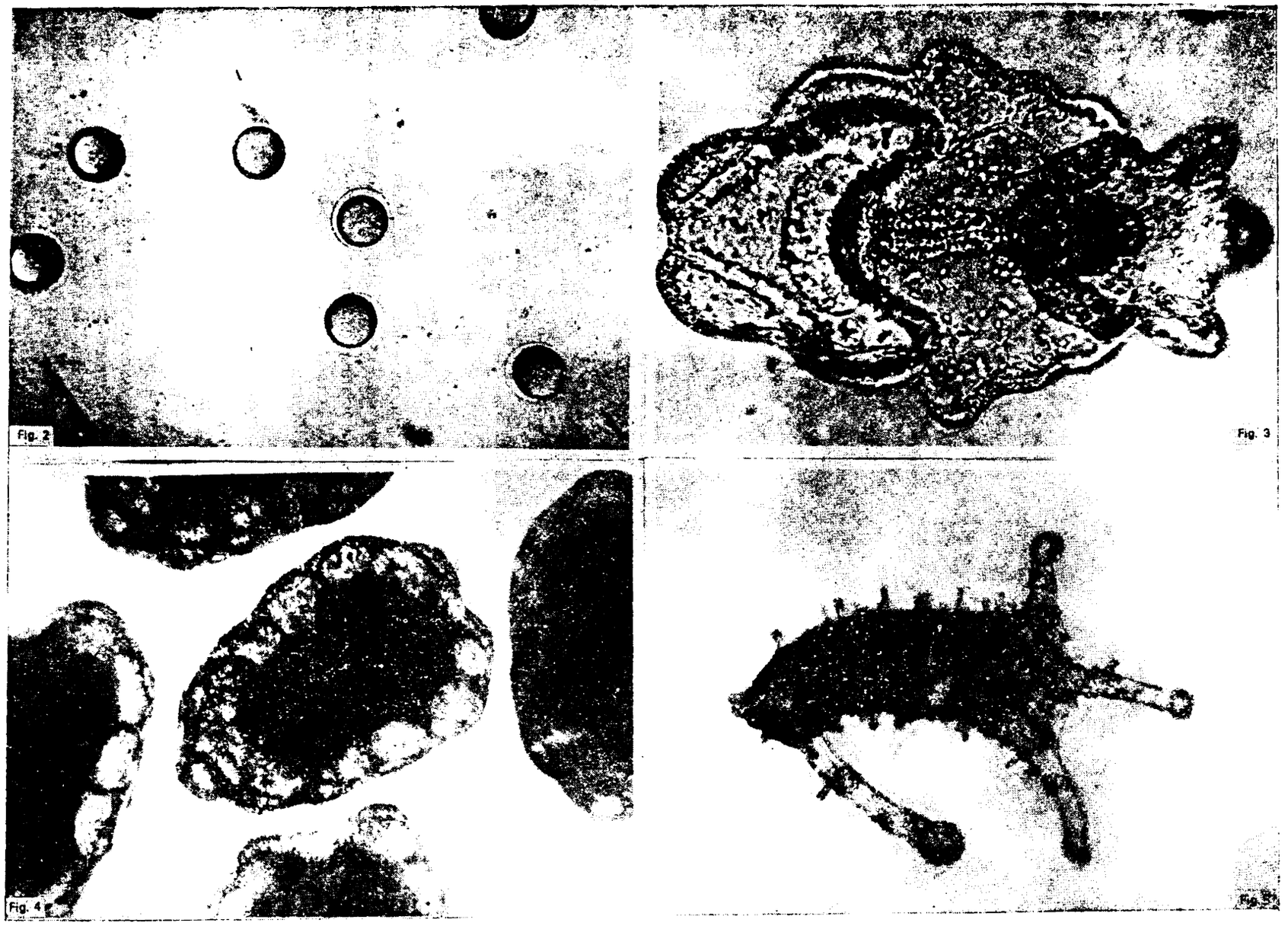


Fig. 2. A group of eggs.
Fig. 4. Doliolaria larva.

Fig. 3. Auricularia larva.
Fig. 5. Pentactula larva.
(*Photographs by:* Mr. M. E. Rajapandian)

under 37°C spawned and this was also put in normal sea water separately. Both the specimens continued to spawn for 15-20 minutes. On completon of spawning the sperm suspension was transferred to a beaker and the same was poured into a tank with sea water of normal temperature. Into this tank the remaining eight specimens were introduced. The sperms induced a female to spawn in a few spurts. The eggs (Fig. 2) were spherical, white and visible to the naked eye and were found floating. The diameter of the eggs varied from 180-200 μ. The number of eggs was estimated at nine lakhs.

After fertilization the eggs underwent cleavage and were transformed into Dipleurula stage which ranged in length from 190–256 μ. The Dipleurula transformed into Auricularia larvae after 24 hours (Fig. 3). They measured 430 μ in length and 280 μ in breadth. The Auricularia were fed on *Isochrysis galbana* and mixed culture dominated by species of diatoms of *Chaetoceros* and *Skeletonema*. The Auricularia larvae actively fed on *Isochrysis galbana*. The mouth region exhibited constant pulsating movements and the yellowish-green concentration of *Isochrysis* in the stomach was seen in circular movement. As days passed on, the Auricularia larvae became more transparent and the lateral projections also became more prominent. On each side there were four lateral projections and at the tip of each projection there was a round structure. The bands also showed a number of pigment spots. The length of the Auricularia larvae at this stage varied from 660 to 1050 μ (average 860μ) and breadth 240 690 μ (average 500 μ). Some of the Auricularia were smaller in size. A few Auricularia transformed into Doliolaria stage (Fig. 4) on the tenth day. The Doliolaria were barrel-shaped with five bands and with two tentacles projecting out. The posterior portion was slightly tapering. On each side there were five round structures with ossicle distinct at the posterior end. There were five groups of cilia like structures on each side. The Doliolaria moved fast in the forward direction. Their length varied from 420 570 μ (average 485μ) and 240 to 390 μ in breadth (average 295 μ).

On the thirteenth day some of the Doliolaria transformed into Pentactula stage (Fig. 5). The body of Pentactula was tubular with five tentacles at the anterior end and with one short stumpy tube-foot at the posterior end. The cloacal opening was distinct. Colour was greenish brown. The length varied from 330 to 750 μ (average 474μ) and breadth from 250 to 400μ (average 307μ). By eighteenth day the tube-feet and tentacles became more distinct and a number of tables were seen in the skin. The tentacles had a web in between them. At the posterior end two long tube-feet were seen. The spires of the tables were projecting out of the skin. The tentacles and tube-feet also had tables sparcely distributed. The length of the specimens varied from 550 to 720 μ (average 656 μ) and breadth varied from 210 to 320 μ (average 262 μ). The Pentactula have the habit of moving to the edge of the tank and remaining just below the surface of water. Soon they settled down to the bottom and started feeding on powdered *Ulva* and *Sargassum*.

The early development of fertilized egg took place on the surface and column of water. From the Dipleurula stage the larvae started feeding on micro-algal cultures. The Auricularia and Doliolaria are planktonic but the Pentactula settles down to the bottom of the tank. The larvae were reared in one tonne tank in filtered and aerated sea water of salinity 32–34‰ and temperature 27-29°C. Water was changed every day. The temperature, pH and salinity were regularly monitored.

NATIONAL WORKSHOP ON

BECHE-DE-MER

MANDAPAM CAMP, INDIA * 23-25 FEBRUARY, 1989

ABSTRACTS

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
COCHIN - 682 031 INDIA

SOME OBSERVATIONS ON THE BIOLOGY OF THE HOLOTHURIAN *HOLOTHURIA (METRIATYLA) SCABRA* JAEGER

B. K. BASKAR
Central Marine Fisheries Research Institute, Cochin-682 031

Some aspects on the biology of commercially most important holothurian *Holothuria (Metriatyla) scabra* are presented. It subsists on the organic matter present in the mud or sand. An

analysis of gut contents revealed fine mud (75-125μ), sand particles (250-500μ), molluscan shells, debris and bits of algae. This species spawns in June and October. By external examination and by taking sections of the gonads, five stages of maturity such as immature, maturing, early mature, late mature and spent have been fixed. The characteristics of different stages of maturity are presented in detail.

BREAKTHROUGH IN INDUCED BREEDING AND REARING OF THE LARVAE AND JUVENILES OF *HOLOTHURIA* (*METRIATYLA*) *SCABRA* JAEGER AT TUTICORIN

D. B. JAMES, M. E. RAJAPANDIAN, C. P. GOPINATHAN AND B. K. BASKAR

Central Marine Fisheries Research Institute, Cochin-682 031

Holothuria (*Metriatyla*) *scabra* which is commercially the most valuable sea cucumber at present from India has been successfully induced to breed for the first time. The larvae have been reared through various stages till settlement by feeding with microalgae. Details of various stages of larvae are given. The feeding and rearing of juveniles also are presented in this paper.

PRESENT STATUS OF THE *BECHE-DE-MER* INDUSTRY IN PALK BAY AND GULF OF MANNAR

D. B. JAMES AND B. K. BASKAR

Central Marine Fisheries Research Institute, Cochin-682 031

A survey was conducted to study the present status of the *beche-de-mer* from Adirampatnam to Cape Comorin. At present processing of holothurians is conducted from Rameswaram to Sethubavachatram in Palk Bay and from Pamban to Tuticorin in the Gulf of Mannar. In the Palk Bay Rameswaram and Thiruppalakudi are the most important centres and in the Gulf of Mannar Kilakarai, Periapatinam and Tuticorin are important centres. Mostly *Holothuria* (*Metriatyla*) *scabra* is processed. Very small quantities of *Holothuria* (*Theelothuria*) *spinifera* and *Bohadschia marmorata* are also processed. The exploitation is more on the Palk Bay than in the Gulf of Mannar. In most of the places there are indications of overfishing. At present the resource remains untapped from a vast stretch in the Gulf of Mannar from Kilakarai to Tuticorin. The present-day catch and effort from various processing centres are presented.

Mar.Fish.Infor.Serv. T&E Ser. No. 100: 13-16.

SIZE AND WEIGHT REDUCTION IN *HOLOTHURIA SCABRA* PROCESSED AS *BECHE-DE-MER*.

*BECHE-DE-MER**

Along the Tamil Nadu coast *Holothuria scabra* is fished for *beche-de-mer* preparatiosn. The fishing for this species extends from Rameswaram to Kottaipattinam in the Palk Bay and from Pamban to Tuticorin in the Gulf of Mannar in shallow waters. Fishing for holothurian is highly seasonal being restricted to March to October in the Palk Bay and October to March in the Gulf of Mannar. Nearly 1,000 divers are seasonally engaged in this fishing activity. Throughout the area both adult and juvenile specimens are collected by the divers.

*Prepared by B. K. Bhaskar and P. S. B. R. James CMFRI Cochin.

Growing demand for *beche-de-mer* in the marine export market has naturally led to considerable debate among fishery biologists in our country on the problem of irrational exploitation of the natural stock. One important aspect currently discussed is about the minimum size of the live animal that may be safely exploited. The process in the preparation of *beche-de-mer* results in considerable shrinkage from the initial size of the animal and the export control standard prescribed in the country stipulates that *beche-de-mer* below 75 mm (3") should not be exported. The exporters feel that this decision needs revision and that they should be allowed to export *beche-de-mer* above 50 mm size since good percentage of material is below 75 mm and also material of this size has some demand in foreign markets.

The Central Marine Fisheries Research Institute as the nodal institute to give expert opinion on such matters affecting the exploitation of the natural stock, had an indepth discussion on various aspects connected with the *beche-de-mer* industry during the recent National Workshop on *Beche-de-mer* (1989) held at Mandapam and explained the rationale behind the export size stipulation. At the end it was agreed, amongst other things, that the Institute should undertake investigations to throw more light on:

i) The extent of shrinkage or size reduction of *H. scabra* from the fresh to the dried product.

ii) The weight loss of fresh animal to the dried condition and

iii) The size ranges of *H. scabra* entering the commercial catches.

The details presented in this report are the results of the follow-up studies made on the above lines during April-May, 1989.

For the study purpose fresh material was collected from Rameswaram, Devipattinam and Tirupalakudi and processed. The results emerged from the study are presented in Tables 1-3. It has been found that:

i) The size groups of *H. scabra* fall within a range of 130-340 mm. 61.81% of the specimens are in the size range of below 230 mm. This shows that in the commercial catches there is a preponderance of individuals which are maturing (16.37%, 130-170 mm, 24.35%, 171-200 mm) and those about to spawn (21.09%, 201-230 mm). Studies on the size at first maturity of *H. scabra* undertaken by the authors, reported elsewhere, have indicated that the spawning size is 201-230 mm (average 220 mm).

ii) *H. scabra* in the size group 201-230 mm after processing attains a reduced size of 73-80 mm (average shrinkage 76 mm).

Table 1. *Changes in length and weight during processing of the sand fish* Holothuria scabra *at Rameswaram (sample size:* 128*)*

Size group (mm)	Nos.	Initial state		I Boiling		II Boiling		Drying (72 hrs)	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
130-170	12	160	218	130	75	90	35	60	6.3
171-200	8	185	255	140	90	98	44	63	8.0
201-230	8	220	320	140	80	130	60	80	18.0
231-260	16	253	440	190	217	178	134	132	51.5
261-300	56	278	487	184	200	172	134	131	52.5
301-340	28	323	548	194	214	186	140	146	60.0
Total	128	1,419	2,268	978	876	854	547	612	196.3
Mean		236.5	378	163	146	142.3	91.16	102	32.72
% of shrinkage		100.0		68.9		60.18		43.13	
% of weight			100		38.6		24.12		8.66
% of weight loss			100		61.4		75.88		91.34

iii) The weight loss is considerable amounting to 91.34–91.79%.

iv) A perusal of Tables–1–3, indicates that the final reduction in length of the dried product constitutes 43.13% at Rameswaram, 42.65% at Devipattinam and 42.9% at Tirupalakudi. So far as the weight loss is concerned, it was 91.34% at Rameswaram, 91.79% at Devipattinam and 91.73% at Tirupalakudi. Thus it is evident that specimens collected from different places show only negligible variation in size reduction on conversion to *beche-de-mer*.

Table 2. *Changes in length and weight during processing of the sand fish* Holothuria scabra *at Devipattinam (sample size: 56)*

Size group (mm)	Nos.	Initial state		I Boiling		II Boiling		Drying (72 hrs)	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
130–170	12	162	233	121	85	84	26	65	14
171–200	15	192	294	125	91	85	28	65	14
201–230	17	215	346	140	108	96	35	73	18
231–260	8	247	454	192	221	169	134	132	52
261–300	4	272	487	184	197	167	134	129	51
301–340	—	—	—	—	—	—	—	—	—
Total	56	1,088	1,814	762	702	601	357	464	149
Mean		217.6	362.8	152.4	140.4	120.2	71.4	92.8	29.8
% of shrinkage		100		70.04		55.24		42.65	
% of weight			100		38.7		19.68		8.21
% of weight loss			100		61.3		80.32		91.79

Table 3. *Changes in length and weight during processing of the sand fish,* Holothuria scabra *at Tirupalakudi (sample size: 120)*

Size group (mm)	Nos.	Initial state		I Boiling		II Boiling		Drying (72 hrs)	
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
130–170	22	162	236	121	86	85	27	66	14
171–200	48	191	294	126	92	85	28	66	15
201–230	32	217	354	141	109	97	37	74	18
231–260	10	247	455	192	222	170	134	132	52
261–300	8	274	487	184	198	168	134	130	52
301–340	—	—	—	—	—	—	—	—	—
Total	120	1,091	1,826	764	707	605	360	468	151
Mean		218.2	365.2	152.8	141.4	121	72	93.6	30.2
% of shrinkage		100		70.03		55.45		42.9	
% of weight			100		38.72		19.72		8.27
% of weight loss			100		61.28		80.28		91.73

From the foregoing account there appears to be no need to reconsider the earlier decision banning export of *beche-de-mer* less than 75 mm (3" size) individually since such a step would mean allowing animals of range below 201–230 mm to be fished and processed. As is evident from the data collected now juveniles are indiscriminately removed along with adults since divers maintain that it is not possible to differentiate the size under water. A practical way of overcoming this problem is to adopt the principle of 'closed season' each year. Thus revival of the natural stock can take place and this would help in encountering specimens beyond the size of 75 mm in length. The fishermen need to be educated on these points so that indiscriminate exploitation can be brought under control. However, more studies are required on the biology of holothurians to determine precisely the period of maturity and spawning in different species in a year.

Summary:

i) The fishing of holothurian *Holothuria scabra* extends from Rameswaram to Kottaipattinam in the Palk Bay and from Pamban to Tuticori in the Gulf of Mannar in shallow waters.

ii) In commercial catches the size groups of *H. scabra* from different places fall within a range of 130–340 mm and maximum percentage (61.81%) fall below 230 mm.

iii) Studies on the size at first maturity undertaken by the authors indicated that the spawning size is 201–230 mm (average 220 mm) and this size group after processing attains a reduced size of 73–80 mm (average shrinkage 76 mm).

iv) The size and weight reduction of *H. scabra* from fresh to *beche-de-mer* from different places show only negligible variation (size: 42.65–43.13%; weight: 91.34–91.79%).

v) There is no justification to reconsider the earlier decision banning export of *beche-de-mer* less than 75 mm (3" size) individually. Also it is advisable to observe a 'closed season' each year to conserve the holothurian resources.