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
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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.

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September, 1993.

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

September, 1993

(B.K. Baskar)

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C O N T E N T S

P R E F A C E

Among the echinoderms, holothurians (also known as Sea cucumbers) are commercially important. Introduced by the Chinese, they are in existence in the Gulf of Mannar and Palk Bay for more than one thousand years. They have a high nutritive value and certain medicinal properties. 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. The main international markets are Hongkong, Singapore and Malaysia.

In view of its commercial importance and increasing demand in the international market, culturing holothurians in coastal waters seems to be a promising field. A knowledge on the biology and ecology of holothurians is desirable for such a venture. Very limited information is available on these aspects in the case of Holothuria (M.) scabra, presently the most important species commercially. Some work on the reproductive cycle and a detailed study on the anatomy and regeneration of digestive tract of H. (M.) scabra have been reported. Its association with Pinnotherus decanensis from the Gulf of Mannar and the occurrence of pearl fish Encheliophis vermicularis (Osteichthys:Carapidae)in H. (M.) scabra have also been reported. The importance of

H. (M.) scabra in beche-de-mer industry has been pointed out. It has been successfully induced to spawn and later reared at the hatchery of CMFRI at Tuticorin. Detailed information on the biology and ecology of the animal is, however, lacking. In order to fill up this gap and to provide supportive information for culture practices, 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 adopted. 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 covariance. Reproductive biology which includes gonad index, maturity stages, spawning season, size at first maturity, fecundity and sex ratio is dealt with in chapter seven Chapter eight gives a clear picture of the age and growth of H. (M.) scabra using Von Bertalanffy's Growth Formula. The observations on 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 a list of references.

B.K. BASKAR.

CHAPTER 1

INTRODUCTION

India has a vast coastline of about 6100 Km. Along this coastal stretch, two million hectares are stated to be suitable for farming fishes, crustaceans, molluscs and other marine organisms (Bal and Rao, 1990). As marine capture fisheries have almost reached optimal levels of exploitation, farming of selected species is an urgent need to meet the demand of both our local as well as export market. A prerequisite for this is a thorough knowledge of the biology, food, feeding behaviour, spawning cycle, breeding season, size at first maturity, fecundity, sex ratio, induced maturation, growth etc., of different culturable species available in India.

Holothurians, among echinoderms, are a promising group for culturing in coastal waters. Beche-de-mer or Trepang, a product obtained from the holothurians (sea cucumbers) 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. Some species also grow attached to rocks. Fishing for them is done mainly by skin diving.

Holothurians though distributed all along the Indian coast are concentrated more along the southeast coast of India especially in the Gulf of Mannar and Palk Bay. In addition, many

important species are found in Andaman and Nicobar Islands and the Lakshadweep Islands. They occur in large numbers wherever coral reefs are present.

More than 650 species of holothurians are known from all over the world, of which about 200 species are known from the seas surrounding India. Out of these, nearly 75 species occur in the shallow waters within 20 m depth (James, 1989a). Only a dozen of these species are of commercial value in the preparation of beche-de-mer.

Along the Gulf of Mannar and Palk Bay only two species, namely, Holothuria (M.) scabra and H. spinifera are mainly fished for preparing beche-de-mer. There is some indication of over-exploitation of these species especially of H. (M.) scabra in certain areas as reported by James (1989a). In order to arrest such indiscriminate fishing, the Government of India, imposed a ban on export of beche-de-mer below 3 inches in size (75 mm) with effect from August 1982.

To attempt culture such commercially important holothurian species away from the natural bahitat, a knowledge 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 a few holothurians have been investigated in the past. Sloan and Von Bodungen (1980) gave an account of the distribution and feeding of the sea cucumber, Isostichopus badionotus, in relation to shelter and sediment criteria of Bermuda Platform. 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 of 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 were 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 were 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 extracted organic matter out of sand or mud taken together. Hunt (1925) stated that holothurians ingested the plankton and organic deposits contained in sand or mud. Clark (1954) noted that holothurians and other bottom dwelling animals generally extracted organic matter out of sand or mud which passed through their intestine. Newell (1965) suggested that bacteria provided 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 occurred maximum in coral reef environments and grew to a large size, while subsisting mainly on sediments which contained 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. Akhmet'Eva 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 some information on the relationship existing between the length-weight in holothurians which along with other parameters is of vital importance in estimating the yield. (Conand, 1981, 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 recruitment of stocks. Very little information is available on the reproductive biology of the holothurians in India. Krishnaswamy and Krishnan (1967), Krishnan (1967, 1968) studied the 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 on 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 of the distribution, reproduction, growth and fishery potential of a 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, dealing with

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

Holothuria (Metriatyla) scabra (Jaeger, 1833)

Identifying characters of H. (M.) scabra are : Twenty tentacles; pedicels irregularly arranged on the flattened ventral 'sole'. Papillae usually 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).(Plate I).

From the above review of earlier work, it is evident that no detailed studies on the biology, food, feeding habits, length and (total) weight relationship, maturity stages, spawning season, size at first maturity, fecundity, sex ratio, burrowing behaviour and locomotion, fishery etc., of Holothuria (M.) scabra particularly from Indian waters have

been made. 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, was felt essential and therefore, the present studies were undertaken with the following objectives :

1. To survey the distribution of the candidate species along the southeast coast of India.
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-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 determine the age and growth of the species.
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 along the southeast coast of India was studied to assess the availability of the resources along both the coasts. Material for the study was obtained both from the Palk Bay and Gulf of Mannar zones depending on the season of fishing. Uninterrupted sampling was done by examining material obtained from skin diving and those obtained from Tallu Valai (bottom drift net). The tallu valai at Tuticorin centre was operated round the year while seasonal skin diving was carried out at Tuticorin, Kilakarai and Tirupalakudi.

Among these centres, Tuticorin was selected as the main centre for the studies as the holothurian fishing goes on all the year round and the specimens examined were mostly those landed by skin diving from October to March apart from the catches brought by tallu-valai for the rest of the period.

Specimens were collected from Tuticorin landing centre at fortnightly intervals from March 1988 to February 1990. Specimens were collected by skin diving near Van theevu and Kaswar theevu. On an average 35 specimens were collected in a month and brought to the laboratory in water containing 8% magnesium chloride to avoid evisceration. The total length (TL) of the specimens 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 total weight (TW) was recorded to the nearest 5g and the drained weight (DW) (following the opening of the body and the removal of coelomic water) was recorded to the nearest 5g; gonad weight (G) was recorded to the nearest 0.1g; while the gutted weight (GW) (following removal of gonads, alimentary canal and respiratory tree) was recorded to the nearest 5g following the method adapted 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 as detailed 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 examined for different food items.

2.1.2 Quantitative analysis

For quantitative analysis, the gravimetric method employed by Roberts (1979) was followed. The weight of each grade of food item was expressed as percentage of the weight of the total gut contents. The gut contents from different regions of the digestive tract were collected carefully, washed and dried in hot air oven at 65°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 Feeding Intensity

To ascertain the extent of feeding intensity during various months, the degree of fullness of the stomach was noted before the stomach was cut. The stomach was classified as 'full', '3/4 full', '1/2 full', '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. Similarly, they were classified '1/2 full' and '1/4 full' depending on the relative fullness and the space occupied by the stomach contents. Stomachs termed 'empty' contained practically no food material. From the total number of holothurians examined each month, the percentage ocurrence 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 categorised as having actively fed, while those with 1/4 full were rated as poorly fed.

2.1.4 Relationship between length of animal, length of gut, total weight of anixal, weight of gut.

The total length, the total weight of the animal and

weight of the gut (digestive tract) were taken. The relationship between the total length and gut length, total weight and gut weight and total length with gut weight was determined.

2.2 Biochemical Analysis of Nutrients

The holothurian samples were collected from the bottom sediments and sediments samples were taken by scraping only the top few millimeters of sediments where the individual lies. At the laboratory the animals were immediately dissected and the sediment from the oesophagus, stomach and intestine was collected. The sediment samples, gut materials and faeces were rinsed with fresh water, dried and sieved for the determination of total organic carbon, carbohydrate and nitrogen. The assimilation efficiency (U) was calculated using the formula U = A/C x 100 = % where 'A' is the assimilation and 'C' consumption of food items, as described by Yingst (1976).

2.2.1 Estimation of organic carbon

The total organic carbon and organic matter were analysed according to the method suggested by 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 of 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 flask was shaken well and titrated against ferrous ammonium sulphate solution.

A blank control was also maintained. The colour turned deep violet blue when ferrous ammonium sulphate was added drop - wise with shaking. When the end point is reached, the colour became sharp green.

Calculation :

$$\text{Organic carbon} = \frac{\text{Blank titre - Actual Titre x 0.3 x M}}{\text{Weight of sediment}} = \text{Percentage of oxidizable} \ \%$$

were '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 the Anthrone method (Roe, 1955).

Procedure : To 2g 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. To this 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 30 minutes. 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. To this 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 30 minutes. If frothing was excessive, a small amount of paraffin wax could be added.

On cooling, 90 ml of distilled water was added and re-cooled. To this 25 ml of sulphide solution was added and well 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 and the distilled ammonia was collected in 50 ml boric acid indicator solution. 50 ml of the distillate was collected and titrated against standard acid solution.

Calculation

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

To study the growth of H. (M.) scabra, only the total length of the individual was measured, as already described. The data collected during the study period were grouped into 2 cm intervals and the size frequency distributions were determined. Growth was computed by the modal progression method and fitted to Von Bertalanffy's growth formula.

2.4 Reproductive cycle

The gonads were preserved in 10% neutral buffered formalin for macroscopic and microscopic examination. The macroscopic observation was based on the form, colour and consistency of the gonad. Only four maturity stages were recognised and classified by Krisknaswamy and Krishnan (1967) as immature, mature, gravid and spent. In the present work the mature stage has been divided into early mature and late mature to demarcate the stages more precisely, 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. This procedure permitted five stages of maturity to be defined for the present species.

For histological studies, standard methods (Clark, 1981) were followed. A piece of gonad each was fixed in Bouin's fluid and neutral buffered formalin at 10% dilution. Sections of gonad 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

For determining the size at first maturity which 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 wieght (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 mature (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 would 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. Attempt was made to relate the fecundity 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 under laboratory conditions using round bottom plastic troughs (25 cm height, 60 cm diameter and 50 liter capacity). H. (M.) scabra ranging in size from 20 - 24 cm acclimatized to laboratory conditions, were kept in 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. H. (M.) scabra was exposed to different light conditions viz. 12 hour light and 12 hour dark, 24 hour dark and 24 hr. light. Three animals 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 covering and for light, artificial light (400 - 500 lux) was provided. The experiment

was conducted in triplicates.

2.6 Locomotion

Locomotion of the animals was observed in aquarium tanks of 100 litre capacity containing 50 - 60 mm thick sandy layer at the bottom.

2.7 Fishery

The holothurian landings were observed from Rameswaram to Mallipattinam along the Palk Bay (PB) coast and from Pamban to Tuticorin along the Gulf of Mannar (GM) coast along the southeast coast of India. Five centres viz. Tirupalakudi (PB), Rameswaram (PB), Vedalai (GM), Kilakarai (GM) and Tuticorin (GM) were selected (Fig.1) for making observations on the fishery.

Holothurians are fished either by skin diving or by using nets. Fishing is conducted along the Palk Bay coast from March to October and along the Gulf of Mannar from October to March. Catch Per Unit Effort was determined 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. Tallu valai operation at a depth of 4-8 m also caught sea cucumbers. They also formed part of bycatch in bottom trawls. The catch particulars from different gears, total landings at the respective centres and the method of processing of beche-de-mer are discussed in detail in the respective chapters.

PART - I.

BIOLOGY

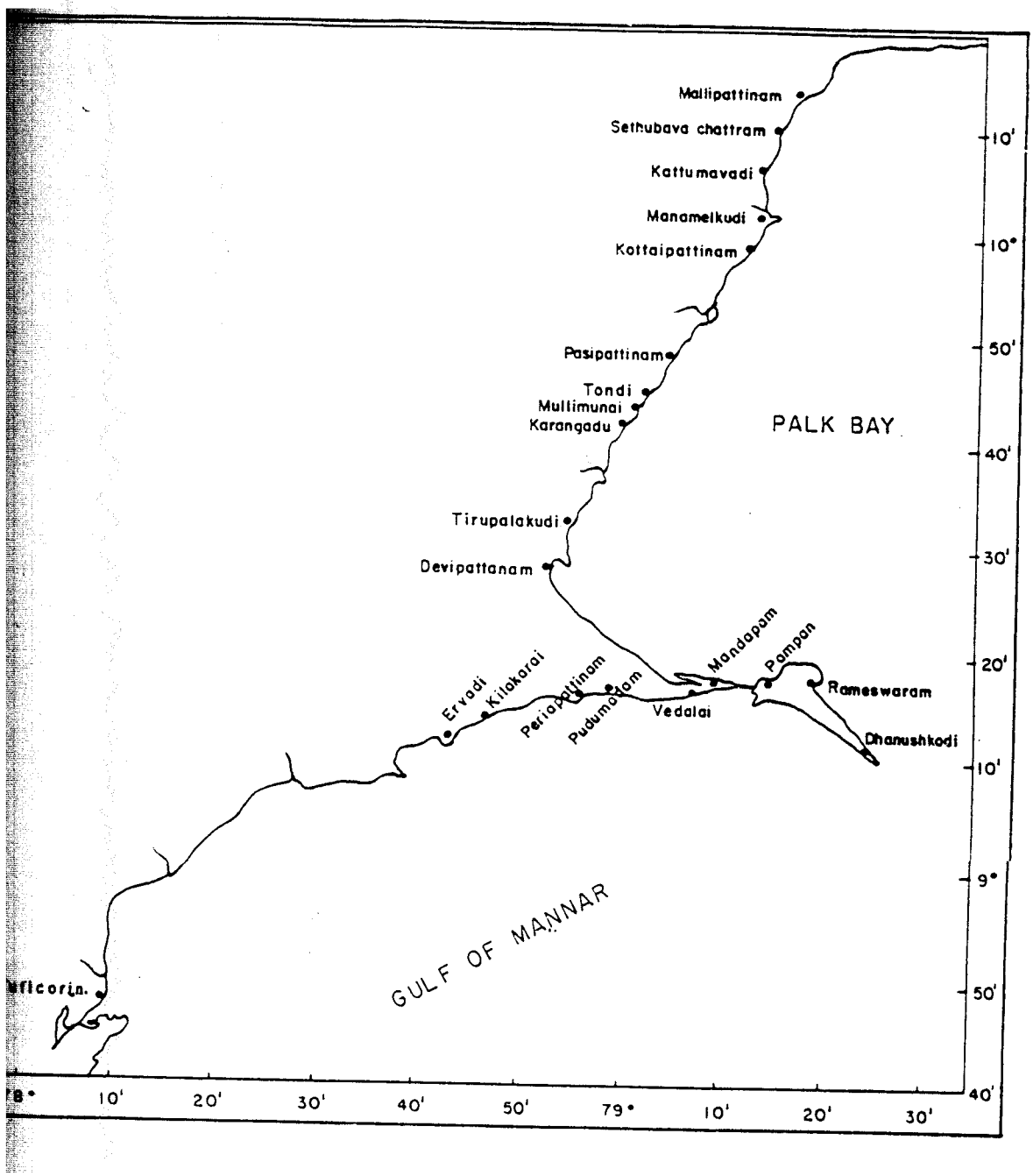
CHAPTER 3

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). Along the west coast of India, it is recorded from Bedi Port (Gulf of Kutch) by James (1969) and from Malvan by Parulekar (1981). Holothuria ocellata reported by Gopal krishnan (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

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


Mallipattinam
Sethubava chattram
Kattumavadi
Manamelkudi
Kottaipattinam
Pasipattinam
Tondi
Mullimunai
Karangadu
PALK BAY
Tirupalakudi
Devipattanam
Mandapam
Pampan
Rameswaram
Dhanushkodi
Ervadi
Kilakarai
Periapattinam
Pudumadam
Vedalai
GULF OF MANNAR
Uficorin.
10'
10°
50'
40'
30'
20'
10'
9°
50'
40'
78°
10'
20'
30'
40'
50'
79°
10'
20'
30'

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, Pudumadam, 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).

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 a mouth located at the anterior end which is surrounded by a circlet of tentacles. The 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 a minimum during different months of the year (Table 1). 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 size of 250-500 μ was abundant during August 1988 (47.6%) and minimum during June 1988 (32.1%). Likewise, 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%) and October 1988 (3.4%).

The particles >1680 μ were found maximum during November 1988 (6.6%) and minimum during October 1988 (1.3%). The same seasonal trends were observed during the year 1989-1990 also, with slight deviations in the percentage occurence of different particle sizes. During the study, sea cucumbers in the size range 150-330 mm were examined. Particles of all sizes were found in all the sea cucumbers. Detailed analysis of the different particles size in the guts during this two years study period did not show much deviation in particle sizes. This accounts for the remarkable similarity in the particle size percentages.

The percentage occurence of different particle size in the gut contents of holothurian from March 1988 to February 1990 is presented in Table 1. The number of individuals analysed in each month is mentioned in Tables 1, 2 and 3. Although the data given in Table 1 are depicted in figs. 2 & 3, Fig. 2. pictorially represents the percentage of different particle sizes during different months and fig.3 shows a magnified picture of the month-wise occurrence of different particle sizes for an easy understanding. The mean value and the standard deviations for the different particle sizes is also calculated and presented in table 1. From this, it is seen that particle size ranging from 250 - 500 μ constituted a mean value of 39.22% with a standard deviation of 4.78%. It is clear from Figs. 2 and 3 that the percentage of particle size ranging from 250 - 500 μ were dominant in all the months as

Table 1 : Month wise percentage occurrence of different particle sizes in the gut contents of H. (M.) scabra (March 1988 - February 1990)

Month	Number of Holothurians	% of particle size (μ)							
		<90	90-125	125-250	250-500	500-710	710-1003	1003-1680	>1680
March'88	18	6.80	9.60	16.90	38.40	7.20	12.30	5.20	3.60
April	22	3.90	9.90	23.50	40.70	6.10	10.00	3.30	2.60
May	21	2.88	5.70	14.30	34.52	12.60	16.80	7.80	5.40
June	20	1.70	3.40	11.00	32.10	19.20	18.60	9.30	4.70
July	20	0.70	2.40	9.80	40.30	13.30	21.10	6.80	5.60
August	22	0.80	3.10	13.80	47.60	10.20	15.00	5.80	3.70
September	20	3.00	3.50	10.30	45.90	10.50	13.90	7.90	5.00
October	21	2.90	11.70	16.90	41.20	8.90	13.70	3.40	1.30
November	22	1.60	5.10	13.00	39.10	8.20	15.70	10.70	6.60
December	20	3.00	5.30	16.80	36.60	12.10	14.80	6.80	4.60
January'89	19	2.00	3.80	10.20	34.20	17.90	18.30	9.10	4.50
February	22	3.30	4.70	19.80	43.50	6.10	11.10	6.20	5.30
March	21	7.10	9.00	16.70	37.80	8.20	12.20	5.10	3.90
April	23	4.10	10.30	24.50	40.20	5.80	9.20	3.20	2.70
May	20	2.76	5.44	14.60	32.20	14.40	18.20	7.60	4.80
June	21	1.77	2.54	7.19	31.27	22.53	19.75	9.94	5.01
July	22	0.70	2.50	9.80	40.00	13.30	21.10	6.90	5.70
August	24	0.80	3.20	14.20	47.20	10.00	14.90	5.00	3.80
September	21	3.10	3.50	10.50	45.60	10.30	14.00	8.00	5.00
October	20	3.20	11.80	16.90	40.90	8.90	13.60	3.50	1.20
November	22	1.30	4.50	12.30	38.60	8.40	16.40	10.80	7.70
December	23	3.00	5.30	16.90	36.20	12.40	14.60	6.80	4.80
January'90	22	2.30	3.90	9.60	33.80	18.20	18.40	9.20	4.60
February	20	3.30	4.90	19.60	43.40	6.30	11.20	6.20	5.10
	$\bar{X}$	2.75	5.63	14.55	39.22	11.29	15.20	6.89	4.47
	SD	1.64	3.01	4.48	4.78	4.52	3.34	2.27	1.48

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

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

Fig. 2.

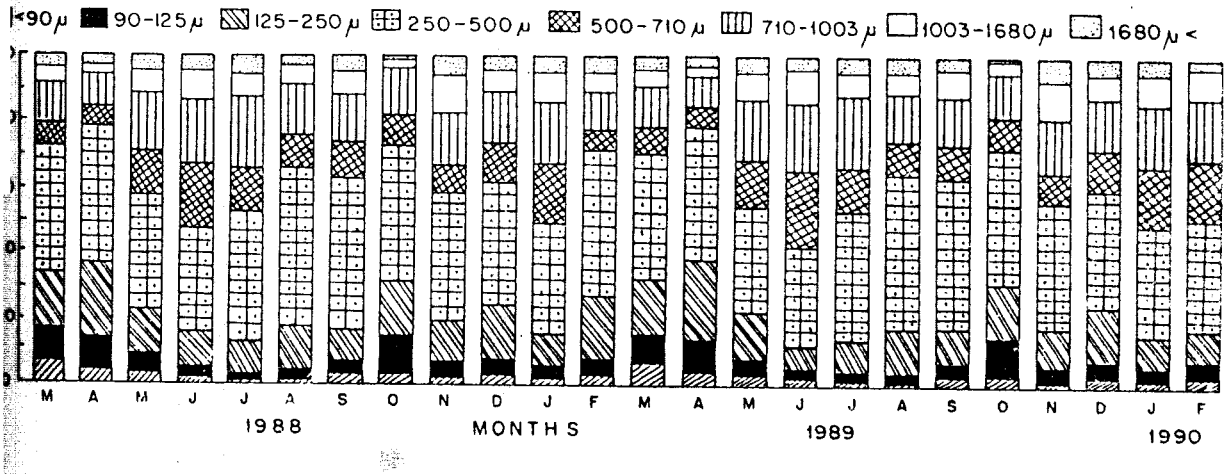
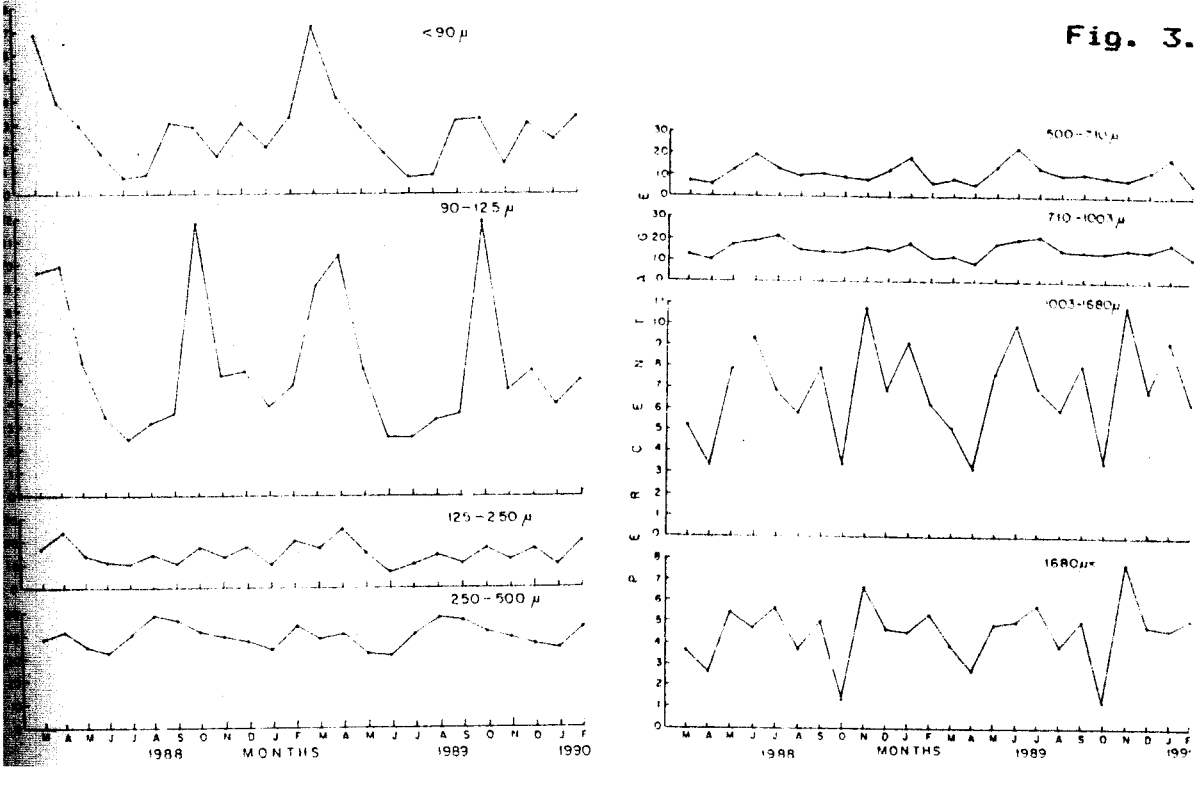

<90μ
90-125μ
125-250μ
250-500μ
500-710μ
710-1003μ
1003-1680μ
1680μ<
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990

Fig. 3.


<90μ
90-125μ
125-250μ
250-500μ
500-710μ
710-1003μ
1003-1680μ
1680μ<
PERCENTAGE
1988
MONTHS
1989
1990

compared to particle sizes ranging from 125 - 250 μ and 710 - 1003 μ.

4.2.2 Particle size in relation to the size of holothurian

Size wise details of the percentage occurrence of different particle sizes in the digestive tract of H. (M.) scabra during March 1988 to February 1989 and March 1989 to February 1990 are presented in Tables 2 & 3. It can be seen from the tables that during both the years, the particle size ranging from 250-500 μ formed the dominant particle size of the food in all the size groups of holothurians (15-33 cm). During 1988-1989, the size range of 30-31 cm was dominant (49.91%) (Table 2) and 17-18 cm size amounted 58.88% (Table 3), during 1989-1990.

The particle sizes below 90 μ and between 90-125 μ were found maximum percentages (9.35% and 16.25% respectively) in the size range of 15-16 cm during 1988-1989. During 1989-1990, the <90 μ and 90-125 μ sizes formed maximum in the 20-21 cm (3.99%) and 18-19 cm (9.2%) size holothurians respectively.

The size of the particles ranging from 125-250 μ were found maximum in the size group of 32-33 cm (30.29%) during 1988-1989 while it was observed in the 30-31 cm size group of holothurian (24.31%) during 1989-1990. Particle size ranging from 500-710 μ were observed more frequently in size group of 29-30 cm (20.30%) during 1988-1989 while 19.46% were recorded in the size of 27-28 cm during 1988-1989. The percentage of

Table 2 : Size wise percentage occurrence of different particle sizes in H. (M.) scabra (March 1988 - February 1989)

Size group (cm)	Number of Holothurians	% of particle size (μ)							
		<90	90-125	125-250	250-500	500-710	710-1003	1003-1680	>1680
15-16	4	9.35	16.25	23.38	21.80	7.78	13.45	4.94	3.05
16-17	6	3.15	8.67	14.73	34.57	12.92	14.08	7.81	4.07
17-18	7	2.72	9.92	19.37	36.60	7.37	15.80	6.66	1.56
18-19	9	2.50	8.70	22.00	38.20	5.60	15.30	6.40	1.30
19-20	13	2.00	6.83	16.98	36.49	12.10	15.15	6.61	3.84
20-21	17	3.25	6.13	12.65	40.06	10.78	14.30	7.56	5.27
21-22	22	4.75	5.08	19.37	39.71	10.13	13.15	5.10	2.71
22-23	29	3.04	3.45	11.51	32.83	10.40	23.96	8.21	6.60
23-24	32	1.83	4.27	18.47	39.81	11.22	12.25	7.42	4.73
24-25	35	1.39	3.40	11.24	39.86	12.60	18.77	7.51	5.23
25-26	21	2.97	6.70	12.64	41.46	9.70	16.13	6.57	3.83
26-27	15	2.04	3.19	10.24	35.04	12.84	19.41	9.67	7.57
27-28	11	2.81	4.41	11.96	27.31	18.88	20.82	8.72	5.09
28-29	8	1.59	1.24	6.02	21.08	8.48	21.72	17.07	22.80
29-30	8	2.90	2.70	9.70	34.00	20.30	22.60	6.20	1.60
30-31	4	3.69	7.74	24.96	49.91	5.31	6.12	1.86	0.41
31-32	3	2.20	7.60	28.20	41.60	6.60	9.20	2.80	1.80
32-33	3	2.30	6.55	30.29	47.14	3.67	6.67	1.84	1.54
	a	6.446	14.693	14.298	25.684	10.193	18.339	8.618	1.775
	b	-0.142	-0.349	0.107	0.451	0.007	-0.119	-0.075	0.118
	r	-0.42	-0.54	0.08	0.32	0.009	-0.12	-0.11	0.13

Table 3 :Size wise percentage occurrence of different particle sizes in H. (M.) scabra (March 1989 - February 1990)

Size group (cm)	Number of Holothurians	% of particle size (μ)							
		< 90	90-125	125-250	250-500	500-710	710-1003	1003-1680	> 1680
16-17	5	2.33	6.17	10.73	39.20	11.95	14.00	9.52	6.10
17-18	7	1.26	3.37	17.00	58.88	3.30	7.05	4.76	4.38
18-19	8	2.30	9.20	21.00	35.80	8.40	16.00	5.30	2.00
19-20	12	2.65	5.38	15.99	41.77	10.72	14.98	5.46	3.05
20-21	19	3.99	7.62	16.77	38.12	9.64	13.59	6.06	4.21
21-22	20	3.09	6.10	13.95	42.89	11.11	13.71	5.93	3.22
22-23	26	2.10	4.32	13.74	40.57	10.47	15.44	8.95	4.41
23-24	33	2.26	4.60	14.34	41.77	11.50	14.41	7.05	4.07
24-25	37	1.51	3.30	9.64	42.98	12.68	19.10	7.13	3.66
25-26	28	1.88	3.14	12.21	34.07	12.05	17.56	9.60	9.49
26-27	18	1.35	2.33	7.80	35.80	13.99	17.85	9.97	10.91
27-28	13	1.37	5.70	10.49	28.78	19.46	21.39	7.62	5.19
28-29	9	0.36	1.97	5.84	45.28	13.24	23.74	6.42	3.15
29-30	8	0.84	3.05	9.10	24.61	19.12	31.02	7.89	4.37
30-31	6	1.89	5.91	24.31	49.80	5.10	8.14	2.60	2.25
31-32	5	1.65	5.30	22.95	45.73	3.89	16.22	2.21	2.05
32-33	5	1.62	2.43	21.32	44.08	7.86	12.98	5.47	4.24
	a	4.0717	9.3256	11.9176	45.7451	8.4108	6.6560	9.1788	4.6948
	b	-0.088	-0.189	0.107	-0.210	0.099	0.393	-0.105	-0.007
	r	-0.52	-0.48	0.09	-0.14	0.11	0.35	-0.24	-0.02

particles ranging from 710-1003 μ were abundant in the 22-23 cm size group which constituted 23.96% 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.

Thus, the data showed that there was no perceptible difference between particle size and the size groups of the animal. It is true that the particle sizes do not vary with the size of the animal.

4.2.3 Feeding Intensity

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 in H. (M.) scabra showed an interesting pattern. During the course of two years study, maximum percentage of empty stomachs were encountered during the months of April, May, September, October and November. This has a direct correlation with the development of the gonad. The present study clearly showed that this species has two breeding peaks. One during March - May and the other in October - December. When the gonad is fully ripe, it occupies 1/3 of the body cavity at the anterior region. This is exactly where the stomach is positioned. Due to the enormous growth of the gonad

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

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

Fig. 4.

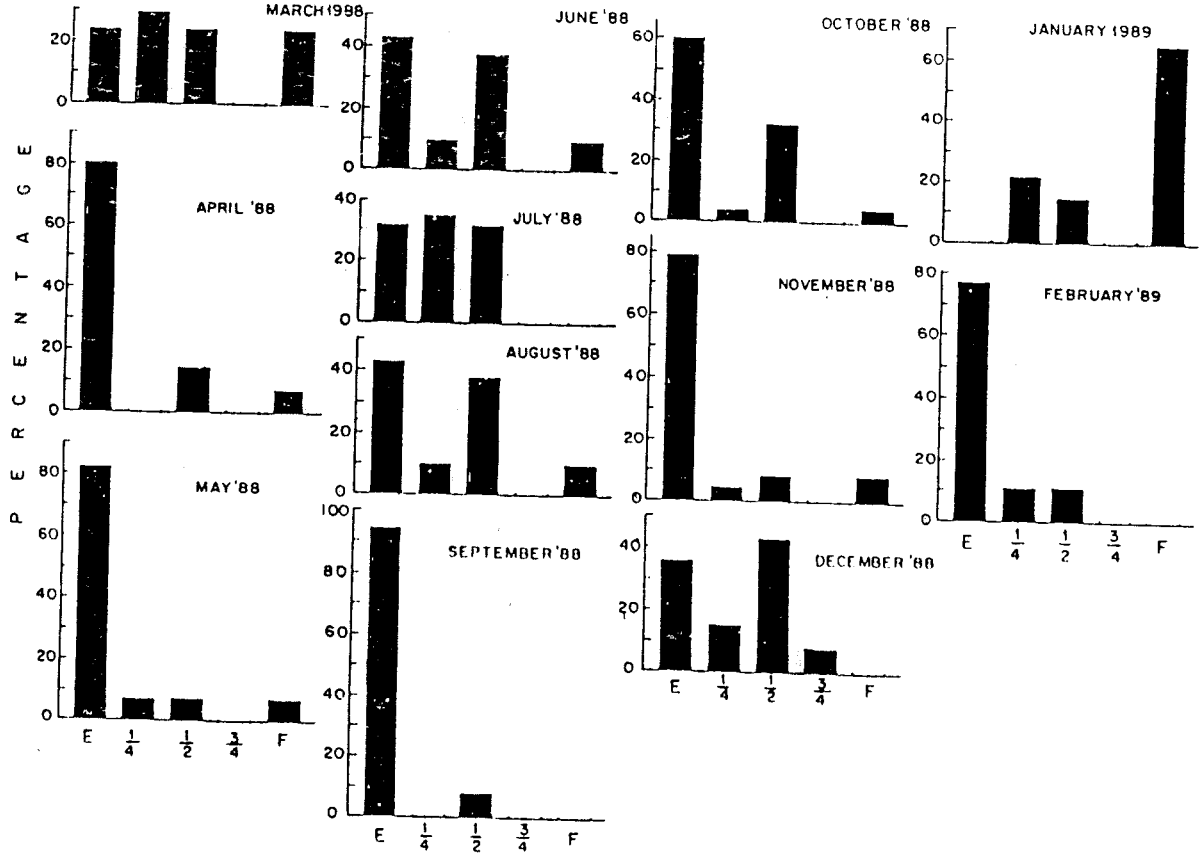
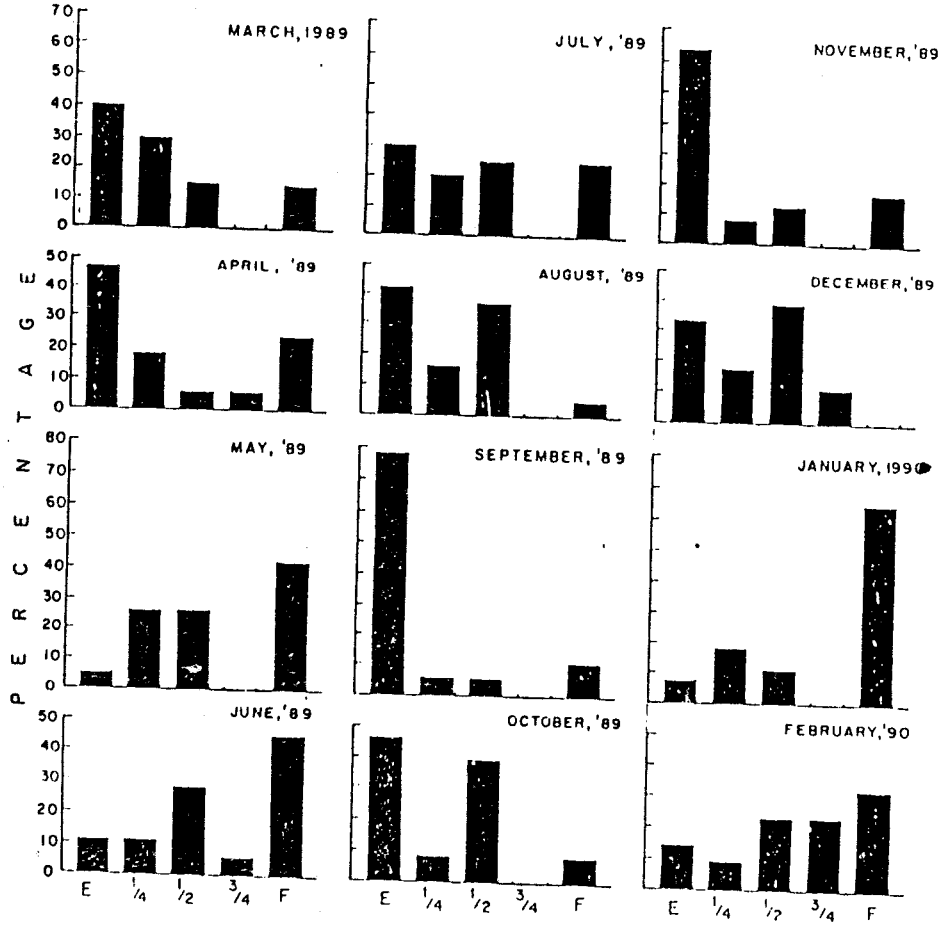

MARCH 1988
JUNE '88
OCTOBER '88
JANUARY 1989
APRIL '88
JULY '88
NOVEMBER '88
FEBRUARY '89
AUGUST '88
MAY '88
SEPTEMBER '88
DECEMBER '88
PERCENTAGE
E
1/4
1/2
3/4
F

Fig. 5.


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

the stomach gets compressed with the result that the feeding activity becomes less and this accounts for the greater percentage occurrence of empty stomachs.

By the end of December the animal completely empties out the gonad which releases the pressure on the stomach and hence the animal starts feeding at greater intensity and this accounts for the greater percentage of full stomach during the month of January in both the years.

For the study of food and feeding habits, the number of specimens examined during different months varied between 18 and 24 individuals per month with a total of 506, i.e., 247 during the first and 259 in second year. This number is quite adequate for the study.

4.2.4 Relationship between length of animal, length of gut, total weight of animal and weight of gut.

Studies were undertaken to establish whether or not any possible correlations existed between total length of the holothurian and gut length; total weight of the holothurian and wet weight of the digestive tract and total length of the holothurian with wet weight of the digestive tract. For this study, 208 specimens have been used. The details are presented in the Table 4.

From Table 4, it is clear that there was no significant correlation between the total length of the holothurian and the length of the digestive tract, total weight and wet weight of

Table 4 : Correlation between total length and length of digestive tract, total length and wet weight of the digestive tract and total weight of the holothurian and wet weight of digestive tract of H. (M.) scabra.

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.

the digestive tract and total length and wet weight of the digestive tracts.

4.3 Discussion

The present investigation indicated that H. (M.) 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). But a few tropical holothurians reportedly feed on plankton, organic matter on rocks, minute crustaceans and polychaetes (Bakus, 1973). Nevertheless, 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 high concentrations in tropical waters. Choe (1963) briefly explained that the young individuals of Stichopus japonicus fed 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 deosit 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, the present species H. (M.) scabra consumes particles of size ranging from <90 to >1680 μ in diameter. The gut content indicates that the holothurian prefers particles size of 250 - 500 μ which constituted a maximum of (39.22%).

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 were <250 μ in diameter and the remaining comprised of calcareous fragments measuring upto 2 mm; H. atra fed mainly on coral rubble measuring upto 2 cm. Glynn (1965) found that Astichopus multifidus fed on 212 μ, median sized fine grained calcareous fragments. Hauksson (1979) commented that Stichopus tremulus, selectively ingested coarser material (200-300 μ) from ambient sediments. Towonsley and Towonsley (1973) reported that S. chloronotus rejected particles (> 1 mm diameter) in favour of particles around 0.25 mm diameter. Roberts (1979) reported a means 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 selected the grain size of 125 - 250 μ ; H. edulis preferred 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 in the holothurians examined during the course of this study which had dominant size of 220 - 270 mm. Based on the data presented in table 1, it is seen that H. (M.) scabra examined feeds on particle size of less than 90 to morethan

1680 μ . This confirms that H. (M.) scabra is a nonselective deposit feeder swallowing the surrounding substrates by means of oral tentacles and eliminates the semidigested waste as faecal pellets. The occurrence of particle sizes of less than 500 μ in H. (M.) scabra have been found to be maximum.

In the present study, no relationship could be established between the body size and particle size of food. The present observations on H. (M.) scabra agree 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. Also, 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, H. (M.) scabra showed that during spawning season the holothurian fed poorly. Similarly, Fish (1967) reported that in Cucumaria elongata the individuals remained dormant from October to late April and the

feeding behaviour was seasonal.

Examination of 208 specimens for relationship between total length and length of the digestive tract, total length and wet weight of the digestive tract, total weight of the holothurian and the wet weight of the digestive tract, indicated no significant correlations.

CHAPTER 5

BIOCHEMICAL ANALYSIS OF NUTRIENTS IN GUT CONTENTS

The holothurians feed on organic detritus available in the natural bed. Any information on the biochemical constituents 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 digestive 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. During the course of the study 30 individuals were examined for biochemical studies.

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 ± 0.07, 1.45 ± 0.07 and 1.10 ± 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 ± 0.13 in oesophagus, 2.90 ± 0.14 in stomach and 2.20 ± 0.08% in intestine and 2.37% 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 0.377 µg/mg. The carbohydrate content in different regions of the digestive tract was found to be 0.340 ± 0.015 µg/mg in oesophagus, 0.297 ± 0.013 µg/mg in stomach and 0.277 ± 0.008 µg/mg in intestine. The assimilation efficiency of carbohydrate from sediment to faeces was 26.53% and oesophagus to faeces was 18.53%.

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 13.06 ± 0.37, 13.0 ± 0.38 and 8.81 ± 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 eosophagus to faeces 32.41% efficiency was recorded.

5.2 Discussion

In the present study, H. (M.) scabra was found to ıtilize 16.29% of organic carbon and 7.56% of organic matter ›resent in bottom sediments. Yingst (1976) reported an ıssimilation efficiency of 22% for organic carbon utilized by arastichopus parvimensis while Stichopus tremulus assimilated -15% of organic carbon from sediments, with a mean of 27%

(Hauksson, 1979). An assimilation efficiency of 40 ± 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 avarage the carbon levels are found to be 16 to 34% more in the foregut than in the sediment.

Carbohydrate content in the faecal matter and the sediment of the environments and the carbohydrate contents in the matter found at the oesophagus were estimated. It was seen that the carbohydrate content in the faecal matter was lesser than in the sediment examined from the oesophagus. This indicates that (i) the assimilation of carbohydrate takes place between oesophagus and intestine, (ii) further assimilation takes place in the sediment and faeces and (iii) the carbohydrate is not fully assimilated by the animal and little amount of carbohydrate is still left in the faecal matter. The assimilation efficiency of carbohydrate observed now in the case of H. (M.) scabra from sediment to faeces was 26.53% and from oesophagus to faeces was 18.53%.

The reason for higher assimilation efficiency from sediments to faeces compared to oesophagus to faeces is that

the carbohydrate content from the natural substratum covers a much wider area than the carbohydrate content in the oesophagus of the animals. Because of the restricted habit of feeding of the animal from a particular place, the values in the oesophagus are relatively lower when compared to samples collected from the substratum as well as the limited size range (220-270 mm) of the material examined.

From the present study, the confidence limits arrived for total organic carbon, organic matter, nitrogen, protein and carbohydrates showed a narrow range when compared to the results obtained by earlier workers. The reason may be due to the limited size range of the material examined. Also, the differences in assimilation efficiences between the holothurians Stichopus tremulus and H. difficilis and H. (M.) scabra may have been due to variation in the quantities of organic matter available in the environment as well as the particle sizes ingested by the holothurians. There is no mention about the particle sizes in Stichopus tremulus and H. difficilis in the earlier works.

It may not be out of place here to mention that 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, revealed 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%.

From the above, it is clear that the concentration of total 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). Holothurians appear to 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 are in line with the findings of Massin (1979).

CHAPTER 6

LENGTH - WEIGHT RELATIONSHIP

The length-weight relationship of holothurian is investigated 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 estimating the yield. Very few investigators have attempted this type of work in holothurians (Conand, 1981, 1982, 1986, 1990; Choe, 1963; Lawrence, 1979; Tyler *et al.*, 1987). In view of its practical utility, an attempt has been make here to determine the length-weight relationship of *H.* (*M.*) *scabra* by considering total length (as length) and total weight (as weight) of the individuals and the details are presented below.

Numerous inaccuracies occur while measuring a holothurian. Length(L) 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.

For the present study, a total of 272 holothurians in indeterminate stage were collected from March 1988 to February 1990. During March 1988 to February 1989, 149 females (16-33

cm) and 114 males (15-33 cm) were collected. In addition, 136 females (21-33 cm) and 113 males (17-31 cm) collected during March 1989 to February 1990, from Tuticorin were also studied.

The following empirical formula was employed to describe the relationship between total length (cm) and total weight (g), viz, $W = a L^b$, where a & b are constants to be estimated from the data. The parameters a & b were estimated by regression analysis after the log transformation of the data (Snedecor & Cochran, 1967).

6.1 Results and Discussion

The fitted equations were :

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

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

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

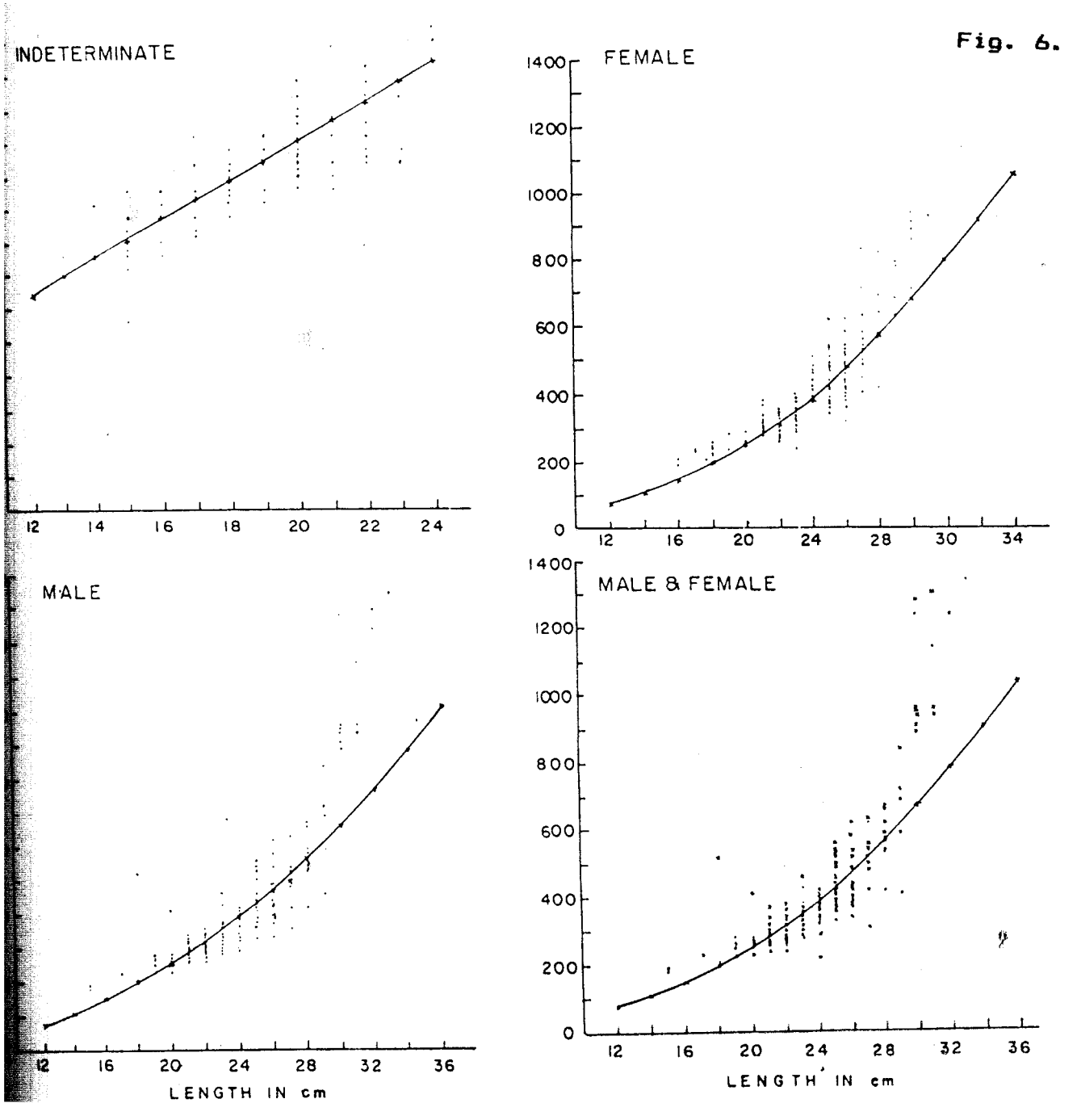
In the case of indeterminates, the expoent did not differ significantly from unity indicating that total weight is directly proportional to total length. In case of males and females, the exponent was significantly different from 3 indicating that the relationship was not isometric. Further, analysis of covariance revealed that there was no significant difference between sexes in respect of total length and total weight relationship (Table 5). Hence, a common relationship was obtained by combining the sexes and the relationship is given by : $W = 0.1877987698 \; L^{2.4049}$ $(r = 0.88)$ (Fig.6). In

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

Fig. 6.


INDETERMINATE
12
14
16
18
20
22
24
FEMALE
1400
1200
1000
800
600
400
200
0
12
16
20
24
28
30
34
MALE
12
16
20
24
28
32
36
LENGTH IN cm
MALE & FEMALE
1400
1200
1000
800
600
400
200
0
12
16
20
24
28
32
36
LENGTH IN cm

this context, Conand (1986) reported a "b" value of 1.87 in H. (M.) nobilis, 3.23 in H. (M.) scabra and 2.18 in H. (M.) scabra var. versicolor from New Caledonia. The reason for differences in "b" values in the same species could be due to the locality of occurrence as well as the environmental conditions favouring the individuals. Also, no significant relationships were found between total length and gutted weight and, total weight and gutted weight.

CHAPTER 7

REPRODUCTIVE BIOLOGY

A knowledge of the reproductive cycle which plays a major role in understanding the life history of an individual, helps to arrive at the rate of annual recruitment of its stocks. Reproductive parameters such as size at first maturity, spawning frequency, fecundity and recruitment are important in fishery predictions which in turn are necessary for formulation of management measures. Therefore, an attempt has been made to study separately the sexual cycle of males and females of H. (M.) scabra in detail.

7.1 Reproductive system

The gonads of H. (M.) scabra are white in immature and yellow in mature stages. Composed of a single tuft of tubules, each tubule is generally divided into three branches, attached to the left side of the dorsal mesentery and hanging 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 the present study, 249 females and 263 males were examined. 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 designated stages I, II, III, IV & V respectively.

The characteristic features of the maturity stages of male and female H. (M.) scabra are as follows:

MACROSCOPIC OBSERVATIONS

INDETERMINATE STAGE

Immature (I) and Maturing (II)

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 (III)

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 (IV)

Gonadial tubules are 10-13 cm in length, tubules with

MALE

Early mature (III)

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

Late mature (IV)

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

Spent (V)

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

FEMALE

Early mature (III)

The diameter of the oocyte range from 30-130 μ (Plate V, d).

Late mature (IV)

Oocytes measure 120-197 μ in diameter (Plate V, e).

Spent (V)

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

7.2.2 Ova Diameter

Ova from as many as 20 ovaries in different stages of maturity were collected and their diameters measured. Based

on their characteristic macroscopic appearances correlated with their microscopic details, five stages of maturity were identified as described earlier.

All the five stages of the ovary were selected for constructing 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 range of the ova was 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 range of the ova was 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 mode at 60 μ. The smaller eggs encountered in stage V indicate a new batch of eggs added to the gonad.

7.2.3 Spawning

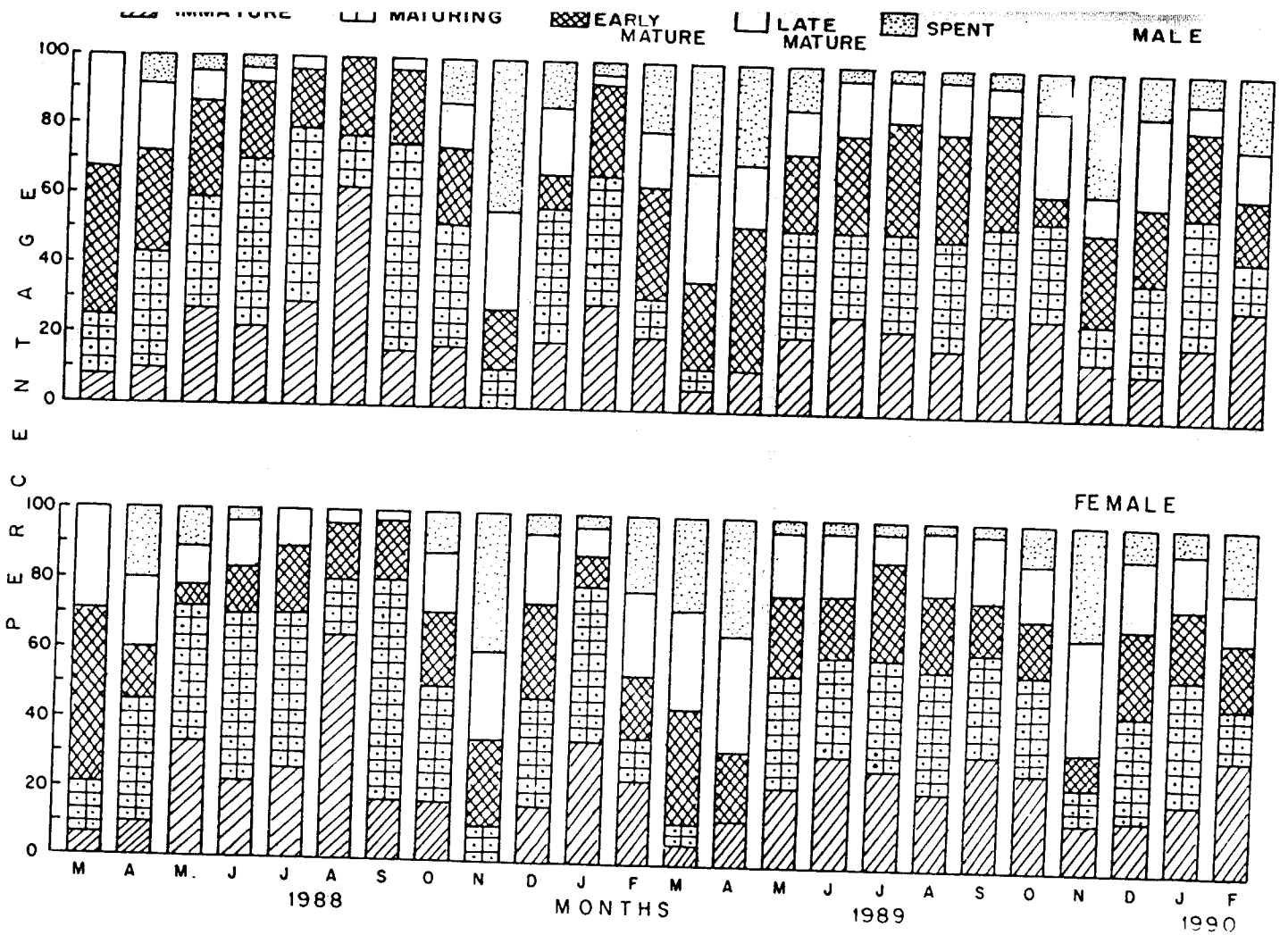
A total of 381 holothurians during March 1988 to February 1989 and 404 holothurians during March 1989 to February 1990, were examined to study the percentage occurrence of gonads in different stages of maturity. The details for male and female are presented in Tables 6 & 7 respectively and Fig. 7.

Male

During the year (March 1988 to February 1989) the following observations were made. In March 1988, stages I to IV were present, stage III being dominant (Fig. 7). In April, all stages were present, stages II & III being dominant. In

Table 6 : Perçentage 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	20	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	23	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


IMMATURE
MATURING
EARLY MATURE
LATE MATURE
SPENT
MALE
FEMALE
PERCENTAGE
100
80
60
40
20
0
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
1989
1990
MONTHS

May and June, almost the same picture as in April was noted with the exception that 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 was 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 (Table 6).

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

Female

During the year (March 1988 to February 1989) (Table 7 and Fig.7), stages I to IV were present, stage III being

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

dominant. In April, all stages were present, stage II was maximum. In May and June, Stages I and II were dominant and in July and September, stage II was maximum. Stage V was absent from July to September while stage I was maximum in August. During October, all stages I to V were present while stage II was dominant. In November, Stage I was absent and stages III to V were maximum with stage V at its peak. During December, stages II and III were dominant and in January 1989, stages I and II were recorded maximum. In February, Stages I, IV and V were dominant.

During the following year (March 1989 to February 1990) (Table 7 and Fig.7), the following observations were made. 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 stages IV and V were maximum. During May, stages I to III were dominant and stage II at its peak. The same condition was noticed in June, July and August. In September, stages I and II were maximum and in October, stages I to IV were maximum. In November, stages IV and V were recorded maximum and in December, stages II and III were dominant. In January 1990, stages I to III were recorded maximum and in February, stages I, III and V were maximum with stage I at its pkeak.

A comparison of observations on the maturity of H. (M.) scabra made over the two successive years, indicates that holothurians in 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 mature individuals occurred in all the months, with peak spawning in certain month of 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, mature male and female holothurians 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. In females, the mature individuals occur with peaks in March, May to October, December during 1988 and June to July in 1989. This, however, does not prove that spawning occurs round the year, because it is difficult to ascertain the duration of time the holothurians remain at these stages before spawning. 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. Thus, a detailed study and analysis of the data on maturity,

revealed that the percentage occurrence of difference stages of maturity during different months in males and females showed a remarkable similarity. Also the similarity in the month-wise distribution of particle sizes in the sea cucumber and the similarity in percentage occurrence of different stages of maturity in males and females in reconfirmed. This is now specially mentioned in the text.

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 may have taken place three or four months earlier. James (1976) recorded 30 mm long H. (M.) scabra in April, 70 mm long in February 1978 from Mandapam (Palk Bay). 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 took three weeks to reach the juvenile stage (0.5 mm) as reported by James et al. (1988, 1989) who also pointed out that the juveniles grew faster than the adult. It is therefore, possible that the young ones recorded in March 1989 may have been recruited some time in the period from 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

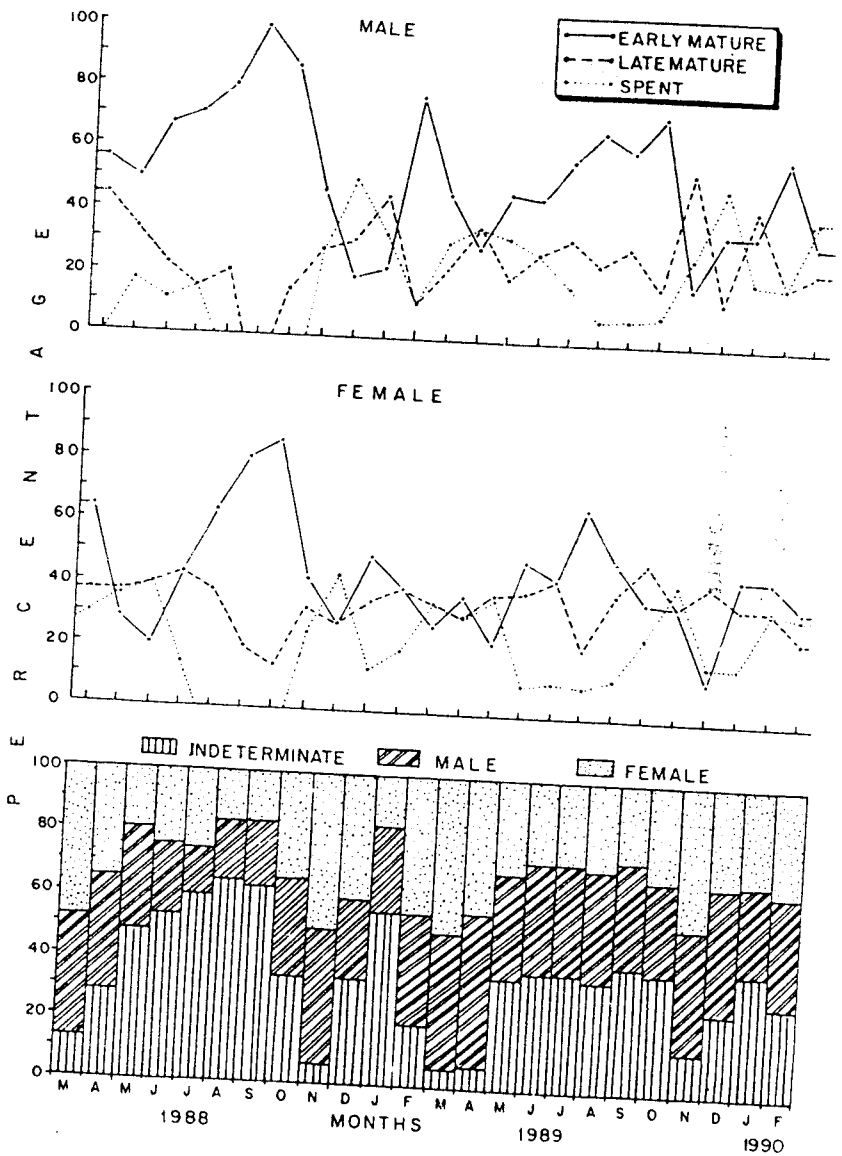
Fig. 8. a) Percentage occurrence of early mature, late mature and spend stages of males of H. (M.) scabra (March 1988 to February 1990).

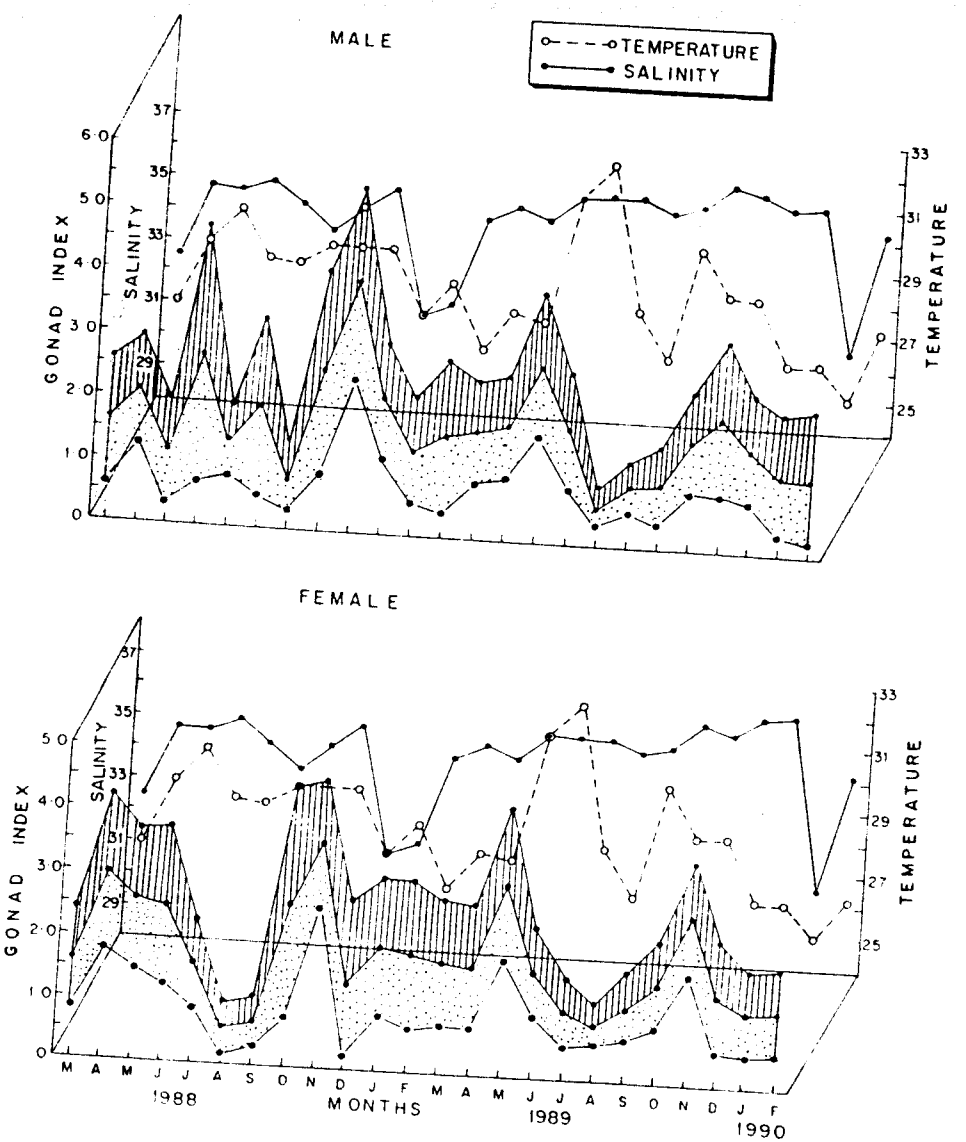
b) Percentage occurrence of early mature, late mature and spent stages of females of H. (M.) scabra (March 1988 to February 1990).

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.)


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


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

calculated separately for male and female holothurians collected from Tuticorin during March 1988 to February 1990 (Fig. 9).

Male : The GI showed an increase during April 1988 (2.09 ± 0.85), June (2.67 ± 2.01), October (2.5 ± 1.63) and November 1988 (3.96 ± 1.53). There was a decline in the gonad index during July (1.29 ± 0.51) to September 1988 (0.88 ± 0.46), January 1989 (1.35 ± 0.81) and February 1989 (1.61 ± 1.21). It increased again in May 1989 (2.82 ± 1.13) and November (2.09 ± 1.21) (Fig.9).

Female : The female gonad index values showed an increase in April 1988 (3.05 ± 1.15), November 1988 (3.63 ± 1.04), May 1989 (3.07 ± 1.16) and November 1989 (2.73 ± 0.91). During July 1988 (1.57 ± 0.72) to October 1988 (2.56 ± 1.83) and during June (1.75 ± 0.70) to October 1989 (1.64 ± 0.72) a decrease was observed (Fig.9).

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 suggests that the individuals have attained spent of maturing stage.

7.2.5 Relationship between gonad index, temperature and salinity.

During the study period from March 1988 to February

1989, water temperature ranged between 26-30°C. The maximum temperature was recorded in May 1988 (30°C) and minimum temperature was noted in January 1989 (26°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°C and 30.5‰ respectively). A maximum temperature of 32°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 coefficients of gonad index with salinity and temperature were -0.278 and 0.009 respectively. Both were statistically not significant. However, there was an inverse relationship between salinity and gonad index indicating possible reduction in gonad indices at higher levels of salinity. Also 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 obtained (no. of observations = 378)

(a) $G = -6.89096 + 0.00173\ TW + 3.027885\ MS$ ($r^2 = 72.7\%$)
$(+\ 0.00055)\quad (+0.126)$

(b) $G = -7.35590 + 0.00483\ GW + 3.127884\ MS$ ($r^2 = 72.3\%$)
$(+0.0024)\quad (+0.122)$

(c) $G = -8.26280 + 0.008596\ TL + 3.032599\ MS$ ($r^2 = 72.3\%$)
$(+0.0042)\quad (+0.150)$

Figures in paranthesis are the standard errors of the estimates. All the mentioned empirical relationships explain that about 72% of the variation in gonad weight indicates that the above equations 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 each of the classes was calculated.

For the purpose of calculating the size at first maturity, holothurians belonging to three stages viz., III, IV and V were grouped under one stage viz., mature. The details are presented in figs. 13 and 14 and Tables 8 to 11.

From table 8, it can be seen that in males during March 1988 to February 1989, upto 14 cm, all the holothurian were in the immature stage. From 14-25 cm the individuals were in maturing stage with a peak at 19-20 cm (79.5%). The early mature male holothurians were recorded from 17-26 cm, with maximum percentage (61.9) at 22-23 cm and the late mature individuals were recorded from 18-26 cm with a maximum peak (44%) at 23-24 cm. The spent individuals were observed from 23-33 cm with a peak (100%) in 26-27 cm (Fig. 13).

As can be seen from Table 9 all the females 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 females 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 spend holothurians were observed from 23-33 cm, having 100% in the 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 holothurians were in the maturing stage, and more than 90%

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

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.

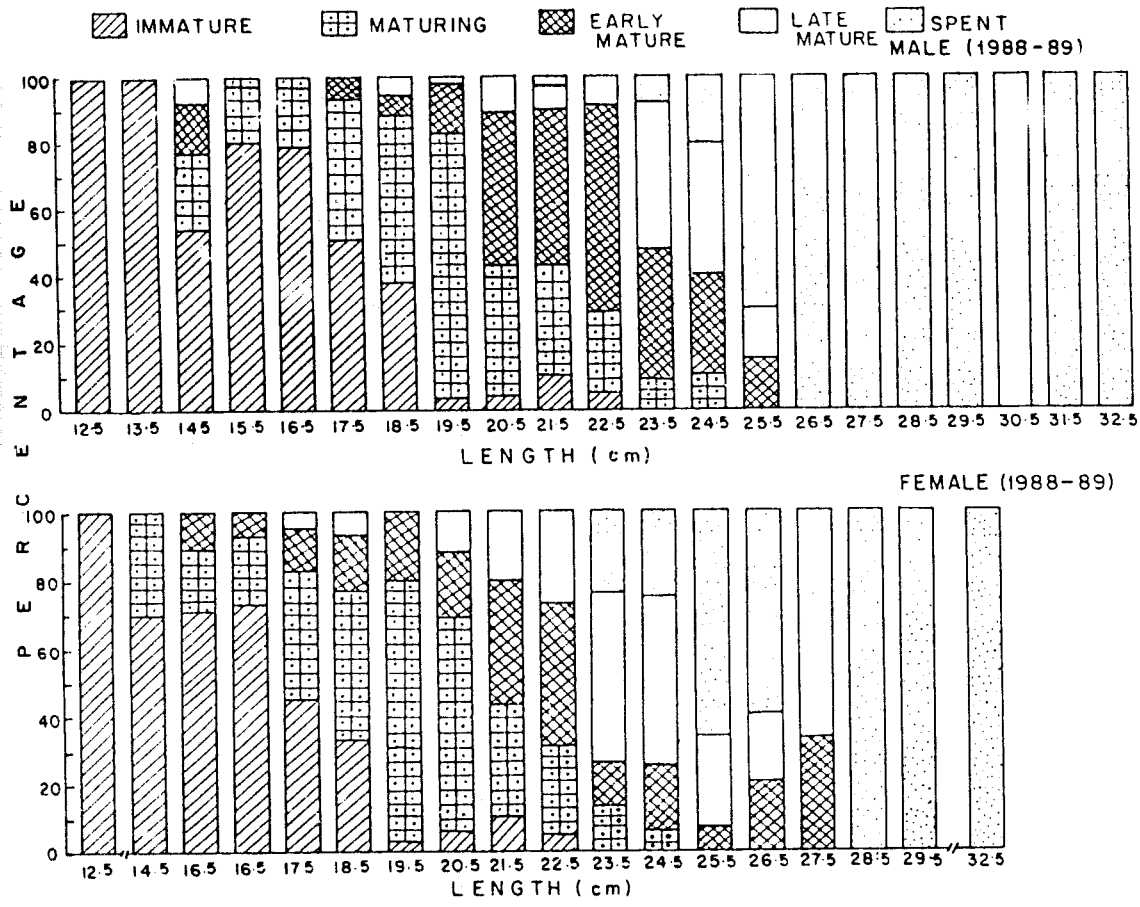

IMMATURE
MATURING
EARLY MATURE
LATE MATURE
SPENT
MALE (1988-89)
PERCENTAGE
100
80
60
40
20
0
12·5 13·5 14·5 15·5 16·5 17·5 18·5 19·5 20·5 21·5 22·5 23·5 24·5 25·5 26·5 27·5 28·5 29·5 30·5 31·5 32·5
LENGTH (cm)
FEMALE (1988-89)
PERCENTAGE
100
80
60
40
20
0
12·5 14·5 16·5 16·5 17·5 18·5 19·5 20·5 21·5 22·5 23·5 24·5 25·5 26·5 27·5 28·5 29·5 32·5
LENGTH (cm)

Fig. 14.

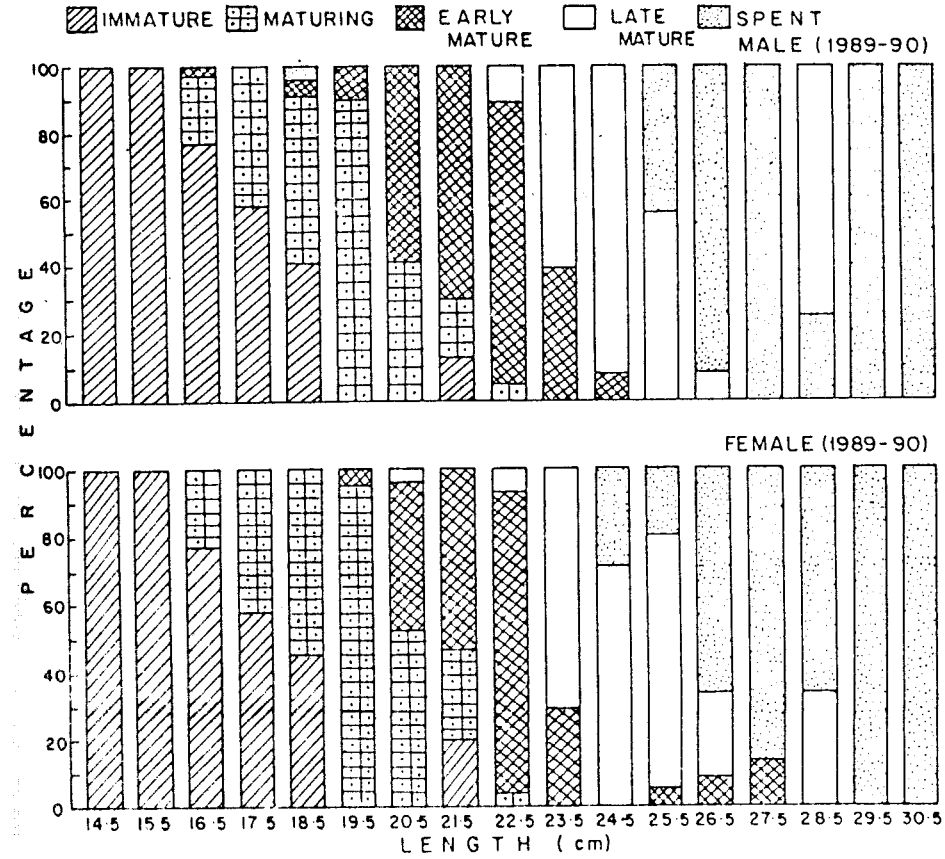

IMMATURE
MATURING
EARLY MATURE
LATE MATURE
SPENT
MALE (1989-90)
PERCENTAGE
100
80
60
40
20
0
14·5 15·5 16·5 17·5 18·5 19·5 20·5 21·5 22·5 23·5 24·5 25·5 26·5 27·5 28·5 29·5 30·5
LENGTH (cm)
FEMALE (1989-90)
PERCENTAGE
100
80
60
40
20
0

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

were noted in the size group of 19-20 cm. The early mature holothurians 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 (Table 10 & Fig. 14) while the females were matured from 19-28 cm, with a peak (88.89%) in the 22-23 cm size range (Table 11 & Fig.14). The late mature holothurians were observed from 22-29 cm having maximum percentage of 91.67% in 24-25 cm in males (Table 10 & Fig. 14) and 75% of females in the size group of 25-26 cm. The occurrence of females of late mature stages were found from 20-29 cm (Table 11 & Fig.14). The spent holothurians 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 (Table 10 & Fig.14) while in females, the spent were recorded in 16-17 cm and from 24-31 cm with 100% in the 29-30 cm size group (Table 11 & 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 table 12 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 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 holothurians increased steadily in the higher size groups and practically all the holothurians were mature at 25-26 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

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 1988-1990.

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 1988-1990.

Fig. 10.

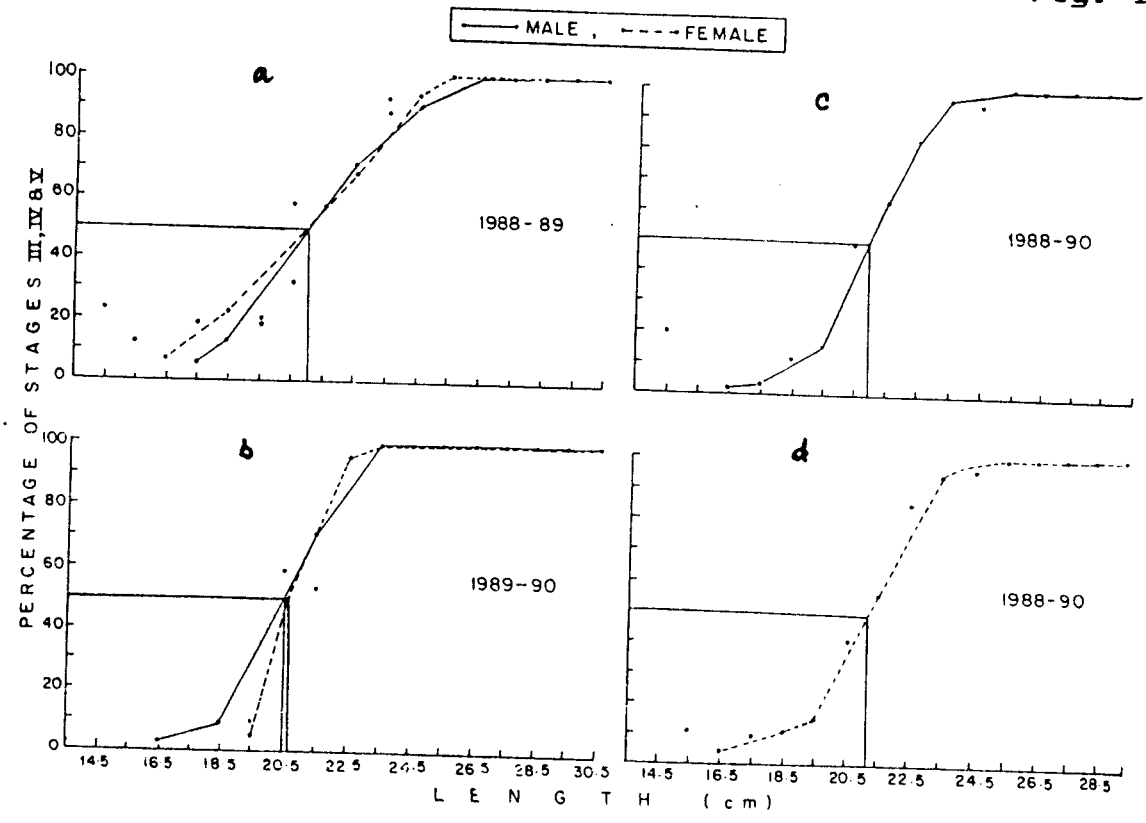

MALE , ----FEMALE
a
b
c
d
1988-89
1989-90
1988-90
1988-90
PERCENTAGE OF STAGES III, IV & V
0
20
40
60
80
100
14.5
16.5
18.5
20.5
22.5
24.5
26.5
28.5
30.5
L E N G T H (c m)

Fig. 11.

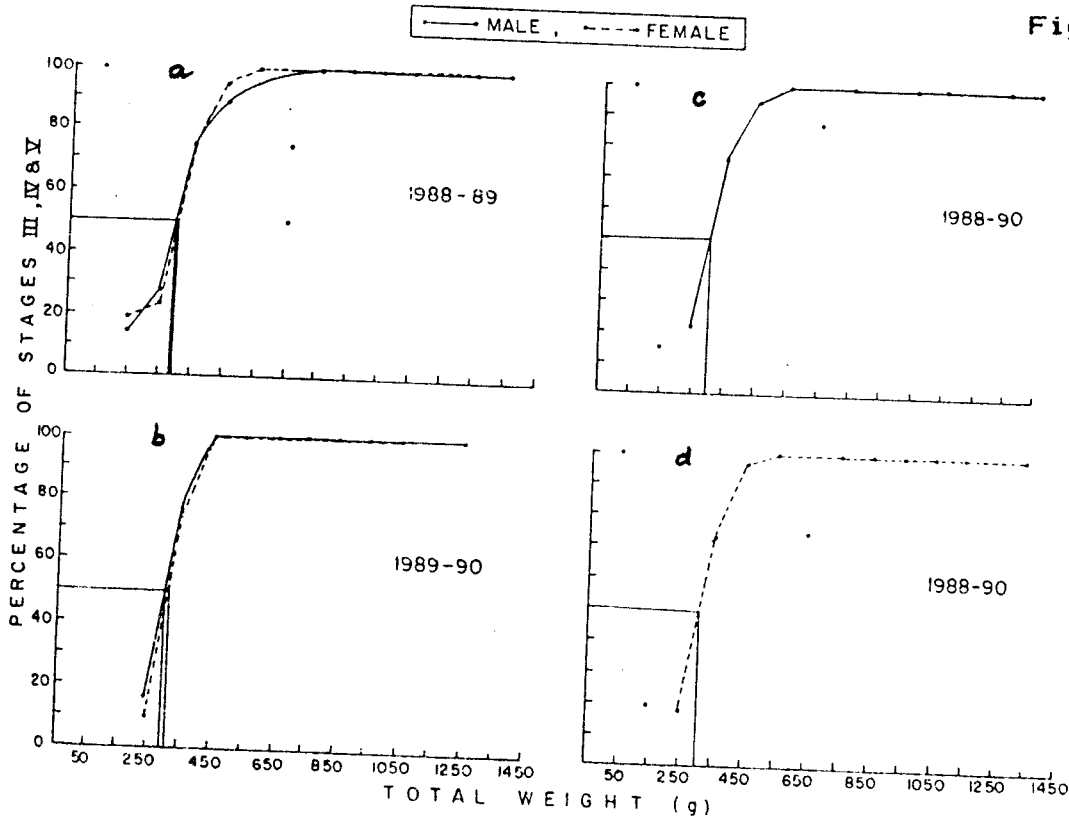

MALE , ----FEMALE
a
b
c
d
1988-89
1989-90
1988-90
1988-90
PERCENTAGE OF STAGES III, IV & V
0
20
40
60
80
100
50
250
450
650
850
1050
1250
1450
T O T A L W E I G H T (g)

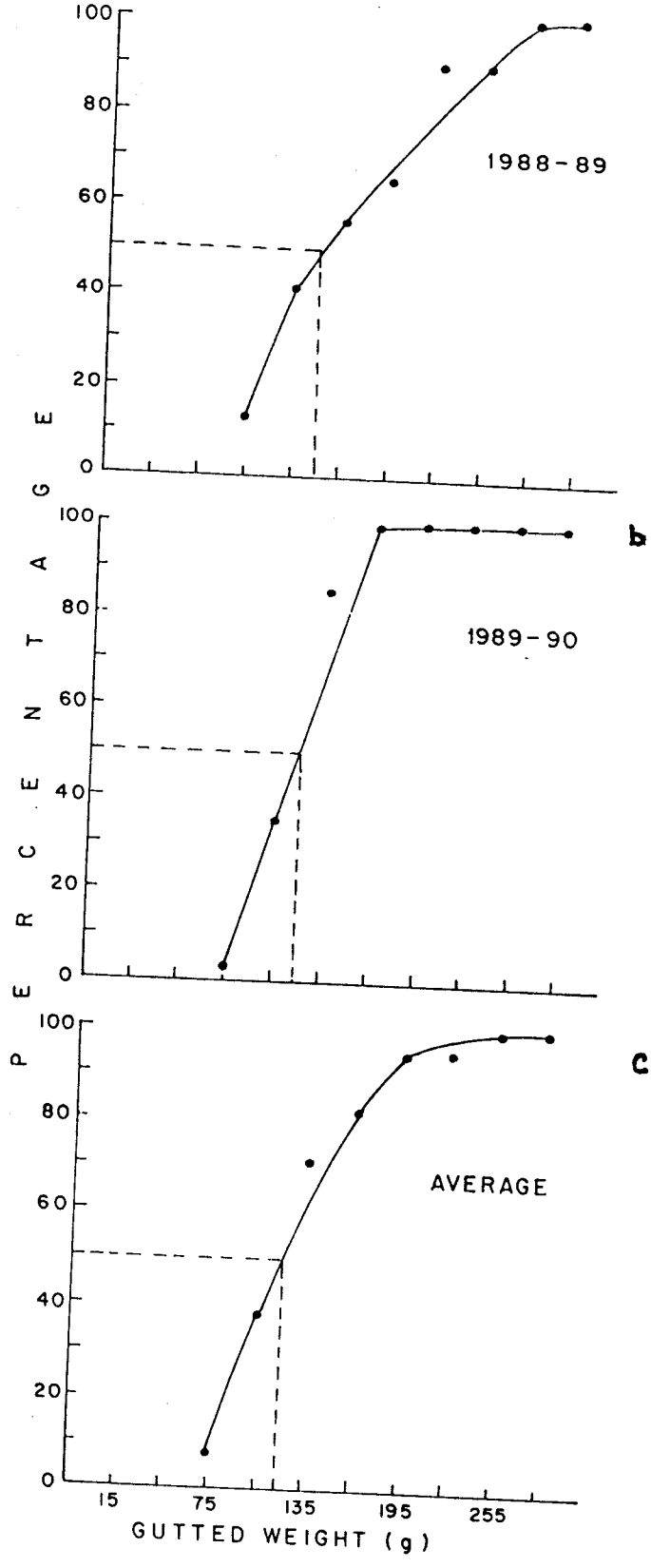
Fig. 12. Gutted weight of H. (M.) scabra at first maturity based on data for the period

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
1989-90
c
AVERAGE
PERCENTAGE
15
75
135
195
255
GUTTED WEIGHT (g)

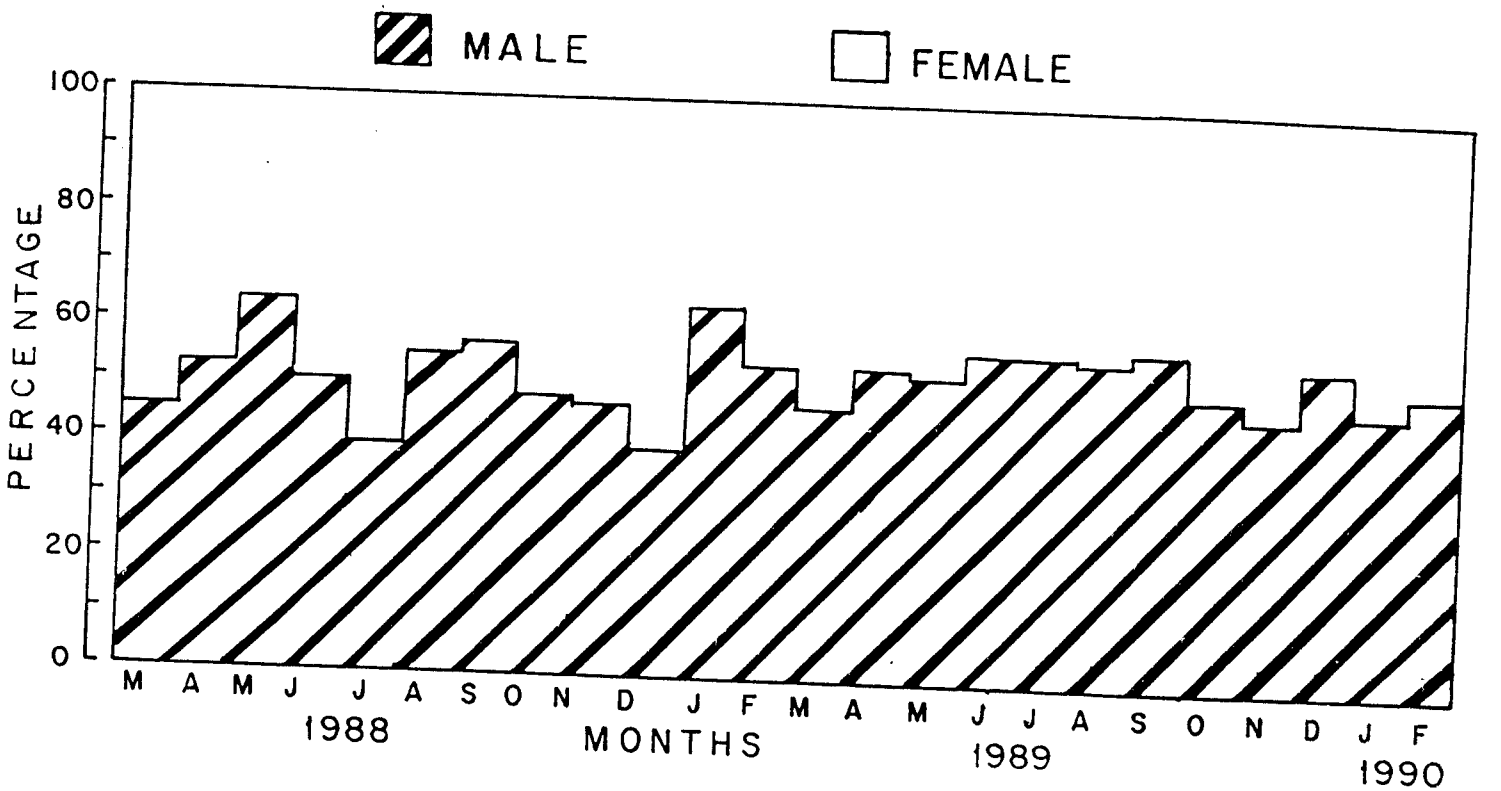
In females (Table 13), the holothurians mature in the 15-16 cm size class (5.88%) and 16-17 cm (4.76%). In the following size group ie. 17-18 cm, the percentage of mature holothurians increased similarly as in males. Fifty percent of the holothurians were mature in the size group of 20-21 cm and 21-22 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 indeterminates, males and females was calculated and are denoted in fig 8 c. The indeterminate holothurians 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 holothurians spawn during March to April and November to December in a year and the immature individuals were found in the subsequent months (June to October).

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

Fig. 15.


MALE
FEMALE
100
80
60
40
20
0
PERCENTAGE
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

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:

$\text{Log}_e F = 0.5993 + 2.2181 \ \text{Log}_e TL; \ r^2 = 0.09$ NS

$\text{Log}_e F = 10.7015 + 0.3694 \ \log_e TW; \ r^2 = 0.06$ NS

$\text{Log}_e F = 9.3892 + 1.6786 \ \log_e G; \ r^2 = 0.82$ 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 sizes but it was not possible to differentiate the sex externally. The holothurian gonads consist of tubules. The tubules were 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 were 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.

7.3 Discussion

Krishnaswamy and Krishnan (1967) reported four stages of maturity viz. immature, mature, gravid and spent in H. (M.) scabra. But according to the present studies the maturity stages were 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) have 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 btween gonad index and temperature, an inverse relationship was found between gonad index and salinity. The present findings are in agreement with the observations made by Jayasree and Bhavanarayana (1989) in Holothuria leucospilota from Goa.

A linear relationship was found between the total length, total weight, gutted weight, gonad weight and maturity stages. 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. As evidenced from the present studies 72% of the individuals were observed to follow the above 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 spawned throughout the year with peak intensities in July and October. The breeding seasons of different species of holothurians have been dealt with by different authors. Stichopus japonicus reproduces in June to August (Tanaka, 1958b) whereas Engstrom (1980) reported that S. japonicus spawned between mid May and September. Cucumaria lubrica spawned in November and early January and Holothuria floridana spawned during late summer in Southern Florida (Engstrom, 1980, 1982). Holothuria atra

bred biannually with spawning in November and May (Harriott, 1982) and H. impatiens in late spring or summer (Harriott, 1985). Actinopyga echinites spawned in January and February, Holothuria nobilis bred in colder season, H. (M.) scabra reproduced in October to November in New Caledonia, Thelenota ananas, H. fuscogilva spawned in warm season (Conand, 1981, 1990). Holothuria parvula spawned during July to September (Emson and Mladenov, 1987).

The spawning behaviour of H. (M.) scabra was observed in the laboratory. The males took a characteristic position like a sigma and every time the anterior end was bent inwards, the sperm were released in the form of white threads. It spawned sometimes even over two hours. The female raised the anterior end and released 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 the female at 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 the smallest mature 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, 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 facundity 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 was 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 ($P < 0.05$). Druing the breeding season, the ratio of males to females was 1 : 1. Conand (1981, 1990) has also found a similar ratio in Holothuria nobilis and Actinopyga echinites.

Yet another important observation made during the present studies was 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. They were also not found in places deeper than eel grass zone on muddy-sandy areas.

CHAPTER 8

AGE AND GROWTH

Growth in Holothuria (M.) scabra 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.

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 total length of the holothurians were measured in cm. The data on length collected during the above period were grouped into 2 cm intervals. The numbers and percentage frequencies are given in Tables 14 & 15. For modal progression analysis, data from September 1988 to May 1989 were used.

8.1 Results and Discussion

Modal progression analysis

In September 1988, two modes could be seen at 19 and 27 cm 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, three modes were recorded at 19, 23 and 27 cm. In January 1989, two modes at

Table 14 : Length frequency of H. (M.) scabra used for modal progression analysis.

Size group (cm)	1988				1989				
	Number of specimens								
	Sept.	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 : Length frequency (in %) of H. (M.) scabra used for modal progression analysis.

Size group (cm)	1988				1989				
	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	--

13 and 21 cm and in February 1989, two modes at 19 and 23 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 were 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 1989 (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 13 cm in 14 months. This 13 cm of January 1990 had shifted to 19 cm in 11 months (6 cm / 11 months) and further has moved from 19 cm to 23 cm in 12 months (4 cm / 12 months). Comparison of these two curves shows that the holothurians had grown faster in November (cohort 13 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

Table 16 : Progress of modes in length frequency 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_2 $\Delta l/\Delta t$
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

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

$a = 1.870157$; $r = 0.946$

$b = -0.02726649215 \doteq -K$ 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.

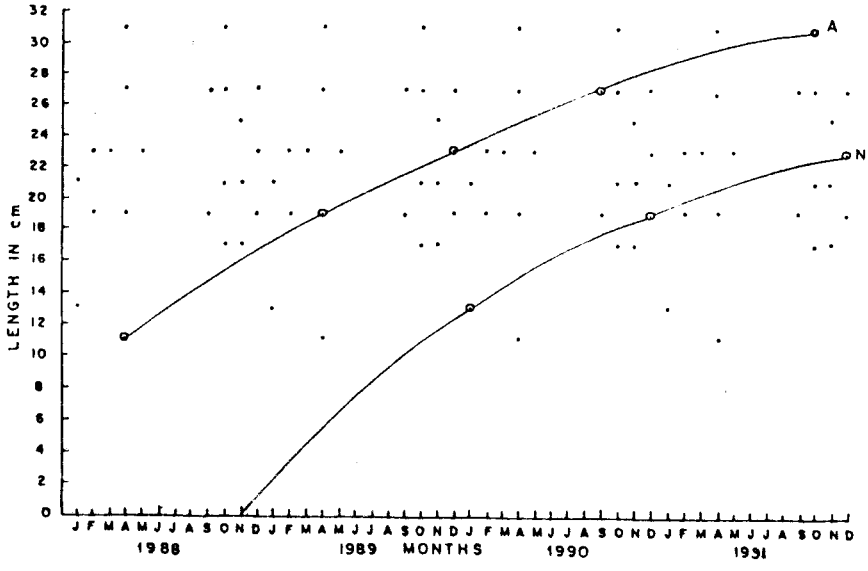


Fig. 17.

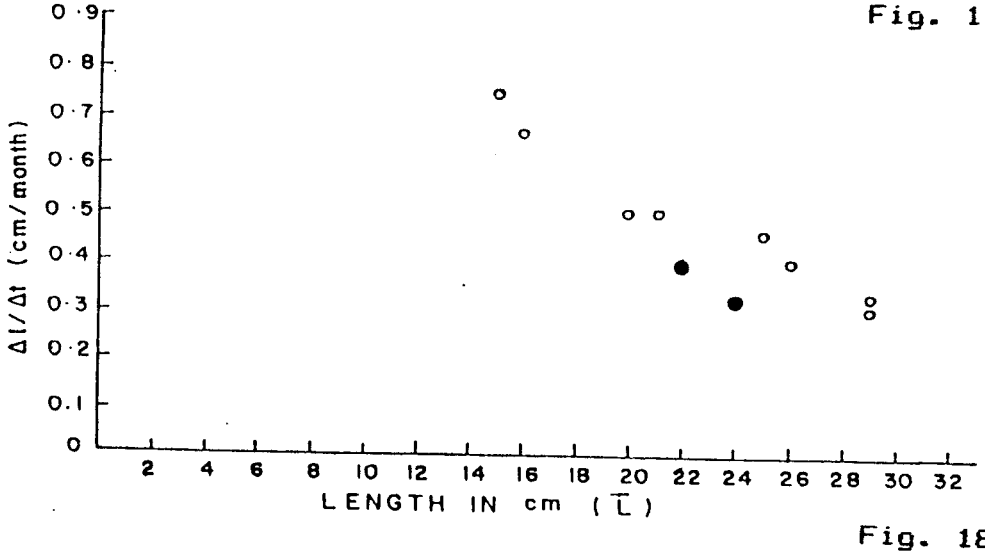
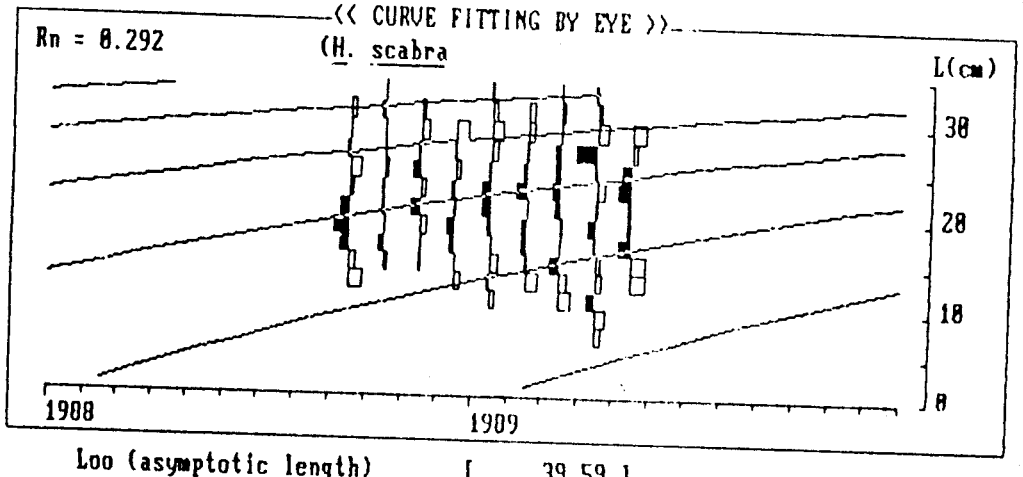


Fig. 18.



Loo (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]

Shelley (1985) which is given as

$$Lt = L_{\infty} \left(1-e^{-k(t-t_o)}\right) \quad \ldots.1$$

where L_{∞} = Length at infinity;

k = growth coefficient;

t_o = (arbittrary) 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'. The 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 follow:

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 way 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 (1991b) recorded one specimen of H. (M.) scabra of 40 cm length from Tarmugli Island (Andaman) at a depth of 2 m. From the 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 is very interesting. Holothurians living in the different habitats are known to exhibit different locomotary behaviour. Benthic sea cucumbers execute relatively rapid movements. In some bathypelagic species rapid progressive movement is regarded as a normal means of locomotion. Deep sea holothurians do not bury themselves in the soft mud of the floor of the ocean but flit more or less readily over its surface. Parker (1921) studied the locomotion of the holothurian Stichopus parvimensis. Glynn (1965) studied the active movements in the holothurians Astichopus and Leptosynapta. To find out how exactly the shallow water species like Holothuria (M.) scabra is able to move about and behave in its habitat and how is reacts to varying intensities of penetration of light, observations were made under laboratory conditions.

9.1 Results and discussion

9.1.1 Mechanism of burrowing

Experiments were undertaken in the laboratory to study the mechanism of burrowing of H. (M.) scabra following the procedure described under (vide chapter 2.5). The specimens were kept in separate tanks for observation . When three

specimens were released in one tank these 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. After some time, 45 minutes, the individual moved further deep into the substratum leaving only the posterior end of the body exposed. This condition was reached in a space of 2 hours and can be referred to as 'semi buried'. This process continued 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 at a time defaecated 3 to 4 pellets of faecal matter, at an interval of 1 to 2 hours. It appears that H. (M.) scabra ingests 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

Experiments conducted as per the procedure indicated under Materials and Methods (chapter 2) following results were obtained. (a) The 12 hour light and 12 hour dark experiment showed that nearly 45% lay buried in the sand from 0900 to 1500 hours and more than 80% of the holothurians

Table 17 : Experiments to study the burrowing behaviour of H. (M.)scabra exposed to light and darkness

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..

surfaced after 1500 hours. (b) In the 24 hour dark experiment, nearly 70% of the holothurians did not bury themselves and (c) in the 24 hour light experiment, 30% of the individuals were buried for 1200 hour only (Table 17). It may be seen that during day time btween 0900 and 1500 hours, the holothurians lay buried in sand and become exposed after 1800 hours. This indicates that light plays a vital role in the burrowing habit of holothurians. With limited number of experiments it was not possible to conclude whether there was a circadian rhythm or not.

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 originated at the posterior end of the animal and swept over to the anterior end. Before the locomotor wave began, the whole length of the body of the individual was attached to the substratum by its ambulacral tube feet (Fig.19a). The tube-feet of the posterior portion were loosened from the substratum 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

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

a) Resting position

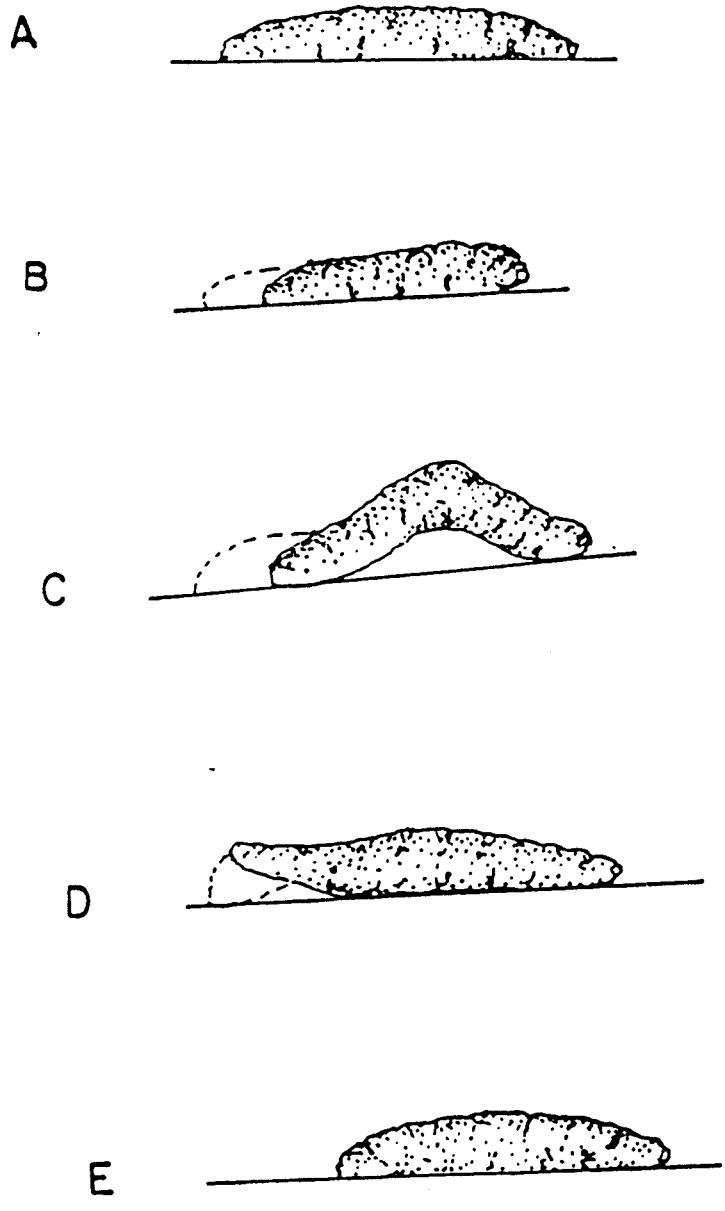
b) Initiation of wave at posterior end

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.

Fig. 19.



position, the posterior portion was then reapplied to the substratum 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 substratum, 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 advanced. In this way H. (M.) scabra moved forward step by step over the substratum.

As per the observations made by D.B. James, (Personal communication) locomotion in H. (M.) atra is effected by the well developed tube feet. First, the tube feet at the anterior far end are fixed firmly to the tank. This serves as an anchor for the animal. Then the hold on the tank is released by the tube feet of the posterior portion. After this the animal is dragged in the forward direction by the contraction of the longitudinal muscles. The tube feet at the posterior portion of the animal are fixed to the tank firmly and the hold on the anterior region is released. This process is repeated during the locomotion of the animal. Similarly, Parker (1921) observed the locomotion of Stichopus parvimensis and Glynn (1965) in Astichopus multifidus. They pointed out that the holothurian attaches itself to the

substratum by means of ambulacral tube feet and moves from end to end. In H. (M.) scabra also an identical pattern of movement has been observed now.

PART - III.

FISHERY

CHAPTER 10

PRESENT STATUS OF THE HOLOTHURIAN FISHERY

Among the many non-conventional marine fishery resources of the Indian coast, holothurians or sea cucumbers as they are popularly known, occupy a significant place from the point of view of export market. A commercial product known as 'Beche-de-mer', otherwise also known as 'Trepang' is prepared from a few species of holothurians. This product is considered a gourmet's delight and is in great demand in China and in many Southeast Asian countries. Beche-de-mer industry was introduced in India by the Chinese as evidenced from the writings of Hornell (1917) who gave authentic account of the fishery and industry as they existed in the early part of this century. In later years, Krishnamoorthi (1957), Chari (1964), James (1973, 1991a), Jacob (1973), Shenoy (1977), Durairaj (1982) and Durairaj et al. (1989) have added more valuable information on the status of the fishery and the processing methods. It is evident from the attention focussed on it that the holothurian fishery enjoys a special status high in the esteem of exporters.

10.1 Species contributing to the fishery

At present Holothuria (M.) scabra and H.spinifera are exploited mostly both from the Gulf of Mannar and Palk Bay areas. Another species Bohadschia marmorata is also fished

from the Gulf of Mannar but only in minor quantities. James and Bahrudeen (1990) have indicated that Actinopyga echinites is found in the deeper waters of the Gulf of Mannar. This species also forms a very minor component of the present day fishery but in future years may play an important role.

Although the above constitute the important species presently, it may not be out of place here to mention that apart from the mainland species, Actinopyga sp. in Andaman & Nicobar islands and Stichopus chloronatus in Lakshadweep are also of commercial value in the preparation of beche-de-mer. The fishery in these two areas do not form the subject matter of the present studies.

10.2 Fishing methods

10.2.1 Skin diving

The easiest method to collect holothurians is to pick them by hand during low tide time from intertidal regions and shallow lagoons wherever they occur. But holothurians are mainly collected by skin diving in shallow waters of depth 2-10 m; in some areas up to 15 m. There are a good number of expert fishermen along Tuticorin, Kilakarai, Vedalai, Rameswaram and Tirupalakudi fishing centres who engage themselves in skin diving for holothurians during seasons. Fruitful diving depends largely on prevailing fair weather in the sea and underwater clarity. Brisk diving in the Gulf of Mannar is resorted to mostly during the Northeast monsoon

months particularly from October to January; very often diving extends upto end of April, if the clarity of water is good. Diving in the Palk Bay side is done sporadically during this period. But organised fishing starts in May and continues upto September, the activity shifting from one place to another depending on the prevalent good weather and sea conditions. By and large, the sea is calm during this period to permit diving.

Local vallams or indigenous non-mechanised canoes are employed for sailing from shore to fishing areas and back. On an average 10-12 divers go in one boat and each good diver will make about 30 dives per day extending over a period of 4-5 hours (Plate VI, 1).

The divers carry net bags with them inwhich the live holothurians collected during diving are put and brought ashore. Use of modern techniques like "SCUBA" diving has not caught up with them because of the initial high cost involved. Aluminium plates are used for feet as improvised flippers instead of rubber flippers which are costly. This enhances their swimming efficiency underwater. Most of them wear glass masks for better vision underwater. However modern accessories in diving are being popularly employed since they increase the efficiency of divers while diving. (Plate VI, 2, 3 & 4).

It should be mentioned that the bulk of the catches

going to the processing industry comes from skin diving only.

10.2.2 Trawl net

Mechanised boats trawling for prawns and demersal fishes do bring in considerable numbers of holothurians as a bycatch. In such operations the possibility of restricting the size range of specimens netted is totally not possible. Hence, it is to a certain extent, indiscriminate exploitation. Nevertheless, those specimens which are beyond the reach of the skin divers are netted. Comparatively, the numbers landed by trawl nets constitute only a small percentage of the total landings of holothurians. This trawling is more common and frequent in the Palk Bay and is done almost on all months though there is a peak season during May - September.

10.2.3 Tallu valai

Traditional small scale fishermen of the Gulf of Mannar and Palk Bay employ sail boats or "Vallams" to operate "Tallu Vallai" - a kind of improvised bag net for scouring the sea bed to catch prawns and other demersal species. Holothurians are netted as a bycatch. Although the net is operated mainly during March to September it is not uncommon to see the tallu valai operations during other months also.

10.3 Fishing areas and season of fishing

Fishing by all the above three methods is done both in the Gulf of Mannar and Palk Bay. The main centres in the Gulf of Mannar from where these activities are carried out are Tuticorin, Kilakarai and Vedalai. On the Palk Bay side, Rameswaram and Tirupalakudi are the important centres.

10.3.1 Gulf of Mannar

Skin diving and Tallu valai operations are done from Tuticorin. As already stated, the skin diving intensity is during the months of October-March. But in certain days during other months when clarity of sea water is good diving is continued. The windward side of many islands, particularly off Van Theevu, Kaswar, Karaichalli and Puzhukuni Challi Islands situated in the proximity of Tuticorin, are good fishing grounds.

At kilakarai also holothurian fishing is done mainly by skin diving. The windward side of the islands Nallatanni Theevu, Anaipaar Theevu, Balyamunai Theevu, Thalayari Theevu, Valai theevu and Uppu tanni Theevu lying off kilakarai are good fishing grounds where holothurians are found at depths 2 to 16 m.

Vedalai, another fishing hamlet also serves as a holothurian landing centre by skin diving in areas lying at

depths of 4 to 15 m, off Manali island, Hare island, Mulli theevu and Pulli theevu.

10.3.2 Palk Bay

Rameswaram is one of the main landing centres from where fishing for holothurians is done by (a) skin diving and (b) trawling operations by mechanised boats where they are brought as by catch. Skin divers here exploit shallow regions within 4 to 15 m depth range between Rameswaram and Dhanuskodi. This is done from May to September. (b) Trawling operations are done at 10 to 20 m depth throughout the year but the peak season is during March to October.

At Tirupalakudi, which is the second major landing centre, skin diving is resorted to seasonally from April to September. The fishing areas are in shallow regions upto 12 m depth. Occasionally, holothurian fishing is done by skin diving from centres like Panaikulam and Attankarai also during the months of May to September.

10.4 SPECIES COMPOSITION

Gulf of Mannar

In the landings at Tuticorin H. (M.) scabra constitutes the major catch and H.spinifera is fished rarely. At Kilakarai, Bohadschia marmorata is also found among the catches but it is only third in rank whereas H. (M.) scabra ranks first

followed by H. (M.) spinifera.

Palk Bay

The species composition of the Palk Bay catches is identical to that of the Gulf of Mannar side. But Bohadschia marmorata is not found among the catches from this zone.

10.4.1 Percentage of catch composition

The details of holothurian landings and the species composition from the Gulf of Mannar and Palk Bay during 1988-1990 are given in Tables 18-21 and Fig.20-24.

Table 18 gives details of total catches observed during 1988-1990 at Tuticorin. A total of 33.35 tonnes was landed there and H. (M.) scabra constituted 100% of the landings.

At Kilakarai H. (M.) scabra constituted 69.79%, H. spinifera 30.18% and B. marmorata accounted for 0.03% of the catches in 1988-1989 and 91.43%, 8.43% and 0.14% respectively during 1989-1990. A total of 31.15 tonnes was landed at this centre during 1988-1990.

At Vedalai, landings showed that H. (M.) scabra was 98.92% of the total whereas H.spinifera was only 1.08% in 1988-1989. In 1989-1990, the percentage composition was

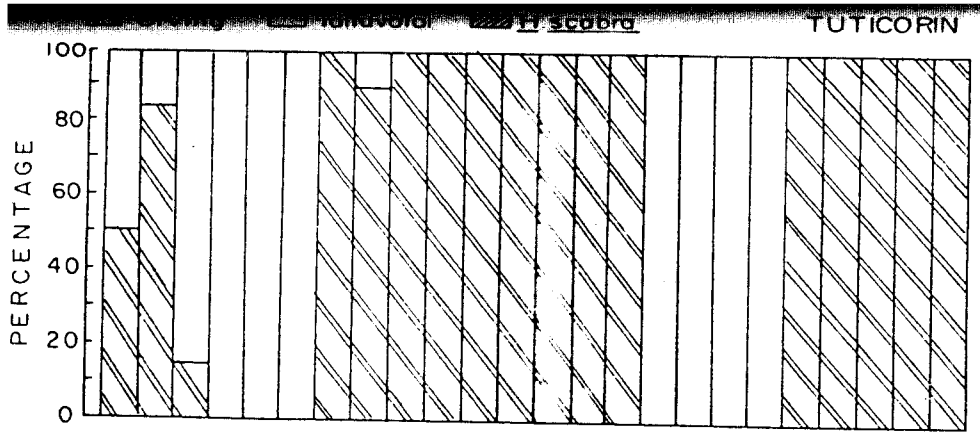
Table 18 : Percentage composition of holothurians from different landing centres during 1988 - 1990.

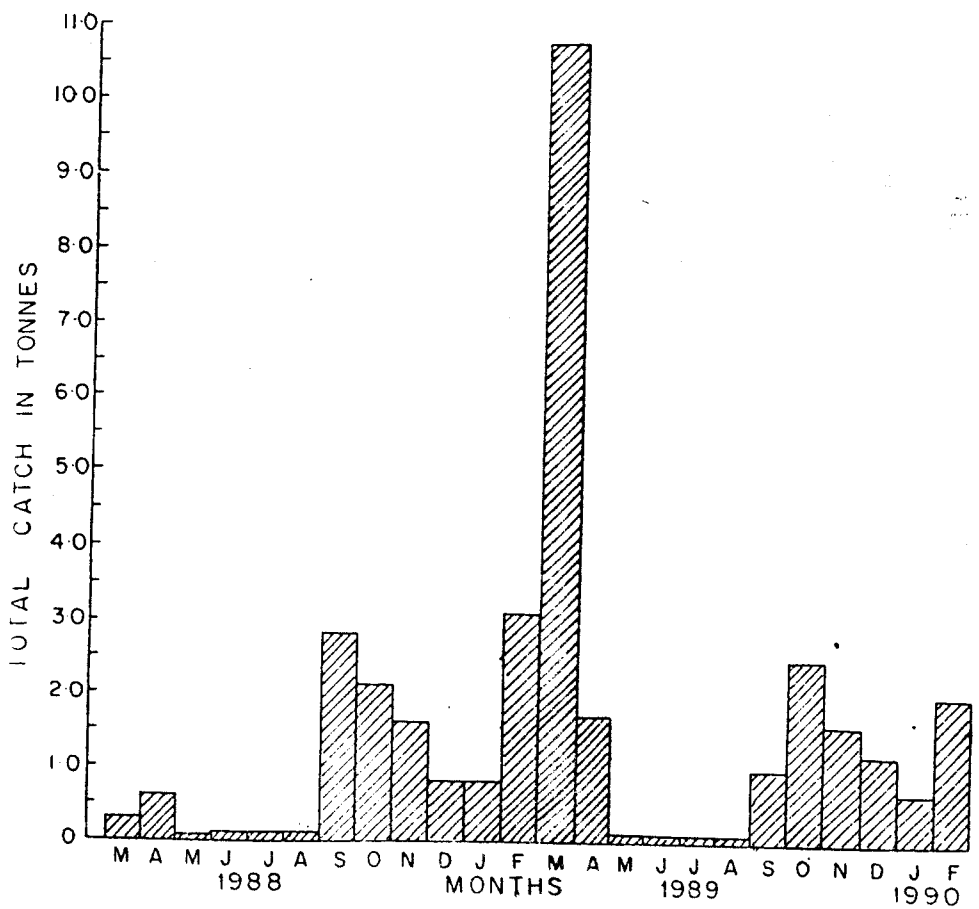
Centres	1988 - 89				1989-90				Average (1988-90)			
	H.sc.	H.sp	B.m.	Total (in tonnes)	H.sc	H.sp	B.m	Total	H.sc	H.sp	B.m	Overall total (in tonnes)
Tuticorin	100.00	--	--	12.45	100.00	---	---	20.90	100.00	---	---	33.35
Kilakarai	69.79	30.18	0.03	27.40	91.43	8.43	0.14	3.75	72.40	27.56	0.04	31.15
Vedalai	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

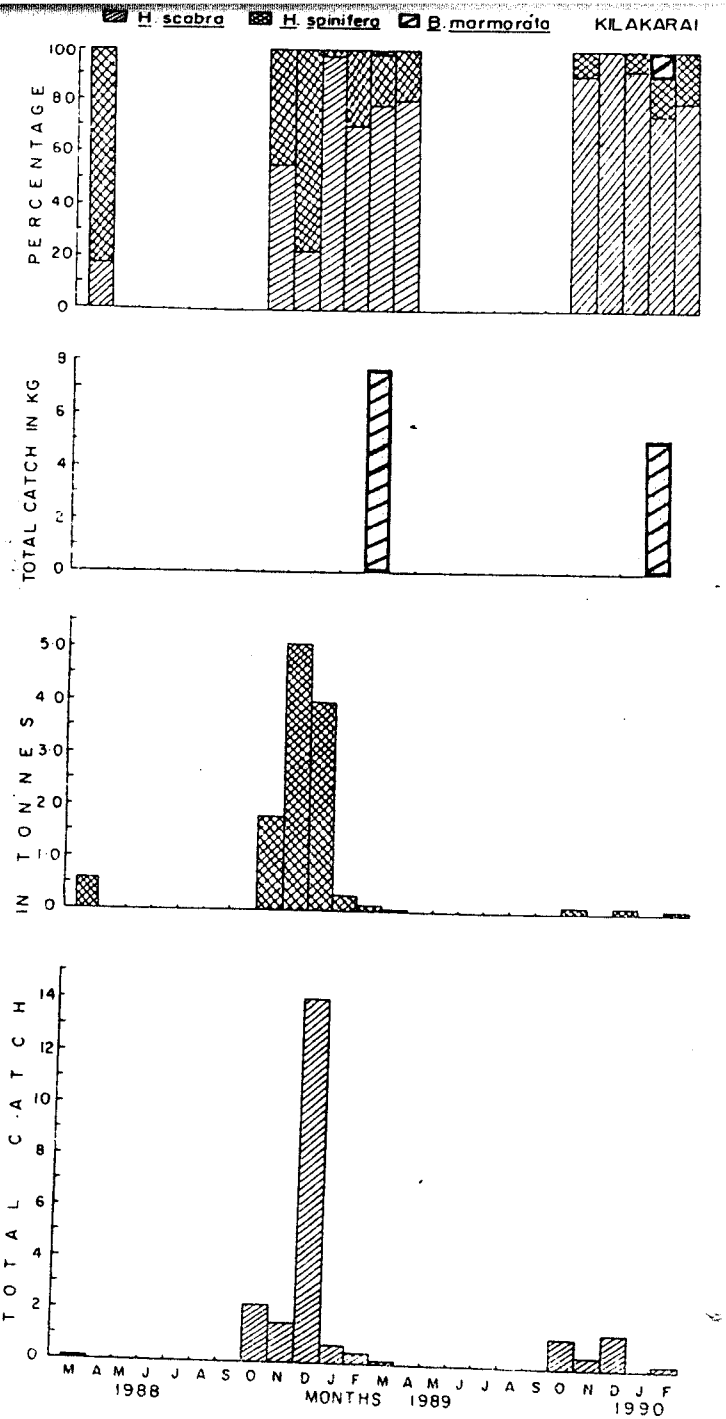
H.sc. = H. (M.) scabra; H.sp = H. spinifera; B.m = B. marmorata

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).


H. scabra
TUTICORIN
PERCENTAGE
0
20
40
60
80
100


TOTAL CATCH IN TONNES
0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
9·0
10·0
11·0
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
0
20
40
60
80
100
TOTAL CATCH IN KG
0
2
4
6
8
IN TONNES
0
1·0
2·0
3·0
4·0
5·0
TOTAL CATCH
0
2
4
6
8
10
12
14
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

more or less identical being 99.2% and 0.8% respectively. A total of 12.66 tonnes was landed at this centre during 1988-1990.

At Rameswaram there was a quantitative difference in the percentage composition of species landed. H. (M.) scabra constituted 52.08% and H. spinifera accounted for 47.92% in 1988-1989 whereas in 1989-1990 it was 97.79% and 2.21% respectively. But the total catch recorded was only 15.26 tonnes during 1988-1990.

At Tirupalakudi, H. (M.) scabra accounted for 87.11% and H.spinifera 12.89% during 1988-1989 while in 1989-1990 they represented 93.41% and 6.59% respectively. The total catches amounted to 134.24 tonnes during 1988-1990.

Fig.20 depicts monthly catches of holothurians at Tuticorin. During the period of study, it was seen that diving for holothurians was recorded in September 1988, November 1988 to May 1989 and October 1989 to February 1990, when 100% of the total landings came from diving only. It is interesting to note that in March 1989, a total weight of 11.00 tonnes of H. (M.) scabra was brought by skin diving. Tallu valai operations were responsible for 100% of the catches during June to August 1988 and June to September 1989.

Fig.21 indicates that at Kilakarai, skin diving during March to October in 1988 and 1989 brought 100% of the total

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

Fig. 22.

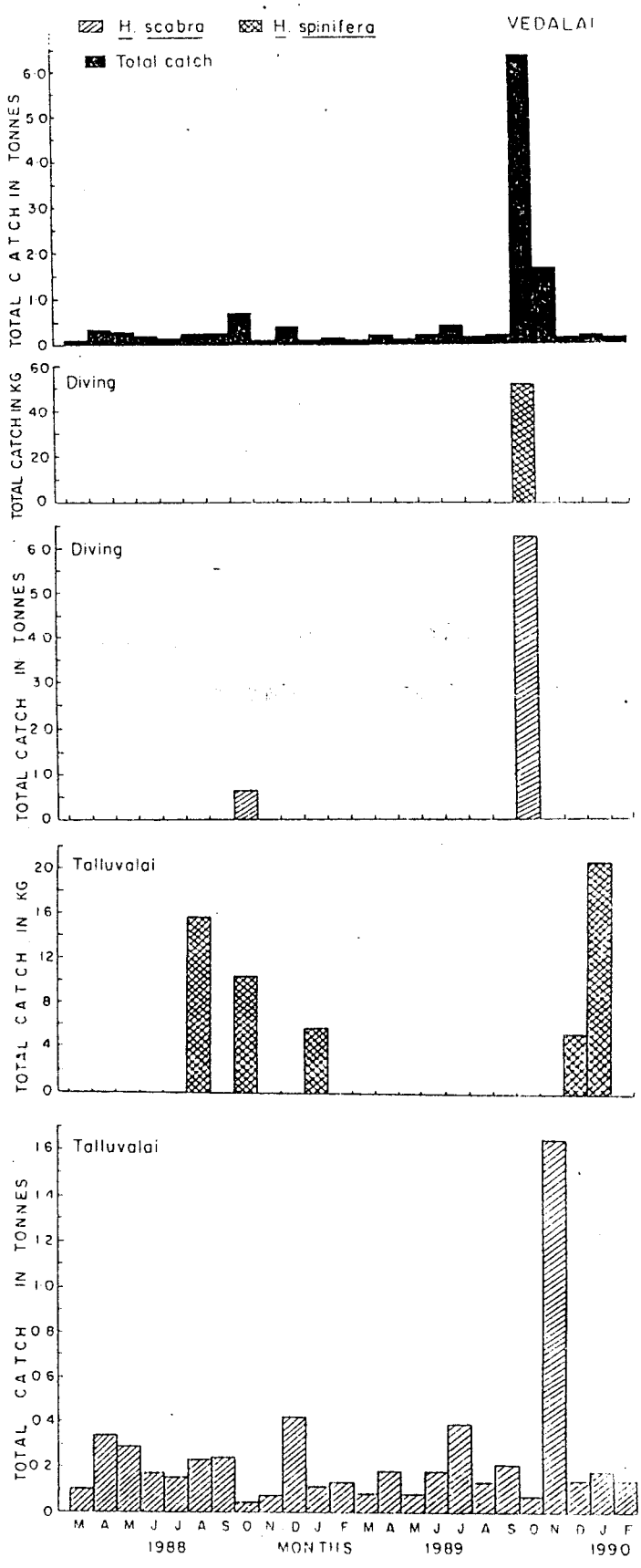
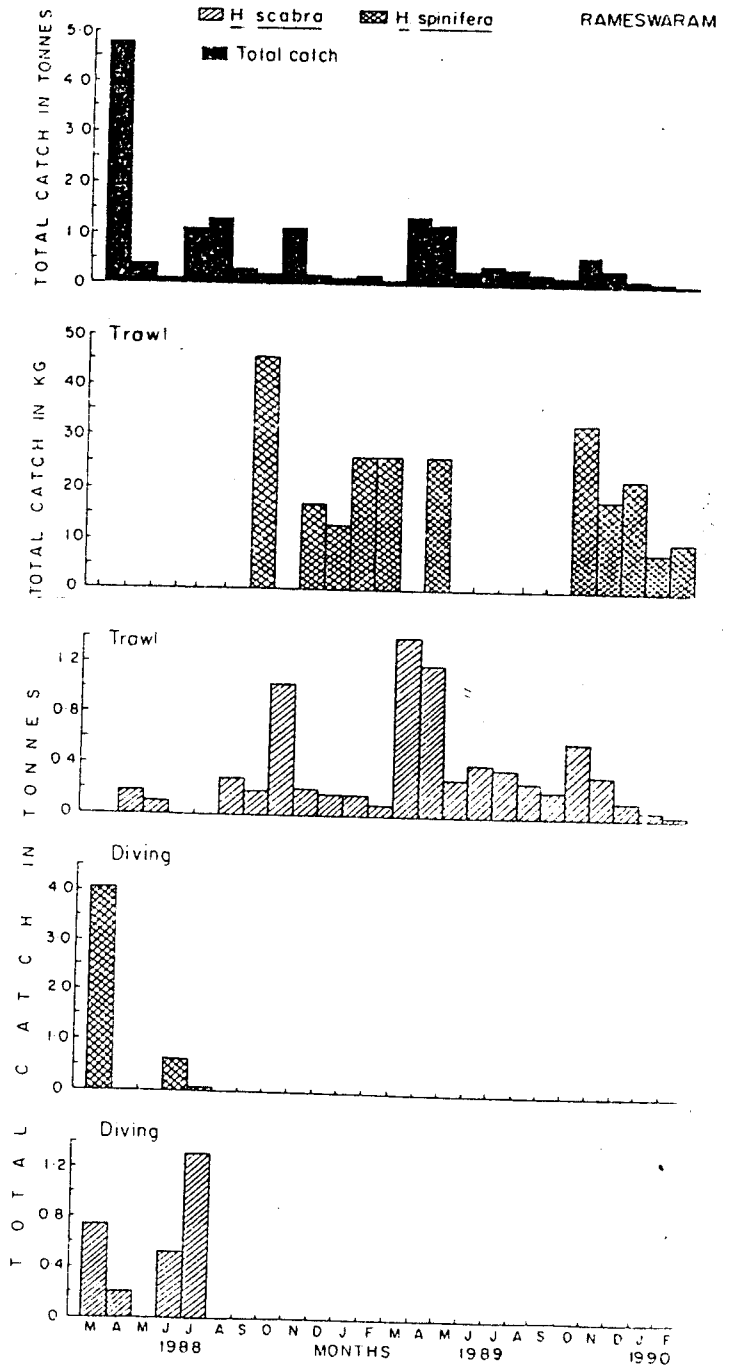
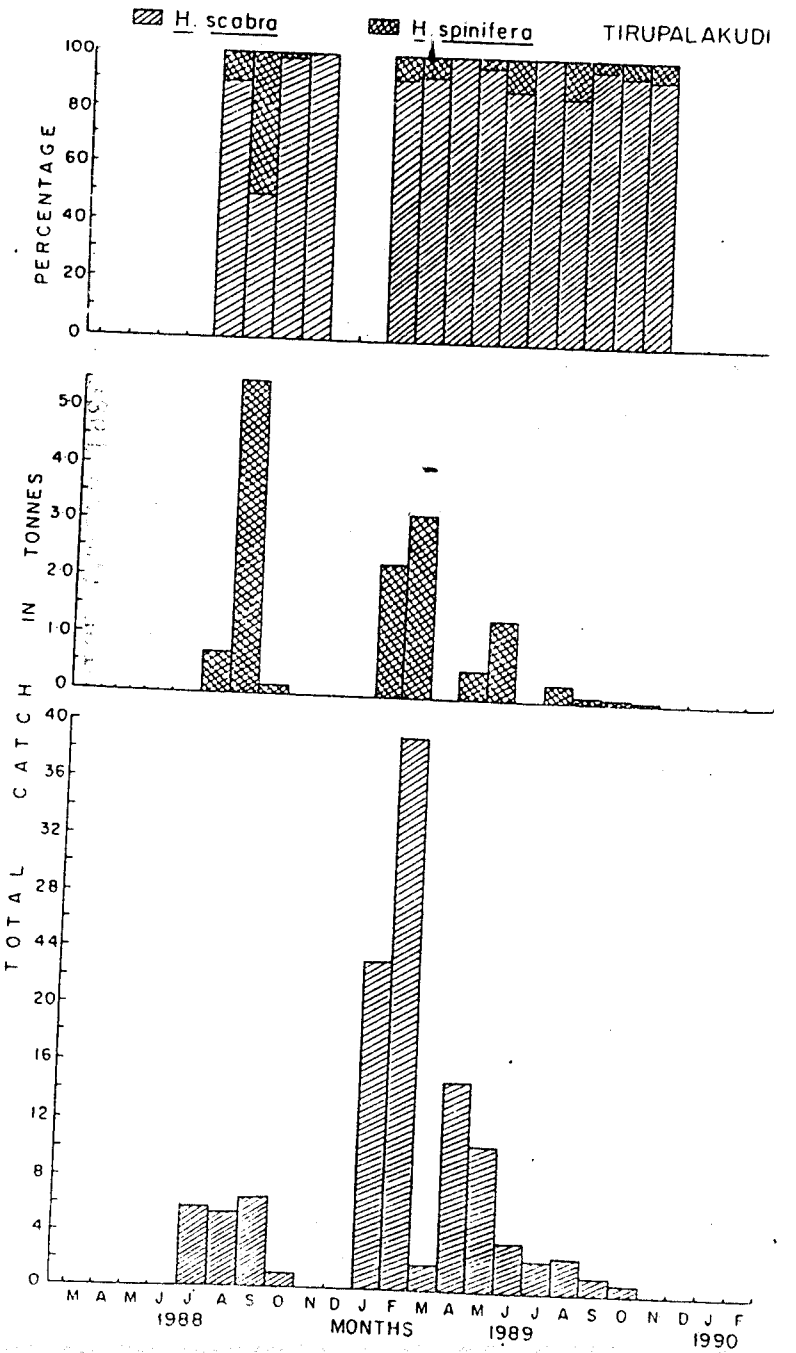

H. scabra
H. spinifera
Total catch
VEDALAI
TOTAL CATCH IN TONNES
Diving
TOTAL CATCH IN KG
Diving
TOTAL CATCH IN TONNES
Talluvalai
TOTAL CATCH IN KG
Talluvalai
TOTAL CATCH IN TONNES
M A M J J A S O N D J F M A M J J A S O N D J F
1988
MONTHS
1989
1990

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
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

landings of H. (M.) scabra and H.spinifera. It is interesting to note that maximum catch of 13.6 tonnes of H. (M.) scabra was brought in December 1989 whereas in November 1988 H. spinifera accounted for 5 tonnes. Landing of the species Bohadchia marmorata was very negligible (7 - 8 kg.) in February 1989 and 5 kg. in February 1990.

At Vedalai, diving was restricted to October in 1988 and 1989. H. (M.) scabra landed during October in 1989 constituted 6.0 tonnes and H.spinifera 50 kg. only (Fig.22). However, Talluvalai was operated throughout during 1988 to 1990. The maximum catch of H. (M.) scabra in talluvalai was in November 1989 (1.6t). H. spinifera was netted in August and October 1988, January and December 1989 and January 1990. The maximum catch of 20 kg. was made in January 1990.

At Rameswaram (Fig.23) diving operation brought 13 tonnes during July 1988, and 4 tonnes in March 1988. The trawl catches of H. (M.) scabra was more in March 1989 (1.4t) and H. spinifera accounted for 46 kg. in September 1988. The maximum catch from this centre was 4.75 tonnes during March 1988.

At Tirupalakudi (Fig.24), skin diving was done from July 1988 to October 1989 except for November and December 1988. Although H. (M.) scabra constituted 100% of the landings in October 1988, March and June 1989 peak landings

of H. (M.) scabra was in February 1989 (39.5t) while H. spinifera was landed in considerable quantity (6 t) in August 1988.

It is evident from the above account that H. (M.) scabra formed the maximum percentage among the exploited holothurians irrespective of the landing centres. It contributed 90.51% of the catches from the Gulf of Mannar and 78.43% from the Palk Bay. This indicated that H. (M.) scabra was the dominant species along the south east coast while H. spinifera and B.marmorata (together constituting 9.49% in the Gulf of Mannar) occupied the next position in order of importance.

10.4.2 Gearwise catch composition

The catch composition of holothurians landed by different methods of fishing as skin diving, tallu valai and trawls, collected from different centres of the southeast coast of India is presented in Table 19.

Table 19 shows that at Tuticorin, skin diving and tallu valai contributed 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 was caught by skin diving and a total landing of 31179.34 kg in 1988-1990 was recorded. At Vedalai, the main catches were by skin diving and tallu valai, the percentages of estimated catches being 54.66 and 45.34 respectively, with a net

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

Centre	1988-89			1989-90			Average (1988-90)			
	Diving	Tallu valai	Trawl	Diving	Tallu valai	Trawl	Diving	Tallu valai	Trawl	Overall Total (in Kg)
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 from Gulf of Mannar and the Palk Bay

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
Total % of catch in 1988 - 90			25.60%
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%

production of 12652.17 kg in 1988-1990.

At Rameswaram holothurians fished by diving constituted 48.63% whereas by trawlers they formed 51.37%, the total catch estimated being 15262.75 kg during 1988-1990. At Tirupalakudi, the holothurians were collected only by skin diving (100%) with a total landing of 134223.05 kg during the year 1988-1990.

It is evident that fishing of holothurians by skin diving was common in all the centres and 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 review 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 that holothurian resources are exploited primarily 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 appears to be more productive and the resources are heavily exploited.

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

The estimated total landings for the Gulf of Mannar were 154.32 tonnes and for Palk Bay coast 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 Seasonal distribution

Centrewise seasonal distribution of the three different species contibiting to the fishery was observed seperately based on the catches from the three different types of fishing namely skin diving, tallu valai and trawling.

10.5.1 Skin diving

Holothuria (M.) scabra : As stated earlier, H. (M.) scabra is the most important species commercially at present. This is exploited to a maximum extent by diving. During the course of this study catch statistics were collected from three centres on the Gulf of Mannar side and from two centres on the Palk Bay side.

Tirupalakudi on the Palk Bay ranked first in the landings for H. (M.) scabra followed by Kilakarai, Tuticorin, Rameswaram and Vedalai. At Tirupalakudi, two peaks were seen. Maximum number of specimens were collected during

January, February followed by another peak in April/May. At Kilakarai, the season started in October and ended in December. Maximum number of specimens were colleted during December. At Tuticorin, there were two peaks, one during February-April which formed a major peak and another during September-December a minor one. The catches were maximum during March. At Rameswaram, there were two peaks one during March-April and another during June-July. The catches were maximum during July. At Vedalai, catches were landed only during October.

Holothuria spinifera : H. spinifera, a commercially less important species was fished from Kilakarai and Vedalai during October to December. At Rameswaram, it was fished during March and also during June-July. Maximum collections were made during March. At Tirupalakudi, two peaks were seen, one during July-September and the other during January-May. Maximum catches were recorded during August. During the month of March there were no landings.

Bohadschia marmorata : B. marmorata is a species of very minor importance for processing because of the presence of large quantities of Cuvierian tubules inside the body which create problems during processing. The species was collected only from Kilakarai during January-February by diving.

10.5.2 Tallu Valai

H. (M.) scabra : H. (M.) scabra was collected by tallu

valai only at Vedalai and Tuticorin. At Vedalai, the peak season was September-December. Maximum number was collected in November. At Tuticorin, the peak was from June to September.

H. spinifera : At Vedalai, H.spinifera occurred in two peaks, one during December-January and another during August and September. The catches were maximum during January.

10.5.3 Trawlers

H. (M.) scabra : The fishery for H. (M.) scabra was supported at Rameswaram by Trawlers to some extent. There were two peaks, one in March-April which formed a major peak and another during September-November forming a minor peak.

H.spinifera also comes in small quantities in trawler catches at Rameswaram from September to February. Maximum catches were noted in September.

10.5.4 Geographical distribution

Of the three commercial species viz., H. (M.) scabra, H.spinifera and B.marmorata, H. (M.) scabra and H.spinifera occur both in the Gulf of Mannar and Palk Bay whereas B.marmorata is restricted only to the Gulf of Mannar zone. H. (M.) scabra is also distributed in the Andaman and Nicobar Islands, whereas it is totally absent in the Lakshadweep. H.spinifera which has a somewhat restricted distribution does

not occur either in the Andaman and Nicobar Islands or in the Lakshadweep. B.marmorata is found in the Andaman and Nicobar Islands and also in the Lakshadweep islands.

10.6 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.

Skin Diving

At Tuticorin, the CPUE was recorded maximum by skin divers during February 1989 (30.08 kg) and March 1989 (24.51 kg) and at Kilakarai, during December 1988 (62.74 kg) and December 1989 (19.43 kg). At Vedalai, the CPUE was found higher in October 1989 (20.17 kg). At Tirupalakudi, the intensity of fishing was brisk in February 1989 (54.6 kg) and March 1989 (18.00 kg) whereas at Rameswaram, it was 12.44 kg during March 1988.

Tallu Valai

In Tallu Valai, the CPUE was more in October 1988 (0.27 kg) and September 1989 (0.20 kg) at Titicorin, while in Vedalai, it was 1.45 kg during December 1988 and 2.03 kg during November 1989.

Trawlers

In trawls, the CPUE was more during October 1988 (0.43

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

Fig. 25.

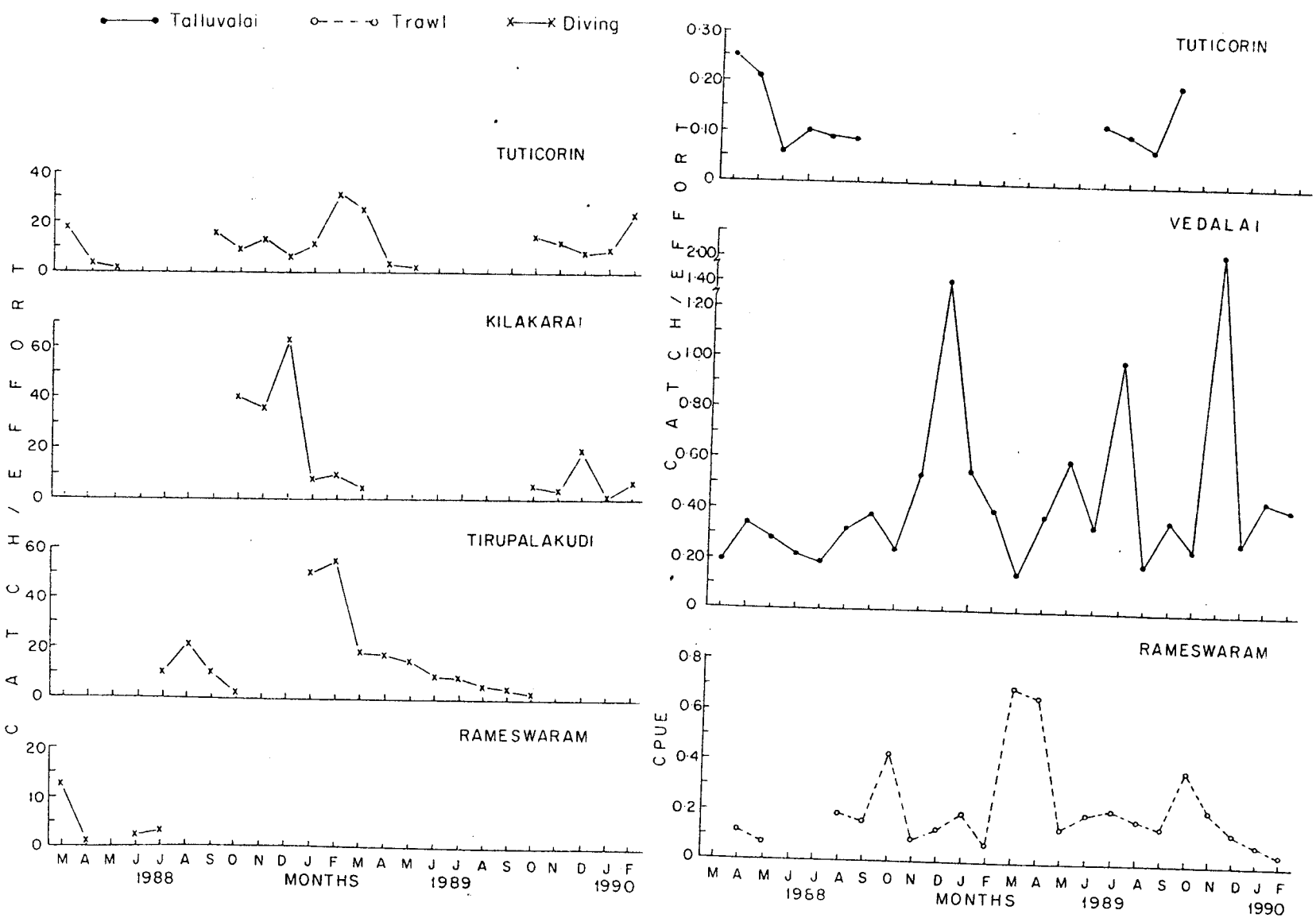

Talluvalai
Trawl
Diving
TUTICORIN
KILAKARAI
TIRUPALAKUDI
RAMESWARAM
CATCH/EFFORT
MONTHS
1988
1989
1990
VEDALAI
CPUE

Table 22 : Beche-de-mer Exportsfrom 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)

kg) and March 1989 (0.70 kg) at Rameswaram.

10.7 Export

Beche-de-mer (Plate VII, e & f) is mainly exported to Singapore, Hongkong and other Southeast Asian countries.

Analysis of the statistics of exported beche-de-mer revealed that during the year 1981, 48 tonnes of beche-de-mer worth Rs.26.69 lakhs were exported. In 1983. In 1983, 71.85 tonnes of beche-de-mer worth Rs.36.97 lakhs were exported. Due to a ban imposed in 1982 on the export of beche-de-mer below 3 inches in size (75mm), there was a downward trend in the quantity exported in 1984 and 1985 thereby bringing down the value of the exported commodity to 17.98 and 11.68 lakhs during 1984 and 1985 respectively. However, the export market recovered in 1987 and 1989 fetching a revenue of Rs.82.34 and 123.03 lakhs respectively (Table 22).

10.8 Beche-de-mer processing

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

Boiling : (a) Boiling is an important step in processing the holothurians and the quality of the product depends on the shape of the vessel used and the stirring done (Plate VII, b). The fishermen use oil drums (Tin) of 200 litre capacity and aluminium vessels for boiling depending on their availability. (b) Coconut husks, coconut shells, mangrove wood and some other hard woods are used as fire material. Initially, sea water is boiled in which the degutted sea cucumbers are put gradually. Boiling is done roughly for 30-45 minutes, the exact boiling time depending on the animal size. (c) While boiling, it is important that the boiling pan gets uniform heat on all the sides as this ensures good quality of the product. Beche-de-mer shrinks slightly and gradually becomes hard. 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. Hardness is the best criterion to judge the quality.

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

Smoking : During rainy season, the boiled specimens are smoked by placing them on top of an 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 are turned up and down at intervals.

Odour : The finished product should be free from bad odour. When the finished product comes in contact with water it develops an offensive odour. This is carefully avoided .

Colour : Dark colour is generally preferred. The chalky white ventral surface is avoided (Plate VII, d).

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

Spoilage : Product is kept carefully stored free from bacterial and chemical spoilage.

Packing and storing :

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

CHAPTER 11

SUMMARY

The results of the present study are summarised as follows:

1. Observations on the distribution of the holothurian H. (M). scabra indicated its availability all along the coastal areas of 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. Fishing for holothurians was mainly done by skin diving at all the centres. In addition, sea cucumbers are caught in tallu valai at Tuticorin and Vedalai and trawls 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 to be a non-selective feeder.

4. Quantitatively, H. (M.) scabra preferred the particle size of 250 - 500 μ size which constituted 39.22% ± 4.78% in the gut content. The particle sizes were found to be stricktly similar in both years of study viz., 1988-1989 and 1990-1991

5. The particle sizes examined from the gut contents of H. (M.) scabra varied from less than 90 μ to > 1680 μ.

6. No significant difference was found between the size of individuals and size of the particles in the gut contents of H. (M.) scabra. There is also no relationship between total length of the holothurian and length of the digestive tract, total length and wet weight of the digestive tract and total weight of the holothurian and wet weight of the digestive tract.

7. It was observed that H. (M.) scabra fed poorly during breeding seasons viz. March - April and November - December. Full stomachs were encountered during the month of January in both years.

8. The analysis of the biochemical constituents viz. total 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 total organic carbon and organic matter, 18.53% of carbohydrate and 32.41% of nitrogen and protein. From the sediment to faeces the assimilation efficiencies were found to be 7.56% of organic matter, 30.38% of total organic carbon and organic matter, 26.53% of carbohydrate, 21.75% of nitrogen and 21.77% of protein.

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

10. The length and weight relationship was found to be: for Indeterminate $W = 11.83080926\ L^{1.0527}$ ($r = 0.79$); Male $W = 0.212819556\ L^{2.3648}$ ($r = 0.86$); Female $W = 0.1652021463\ L^{2.4460}$ ($r = 0.89$); and for (pooled) Male and Female $W = 0.1877987698\ L^{2.4049}$ ($r = 0.88$).

11. Based on the macroscopic and microscopic observations of the gonads, five maturity stages viz. immature, maturing, early mature, late mature and spent conditions could be recognised.

12. The gonad index (GI) values were found to be maximum in males during the months of April-June and October-November while in females the values were high during [illegible]

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

14. Two spawning seasons were observed in H. (M.) scabra one in March-April and the next in November-December. There was a remarkable similarity in the occurrence of different stages of maturity in both the sexes during the period March 1988 - February 1990. Juveniles (3-5 cm) were recorded in March 1989 from Pamban (Chinnapalam) along the Gulf of Mannar coast.

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

16. The fecundity ranged from 1,04,688 to 10,04,160 ova. A significant relationship was noted between the fecundity and gonad weight.

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

18. The ratio of males to females, on an average, was found to be 1:0.89 and during the breeding season the ratio was found to be 1:1. Significant chi - square values were obtained during the months of May, July, December 1988 and January 1989 ($P < 0.05$).

19. 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). The maximum length recorded was 40 cm. 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.

20. Laboratory experiments indicated that light plays a vital role in the burrowing habit of holothurians.

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

22. The species fished along the southeast coast include Holothuria (M.) scabra, H. atra and Bohadschia marmorata. Of these H. (M.) scabra was dominant.

23. The total catches recorded for the two years 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.

24. The total percentage of catches recorded by skin diving, trawlers and tallu valai were 80.04 , 10.27 and 9.69 respectively.

25. Of the total catch of holothurians, 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% of holothurians from the Gulf of Mannar. Trawlers contribute 25.69% of holothurians from Palk Bay.

26. Of the total catches of holothurians 74.4% come from Palk Bay and 25.6% from Gulf of Mannar, indicating that Palk Bay coast is more productive.

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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.

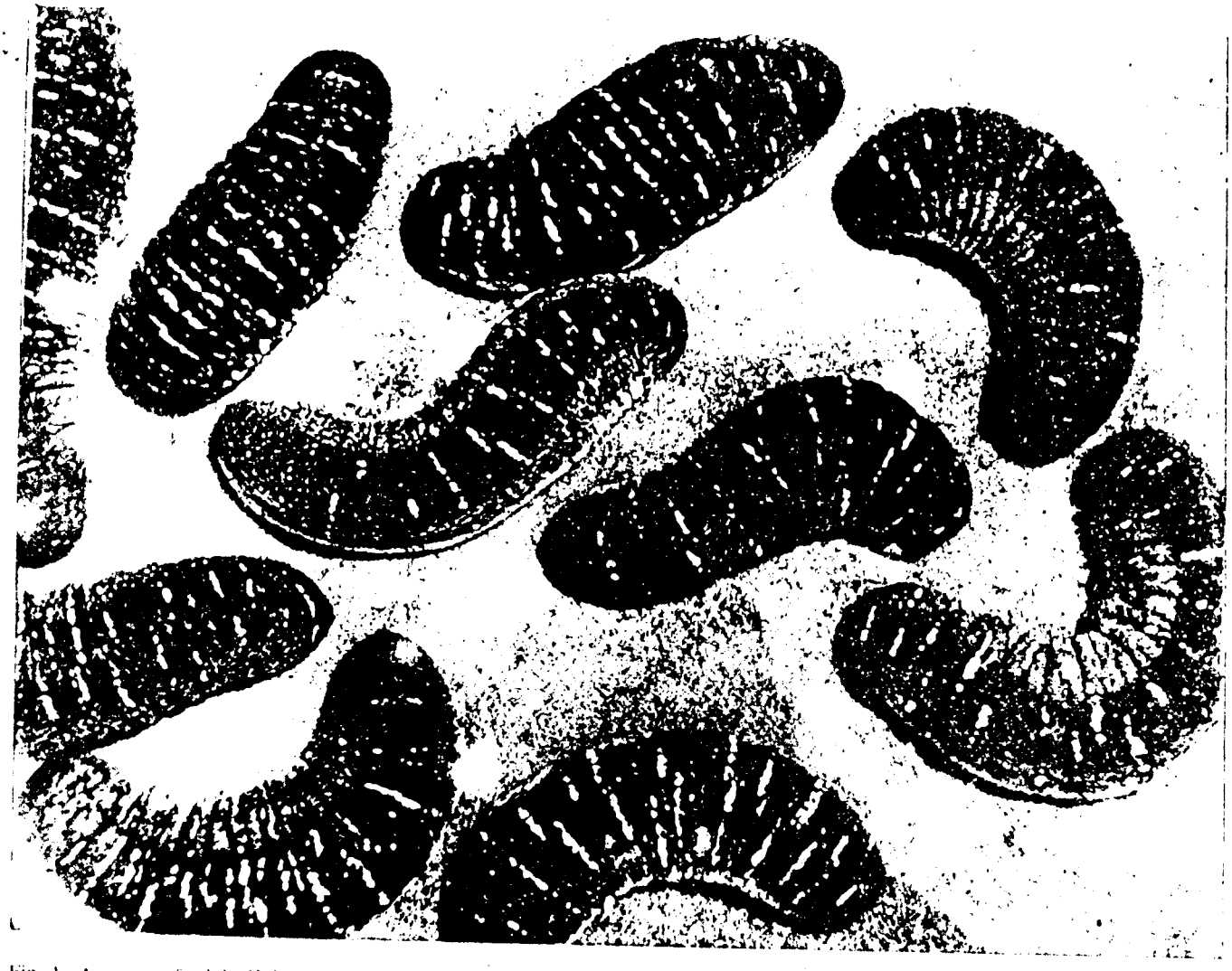


Fig. 1. A group of adult *Holothuria (Metriatyla) scabra*.

(*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

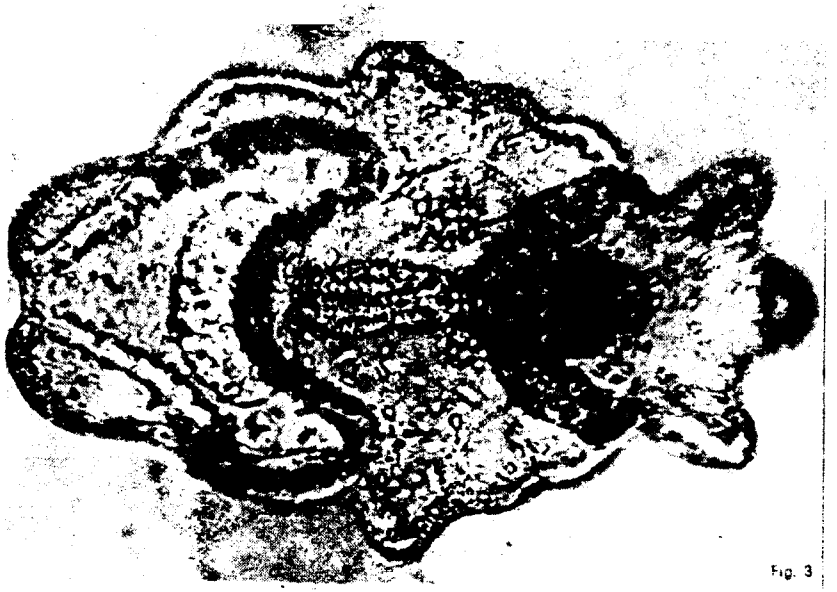


Fig. 2. A group of eggs.
Fig. 4. Doliolaria larva.

Fig. 3. Auricularia larva.
Fig. 5. Pentactula larva.

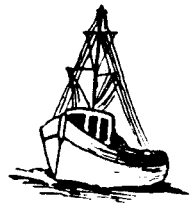
(*Photographs by*: Mr. M. E. Rajapandian)

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.



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BASKAR,B.K., 1989. Some observations on the biology of the Holothurian Holothuria(Metriatyla)scabra Jaeger. Abstract No.9. p: 7-8. Paper presented at the National Workshop on Beche-de-mer organised by the CMFRI, Mandabam Camp held on 23-25 February 1989.

No. 9 Sess. II

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

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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 [illegible] the stages of maturity such as immature, maturing, ripe, mature, late mature and spent have been fixed. The characteristics of different stages of maturity are presented in detail.

JAMES, D.B., M.E.RAJAPANDIAN, C.P.GOPINATHAN and B.K.BASKAR, 1989. Breakthrough in induced breeding and rearing of the larvae and juveniles of Holothuria(Metriatyla) scabra Jaeger at Tuticorin. Abstract No. 15, p:11 Paper presented at the National Workshop on Beche-de-mer organised by the CMFRI, Mandapam Camp held on 23-25 February, 1989.

No. 15 Sess. III

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.

JAMES, D.B., & B.K.BASKAR., 1989. Present status of the Beche-de-mer industry in Palk bay and Gulf of Mannar. Abstract No.20 p: 13. Paper presented at the National Workshop on Beche-de-mer organised by the CMFRI, Mandabam Camp held on 23-25 February 1989.

No. 20 Sess. V

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

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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 Seth Sethavachatram 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: 1989

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 Tuticorin 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.