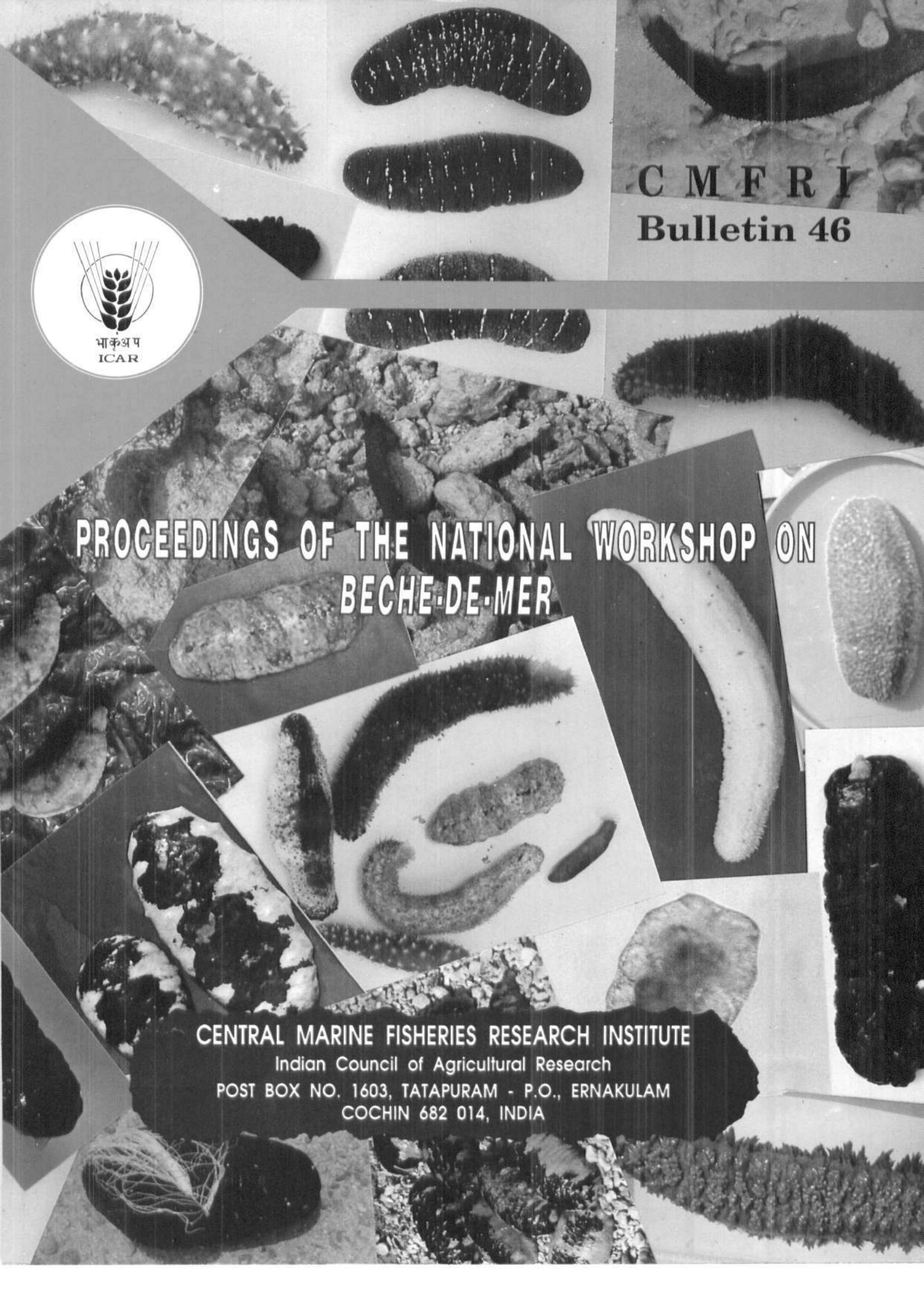

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Bulletin 46

PROCEEDINGS OF THE NATIONAL WORKSHOP ON *BECHE-DE-MER*

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
Indian Council of Agricultural Research
POST BOX NO. 1603, TATAPURAM - P.O., ERNAKULAM
COCHIN 682 014, INDIA

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Dr. K. RENGARAJAN
Dr. D. B. JAMES

Editors

February 1994

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FOREWORD

The term *beche-de-mer* simply means a sea-cucumber. The sea-cucumbers constitute an important marine living resources occurring in the seas around India. India at present is earning a foreign exchange of over one crore of rupees by exporting processed sea-cucumbers. In the seas around India, nearly 200 species of sea-cucumbers are known, of which about 75 are from the shallow waters within twenty metres depth. Of these a dozen species are of commercial value. Sea-cucumbers occur in plenty in the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep. A small scale cottage industry exists in Tamil Nadu Coast for more than one thousand years.

Studies have been conducted by the **Central Marine Fisheries Research Institute** on the taxonomy, biology, morphology, ecology, zoogeography, hatchery and culture of sea-cucumbers during the last 25 years. Considerable amount of information has been collected by the Institute on the above aspects.

At present the sea-cucumber fishery is restricted to small pockets along the Gulf of Mannar and Palk Bay. Earlier some processing was done in Andamans chiefly around Port Blair. There is no processing in the Lakshadweep although valuble species of sea-cucumbers occur. There are signs of overfishing due to continuous exploitation. The Government of India, based on the scientific advice banned in 1982 the export of processed sea-cucumbers which are less than 75 mm in length. At present the fishing is restricted to a very shallow regions and there are indications that the resources might be available in deeper regions as well. The industry is concentrating on a single species whereas a number of other species have been found suitable for processing. There is an urgent need to survey and explore other regions for extending the fishery.

Recently India has achieved a breakthrough in induced breeding of *Holothuria scabra* at the CMFRI hatchery at Tuticorin. This remarkable achievement is expected to pave the way for the large scale culture of different economically important sea-cucumbers in future to replenish the dwindling natural stocks by sea-ranching. With this background, it is felt necessary that all information on the biology, fishery, processing, marketing and export are consolidated in a National Workshop and to provide the necessary backdrop for the industry and render management advice to develop trade on sound scientific basis.

The National Workshop on *Beche-de-mer* was organised with the following objectives: To review the present status of our knowledge on the resource and exploitation; to apprise the industry and the administration of the need for management, development and conservation of the resource; to suggest better methods of handling and processing; to develop a strategy and action plan for the future research and development of the resource and to provide guidelines for export trade.

In the above context and urgent need for creating an awareness among fishermen, as well as different organisations engaged in planning, administration, research, development, management and conservation of these resources and to take stock of the present status of the resources, a "National Workshop on *Beche-de-mer* was organised by the CMFR Institute from 23 - 25 February 1989 at Mandapam Camp.

The National Workshop was inaugurated by Shri. M. R. Nair, Director, C.I.F.T. The Workshop was attended by the representatives of Central Marine Fisheries Research Institute. Central Institute of Fisheries Technology, Marine Products Export Development Authority, Universities, Departments of Fisheries of maritime States/Union Territories and the Industry and Trade took a leading part in the Workshop. Mr. K. Sachithananthan former Processing Expert of the FAO released a Handbook on *Beche-de-mer* written in Tamil for

the benefit of the fishermen. On the third day the proceedings was conducted in Tamil for the benefit of the fishermen, divers and the trade representatives. Commercially important species and various methods of processing different species of sea-cucumbers were explained to the fishermen. The Workshop was organised under the following seven Technical Sessions.

Technical Session I	**Systematics and Zoogeography of holothurians.**
Technical Session II	**Morphology, Biology and Ecology of holothurians.**
Technical Session III	**Hatchery and Culture Techniques.**
Technical Session IV	**Resources and Exploitation.**
Technical Session V	***Beche-de-mer* industry.**
Technical Session VI	**Processing, Quality control and utilization.**
Technical Session VII	**Conservation and Management.**

An exhibition was organised on *beche-de-mer* to create awareness among the public by exhibiting charts and photographs of various commercial species and different methods of processing. The seed produced from the hatchery was also exhibited.

Deliberations were discussed in greater depths in the above 7 Technical Sessions and in the Plenery Session, and suitable and important recommendations were made at the end. All the 23 Technical papers were presented and elaborately discussed. All the papers were further scrutinisd after the workshop, edited and presented in this Prceedings. The whole exercises are very useful to plan, manage, administrate, process on scientific methods to augment our export earnings by this resource.

I place on record my sincere thanks to Dr. P. V. Rao, then Officer-in-Charge and all the staff of the Regional Centre of CMFRI, Mandapam Camp for conducting the Workshop in a successful manner. I thank Dr. D. B. James, Convener who has efficiently organised the Workshop and edited the papers along with Dr. K. Rengarajan, Senior Scientist, C.M.F.R. Institute for the Proceedings. I hope this Proceedings will be a source of information on this little known subject in the years to come

P. S. B. R. JAMES
Director
C. M. F. R. Institute

PREFACE

The National Workshop on *Beche-de-mer* was inaugurated by Shri. M. R. Nair, Director, Central Institute of Fisheries Technology, Cochin on 23-2-1989. He stressed the need for improving the processing techniques so that the commodity could fetch better price. Earlier Dr. P. V. Rao, Officer-in-charge, Regional Centre of CMFRI welcomed the gathering. Dr. P. S. B. R. James, Director, CMFRI, Cochin presided over the Inaugural function. Shri. K. Sachithananthan, Former FAO Processing Expert gave felicitation. A Hand-book in Tamil and the Special issue of the Marine Fisheries Information Service Technical and Extension series, both prepared by Dr. D. B. James on sea-cucumbers were released on this occasion by Shri. K. Sachithananthan and Shri. M. R. Nair respectively. A small exhibition on sea-cucumbers was organised consisting of blow-ups, charts and field survey maps. Live material belonging to six species were also exhibited and people evinced keen interest in this. Processed *Beche-de-mer* samples belongting to various species, various sizes and various grades were packed in polythene bags and exhibited. The exhibition drew a large crowd particularly from various fishing villages. This exhibition was declared open by Mrs. Indra V. James.

Five Technical Sessions were organised. Before the first technical session Mr. K. Sachithananthan delivered a thought provoking Keynote address. Altogether 27 Abstracts were received for the Workshop.

The First Session on resources, exploitation, conservation and management of holothurians was chaired by Dr. P. S. B. R. James. The Second Session on systematics, biology, ecology and zoogeography of holothurians was chaired by Dr. P. V. Rao. Dr. D. B. James chaired the Third Session on culture of holothurians, hatchery and production techniques. The Fourth Session on processing, quality control and utilisation was chaired by Shri M. R. Nair. Dr. M. Sakthivel chaired the last Session on *Beche-de-mer* industry and export. The Technical Sessions were conducted on two days. The third day was set apart for the fishermen and industry. About 30 fishermen and processors attended from various fishing villages. In the forenoon session Dr. D. B. James explained in Tamil about the various commercially important holothurians, their distribution, habitat and utility with the help of colour slides. Later Mr. K. Sachithananthan explained in Tamil, the correct processing methods and pointed out the irregularities made by some persons and mentioned the precautions to be taken while processing. In the afternoon the fishermen and the processors were taken to a nearby processing centre where the practical aspects of processing were explained. From there they were taken to a nearby agriculture and aquatic farm as an educative tour.

The Plenary Session came to a close on the second day evening after drawing up the recommendations. The Technical Sessions came to a close with vote of thanks proposed by Dr. D. B. James, Convenor of the National Workshop on *Beche-de-mer*. On the second day, *Beche-de-mer* preparation was served to all the delegates during lunch time.

The Press covered extensively on the inaugural day. The All India Radio, Madurai also recorded the proceedings on the inaugural day and also recorded interviews from specialists. The National Workshop generated much interest among the fishermen, industrialists, scientists and administrators.

D. B. JAMES
Convenor
National Workshop on *Beche-de-mer*

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PROCEEDINGS OF THE NATIONAL WORKSHOP ON *BECHE-DE-MER*

PRESIDENTIAL ADDRESS BY DR. P. S. B. R. JAMES

Our Chief guest Shri. M. R. Nair, Distinguished Scientists, Ladies & Gentlemen,

I have great pleasure in welcoming you all for the 'National Workshop on *Beche-de-mer*'. This is the first Workshop on *Beche-de-mer* to be conducted in India. Although *Beche-de-mer* industry is existing in India for the last 1000 years, many facts about this industry are not known. As you are aware, India is at present earning a foreign exchange of nearly one crore of rupees by exporting *Beche-de-mer*. The seas around India are rich in sea-cucumber fauna particularly in the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and Lakshadweep. At present the industry is restricted to the mainland along the Gulf of Mannar and Palk Bay. Lot of processing is going on in and around Mandapam and for this reason this place has been chosen as the venue for this National Workshop. In the Gulf of Mannar and Palk Bay, chiefly one species namely *Holothuria scabra* is processed, though other species can also be utilised. In the Andaman and Nicobar Islands and in the Lakshadweep more valuable species of sea-cucumbers for *Beche-de-mer* processing are available. Unfortunately these are now not tapped. There was once a flourishing industry in the Lakshadweep in the olden days. The most valuable species for *Beche-de-mer* processing *Microthele nobilis* occurs in the Lakshadweep in great abundance. There is an urgent need to extend this industry to the Lakshadweep since there is now a flourishing industry in Maldives.

The *Beche-de-mer* industry in India is today facing a crisis on account of several problems. As a result of over exploitation in the narrow strip in the Gulf of Mannar and Palk Bay, there is shortage of raw material. The Government of India imposed a ban in 1982 to export material less than 3" in size as a measure of conservation. The Andaman and Nicobar Administration has totally banned fishing of sea-cucumbers in the whole of Andaman and Nicobar Islands which is causing problems to the industry there. In order to focus attention on these vital issues and to make suitable recommendations for policy decisions, we have organised this first National Workshop on *Beche-de-mer*. Here we have a good cross section of people from the Government, industry, trade, fishermen, scientists, administrators and policy makers.

Although the *Beche-de-mer* industry in India is very ancient, it has undergone little or no change since the days the Chinese introduced the processing. The industry never took off the real sense and there was absolutely no innovation or diversification, with the result the industry today stands where it was nearly 1000 years ago. With the result the industry is ill organised and run on unscientific and unhygenic lines by unscrupulous people. Therefore there is an urgent need to bring to light all facts concerning the ancient industry so that it can be put on its feet again to compete in the international market. Our fishermen are ignorant of the value of the species and also the processing methods for different species.

On the last day of the Workshhop the fishermen and the persons from the industry will be taught about the commercial species of sea-cucumbers, correct methods of processing, drying and packing. A small exhibition is also arranged showing some of the important sea-cucumbers in live condition along with processed material from various species belonging to different grades. A number of photographs and charts have also been arranged to educate the delegates concerned with the industry.

We, at the Central Marine Fisheries Research Institutve have started work on sea-cucumbers 25 years back. Considerable amount of information has been collected on the commercial and non-commercial species along the mainland, the Andaman and Nicobr Islands and Lakshadweep, their abundance, their distribution

and their life habits. Detailed surveys have been conducted along the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep and resources have been estimated. At present work on the biology of two commercially important species is conducted. Last year we have achieved a breakthrough at the Tuticorin Research Centre in inducing *Holothuria scabra* to spawn for the first time in the laboratory. Perhaps work on this species is done for the first time in the world. This important piece of research by the Institute opens vast scope for the industry which is already reeling under shortage of raw material. We can see some of the juveniles produced in the hatchery at the exhibition.

I am happy that delegates from different organisations have come for this National Workshop and during the next three days we shall discuss all aspects concerning the *Beche-de-mer* industry and make suitable recommendations. Today we are releasing 2 special publications - one in English and the other in Tamil with colour plates specially for the benefit of fishermen on *Beche-de-mer*. I wish you all a very happy and useful time at this beautiful place.

Thank you.

INAUGURAL ADDRESS BY SHRI. M. R. NAIR

Dr. James, Distinguished Delegates and Friends,

I am happy to associate myself with this National Workshop on *Beche-de-mer* and I thank Dr. James for asking me to inaugurate this National Workshop. I congratulate the Director and the Institute for organising this timely National Workshop on *Beche-de-mer*.

As you all know the *Beche-de-mer* industry in India is very ancient one and introduced by the Chinese more than one thousand years back. In India at present it is restricted to the Gulf of Mannar and Palk Bay. The venue selected is the most appropriate one, since the whole industry revolves round this area.

The industry though it is ancient it is in doldrums and has not taken off despite the fact that the whole product is export oriented and the price offered in recent years is attractive. The industry has made little or no progress from the stage which was introduced by the Chinese. No attempt is made to streamline the industry. This is the first attempt made to bring all the concerned persons at one place to discuss the related problems.

There is vast scope to improve the industry from the processing point of view. The present day processing methods are unscientific and unhygenic, therefore the material from India commands poor price when compared to the products from other countries. Diversification of the industry is another important aspect. All these years the industry is restricted to a narrow region in the Gulf of Mannar. Vast areas even within the Gulf of Mannar are left untouched since there is no fishing for sea-cucumbers between Kilakkarai and Tuticorin, though the resources are known to occur. This industry has to be extended to other places like the Andaman and Nicobar Islands and the Lakshadweep where more valuable species of sea-cucumbers are known to occur. Also the industry has been depending mostly on one species all these years. There are atleast ten species which are commercially important in the Indian Seas and all these species can be used for processing. However, it is gratifying to note that in recent years another species of sea-cucumber has been discovered in the Gulf of Mannar for processing.

The most important aspect of this industry is the judicious exploitation of the resources since the sea-cucumbers can be exploited in no time from a particular place due to their sedentary habits. Therefore adequate thought should be given for the conservation and management of the valuable resources.

Another important lacuna is in the area of taxonomy, biology ecology and zoogeography. The CMFRI has done commendable work during the last 25 years in the field of taxonomy and zoogeography and brought to light many new resources as a result of surveys conducted along the Gulf of Mannar and Palk Bay, Andaman and Nicobar Islands and the Lakshadweep. Some valuable information on the ecology has been collected by the scientists using SCUBA diving. Now they have taken up studies on the biology of commercially important species. It is hoped that much light will be thrown on the life-history of the important species for rational exploitation.

The Central Marine Fisheries Research Institute has to be congratulated for achieving a breakthrough in 1988 in inducing the commercially most important sea-cucumber to breed in the hatchery and produce seed. It is hoped that this step will pave way for intensive seed production, for sea-ranching programmes and also for culturing them to marketable size. This is a new line of work and I hope the industry will be much benefited by the programmes launched by the CMFRI.

As I have already pointed out that our processing leaves much to be desired. We are happy to note that the former Processing Expert of the FAO Mr. Sachithananthan is here with

us today to teach the correct methods of processing. Different species of sea-cucumbers need different methods of processing. Correct methods of processing have to be domonstrated at different places for the benefit of the processors. Handouts should be brought out for the fishermen in local language. I am happy to note that Dr. D. B. James, Convenor for the Workshop has brought out a handbook on *Beche-de-mer* in Tamil and I congratulate him for the same. We are going to release the Handbook today.

As I stated earlier the industry is stagnant and this has to be streamlined. I am glad to know that the *Beche-de-mer* also now comes under Export Inspection Agency for quality control. This will go a long way to boost our exports. At present we are exporting our material chiefly to Singapore. We should diversify the industry and catch other foreign markets also for healthy growth and competition. At present India is earning a foreign exchange of more than one crore of rupees and there is vast scope to boost our foreign exchange earnings.

I one again congratulate the Director Dr. James for organising this three day Workshop at this beautiful place and also congratulate Dr. D. B. James, Convenor for the yeoman service rendered by him to the industry during the last 25 years. I hope the discussions will be very useful to draw meaningful recommendations. I wish the National Workshop on *Beche-de-mer* every success.

Thank you all.

KEYNOTE ADDRESS BY SHRI K. SACHITHANANTHAN

Chairperson and friends,

I am pleased to be here with you today. I am grateful to the organisers of this workshop for having invited me.

The *Beche-de-mer* industry in India has been active since the arrival of the Chinese for trading to the South Indian ports during the pre-christian era. Today this industry is facing a challenge; on the one hand, the known resources have to be conserved; on the other, the industry has to meet the increasing demand for the product. This challenge can be met only through scientific inputs and technological innovations.

Never before did the fishery and trade for *Beche-de-mer* (*Kadal attai* in Tamil) in the Gulf of Mannar (*Mannar valaikuda*) and Palk Bay (*Paakku toduvai*) face such crisis as it is facing today. Along the Indian Coast, the concentration of fishing within a limited area has led to dwindling stocks and the resultant regulation of the fishing effort. Whereas on the Sri Lankan side the export of the produce has been hampered due to unsettled political conditions in areas adjoining the traditional fishing grounds.

Trade statistics from Singapore and Hongkong reveal a steep decline in the arrival of *Beche-de-mer* into these markets from India and Sri Lanka since 1980.

Exports of *Beche-de-mer* from South Asia to the Far East is not a recent phenomenon. Chinese traders have been visiting trading ports in South Asia for more than 2000 years. They came with silk, fire crackers, pottery and other Chinese made goods to exchange them for *Beche-de-mer*, pearls, spices, elephant tusks, artwork, etc. from South Asia. *Beche-de-mer* was one of the items Chinese valued and procured for their home market. Also the Chinese went in search of this prized item to far away places in the world.

Chinese traders visiting South Asia did not fail to identify the edible varieties of sea-cucumber in the Gulf of Mannar and Palk Bay around which the trading ports were located. The Chinese introduced the method of fishing, processing and storage. Few Chinese chose to remain in Tamil Nadu and Sri Lanka. They had the benefit of the patronage of the Pallava, Chola, Chera, Pandiya and Yalppanam kings who gave them lands and facilitated construction of Buddhist temples. One such temple was located in Nakapaddinam. Another was located in Mantai port in northwest Sri Lanka. Such patronage, facilities and donations were inscribed in stone in these places.

Eventhough most varieties of sea-cucumbers living in Indian waters are edible, the fishermen chose for processing the sand-fish *Holothuria scabra*, because of its (1) availability in commercial quantities, in relatively shallow areas, in fishing grounds along with chanks and pearl oysters, (2) visibility even in poor weather conditions, being easily identifiable among the few toxic varieties, (3) capacity to withstand the prolonged post-harvest handling in the tropical heat and (4) methodology of processing and storage under normal conditions.

Even aftr restricting the fishery to a single species, the total volume of the trade and the number of persons engaged in the fishery in South Asia has been very small compared to that of the general fishery in the region. Fishermen counted on *Beche-de-mer* as an additional source of income rather than the main source of income. Like the pearl fishery and the chank fishery, *Beche-de-mer* fishery continued to be seasonal being restricted to few areas and few families.

The frequency of sailings between ports in the Far East and South Asia were low and the *Beche-de-mer* trade was not as lucrative then as it is today.

Beche-de-mer production increased only after the establishment of trading ports in

Penang, Singapore, Makao and Hongkong during the last century by the colonial rulers from the West. Trading ships from the West calling at South Asian ports scouting for cargo to these ports lured *Beche-de-mer* fishermen to produce more and the trade gradually picked up.

Indian traders establishing their own outposts in Singapore and Hongkong gave further impetus, that the flickering industry started glowing. Exports of *beche-de-mer* from the Gulf of Mannar and Palk Bay region became part of an established trade between Far East and South Asia. The fishery was looking forward to a brighter future. More fishermen were recruited to learn to dive. Mechanised boats replaced traditional boats. Areas further away from the coast were explored with ease and confidence. *Beche-de-mer* fishermen had smiles on their faces all the way. There was boom and a sudden awareness.

Fishing effort was intensified. The industry attracted the attention of the authorities. Scientific investigators took active interest in the development of the fishery. Foreign exchange crisis in the post independent South Asia induced the economists towards diversification of the products for export. The hitherto insignificant *Beche-de-mer* became a significant item. Thanks to the ever rising prices in the Singapore and Hongkong markets. *Beche-de-mer* found its rightful place in the export promotion effort.

That the 'recently discovered' commodity became so important, the speed of exploitation of the available resource overtook the speed at which recruitment took place in the natural beds to replenish the dwindling stocks. Depletion of the adult stocks, resulted in the collection and processing of the juveniles and a slow decline in the export trade. Despite heavy exploitation the stocks sustained the fishery till now due to high fecundity and faster growth rate. What happens to a product which is in excessive demand and which is in short supply also happened to *Beche-de-mer*. It became the proverbial 'golden goose'. Authorities stepped in to regulate the fishery. In 1975, Sri Lankan Government imposed a ban on exports of dried *Beche-de-mer* of lengths less than 6 cm. In 1982 Indian Government banned the export of dried *Beche-de-mer* below 7.5 cm in length. In recent years the administration in Andaman and Nicobar Islands have banned the fishery as a measure of conservation.

Scientific investigations were stepped up. *Beche-de-mer* fishery became a field of specialisation in the Fisheries Research Institutes in India and in Sri Lanka. Programmes were drawn to investigate the commercially important varieties, their locations, their abundance, stock assessment of the major species, culturing methodology, simplification and mechanisation of the processing methods, and improving the packing and storage methods. Whatever knowledge that was gained through these investigations were extended to the fishermen.

The Central Marine Fisheries Research Institute (CMFRI) in India has been devoting itself to the study of this fishery for the past twentyfive years. Studies on the biology, ecology and zoogeography of the sea-cucumbers in the Indian seas have been an ongoing programme during this period. Evaluation of the *Beche-de-mer* resources were conducted in the Gulf of Mannar, Palk Bay, Andaman Sea and in the seas around Lakshadweep. Studies on the reproductive biology and other aspects were conducted by the Madurai Kamaraj University under the guidance of late Professor S. Krishnaswamy. CMFRI has recently succeeded in inducing *Holothuria scabra* to spawn in the laboratory; the juveniles are being cultured.

Fisheries Research Station and its successor National Aquatic Research Agency (NARA) in Sri Lanka, has been conducting studies since 1968. A *Beche-de-mer* processing factory was installed in Mannar in 1974. Fishermen were trained to locate and collect teat-fish *Actinopyga nobilis* along Trincomalee Coast. A development project at Kalpitya induced the fishermen from that area to exploit the sand-fish resources in Kalpitya Lagoon and the neighbourhood. University of Jaffna conducted studies on the biology

and reproduction of *Holothuria scabra*. NARA is continuing with the work initiated in 1968.

Let us look at what happened in other parts of the world. The Chinese traders not only introduced the fishery to the South Asia, but also introduced it to other parts of the Far East, Asia and Africa. In the Far East, Chinese settlers were consuming the product in addition to producing them.

Most fishermen in the Arabian Gulf, Gulf of Aden, Red Sea, East African Coast, Zanzibar, Madagascar knew about the economic potential of the fishery even though the product was not consumed locally.

Shipping links with other parts in the Indian and Pacific Ocean to Singapore and Hongkong became frequent. Newly emergent regimes of the third world activated their interest in trading with Far East. One of the items which picked up in trading during the colonial days and which received the attention of post-colonial governments was *Beche-de-mer*.

East African Coast, Arabian Sea, Andaman Sea, South China Sea, Jawa Sea, Banda Sea, Celebes Sea, Sulu Sea, Timor Sea, Makassar Straits, Coral Sea, Arafura Sea, Torres Straits, Bismark Sea, seas around Caroline Islands, Marshal Islands, Mariana Islands, Soloman Islands, Fiji Islands, Loyalty Islands, Society Islands, Samoa Islands became the enquiry targets of traders in Hongkong and Singapore.

The post-colonial governments in these areas sought and received through regional co-operation programmes bilateral assistance projects and through UNDP assistance technical knowhow to exploit their national resources to improve the fishery and to increase the trade.

The Indo-Pacific region abounds with edible varieties of sea-cucumbers *Actinopyga nobilis* the teat-fish, which fetches the highest price per kilo for any variety of *Beche-de-mer* in any market in the world, is taken in commercial quantities by fishermen living in areas east of Makassar Straits to as far as French Polynesia. Fishermen in South Asia or East Africa occasionally locate this variety for fishing or export. Investigations have confirmed the availability of this species in commercial quantities along the Trincomalee Coast in Sri Lanka and Lakshadweep seas in India.

Holothuria scabra, the sand-fish, is located and exploited in most seas bordering the tropical Paific and Indian Ocean. Sand-fish is generally preferred and its price in the market is not very low. In 1987 it fetched US $ 18.00 per kilo in Singapore market. It is affordable to most middle class Chinese. It forms the largest single species imported into Singapore in quantity. Availability in large quantities, particularly from South Asia, accounting for a third of the total supplies to the Singapore market makes sand-fish popular amongst middle and low income groups.

Many other varieties are available in the market. Their prices and the country of origin vary. Processing methods also vary.

It will be of interest to note that the Japanese are keen on having fresh sea-cucumbers; preferably teat-fish, for their cusine. They may eat them raw as well.

Future of the *Beche-de-mer* industry in South Asia appear bright, thanks to the dedicated effort of the scientific community. Specialists are available in the region to cope up with the demands of the industry.

Biologists are concentrating on identifying edible varieties, assessing their stocks, determiniting the maximum sustainable yield, locating new fishing grounds and developing methods to culture some of the varieties. Post-harvest technologists are working on improved processing methods, mechanisation of cleaning, use of solar dryers, use of polythene packs, dehumidified storage and prevention of losses due to insect infestation. Marketing specialists are monitoring the trends, providing information on the price fluctuations and consumer preference.

It is noteworthy to mention few institutions which are actively involved in the

improvement of the fishery, industry and the trade in South Asia.

CMFRI has been playing a pioneering role in India since early sixties. During these years considerable amount of information, on the availability of commercial varieties, their distribution and abundance has been brought out through a number of publications. The National Workshop at which we are here today is the culmination of the untiring efforts of this institution.

NARA in Colombo, Sri Lanka, has been actively engaged in the biology, processing technology and marketing of *Beche-de-mer* since 1968; however *Beche-de-mer* has attracted the attention of the scientists during the early years particularly during the pearl fishery expeditions.

Northern Province Fishermen's Co-operative Societies Union Ltd., based in Jaffna, Sri Lanka enjoying the monopoly of the export trade for *Beche-de-mer* for a period of twenty years upto 1977 had during this period been conducting pioneering work in marketing of *Beche-de-mer*. Fishermen were able to bypass middlemen and reach the market for competitive prices for their produce through this institution.

INFOFISH, an FAO sponsored regional project based in Kulalumpur, Malaysia has been through its marketing Digest and Information Bulletin, providing extensive information on the *Beche-de-mer* trade to South Asian producers and traders in recent years.

In organising this Workshop, CMFRI has brought almost all persons and institutions dealing with this fishery and trade under one roof for the first time in India. It is a commendable achievement.

Science and technology is an integral part of the development process. This has been recognised by the Government of India as one of the basic factors. Third world countries are fascinated by the achievements in India in this sector. This Workshop is yet another example of the efforts by the Government of India in that praise-worthy direction.

I congratulate the organisers, especially Dr. D. B. James, Convenor of the "National Workshop on *Beche-de-mer*" for his dedication and untiring efforts and for his involvement in the preparation and planning of this workshop.

I wish all of you a pleasant time in Mandapam during the period of this Workshop.

Thank you.

NATIONAL WORKSHOP ON *BECHE-DE-MER*

MANDAPAM CAMP • 23 - 25 February 1989

RECOMMENDATIONS

The 'National Workshop on *Beche-de-mer*' organised by the Central Marine Fisheries Research Institute during 23-25, February 1989 at Mandapam Camp discussed the various aspects of this resource such as biology, fishery, culture, conservation and also aspects relating to utilisation, quality improvement and marketing. It reviewed the present status of the *Beche-de-mer* industry and the problems faced by it. On the basis of the deliberations the following recommendations were made to promote stabilized growth of the industry ensuring rational exploitation and management.

Resources

1. Although considerable information is available on the taxonomy and distribution pattern of the commercially important holothurians along the Indian Coast, data on the ecology, biology and population density are scarce. As this information is basic to understand the dynamics of the population, the Workshop recommends that a survey and assessment of the holothurian resources is undertaken along the Indian Coast, particularly in the Gulf of Mannar and Palk Bay.

2. Studies on the biology, ecology and population characteristics of the commercially exploitable holothurians may be intensified providing the necessary facilities and manpower.

3. Holothurians have been exploited for a long time. However, in recent years, wide fluctuations in the production has been noticed. Fishery dependent and independent factors influencing such fluctuations should be investigated so as to formulate strategies for ensuring sustained growth and development to meet the growing demands of the export market and for judicious management of the resources.

4. On the basis of the above studies and surveys, the potential resource available may be estimated for planning the expansion of the fishery on sound scientific basis.

5. Taking into account the recent advances made on the breeding and seed production of one of the commercially important holothurians, intensive seed production with appropriate facilities and inputs may be initiated and large-scale sea-ranching programme undertaken to supplement the natural stocks.

Holothurian fishery and industry

6. Improved and efficient methods of fishing with suitable gears and accessories may be developed and introduced for better exploitation of the resource. Training in the use of underwater diving equipments and accessories be imparted to fish farmers to achieve greater efficiency.

7. Similarly, improved methods of preservation and processing may be evolved, demonstrated and propagated through organised training and extension programmes.

8. The Workshop had an indepth discussion on the restriction of exploitation of holothurians below 7.5 cm. The effect of this restriction on the export industry as well as on the resource were deliberated in detail. It is recommended that this aspect may be reconsidered on the basis of the resource position now heavily exploited, the need for maintaining the resource; at the sustained level, without sacrificing the biological requirements of the population to maintain its balance, but at the same time ensuring an uninterrupted growth of the industry.

9. The total ban imposed on the exploitation of holothurians in the whole of Andaman and Nicobar Islands may be re-examined. Similarly, the *Beche-de-mer* industry may be extended to Lakshadweep and Andaman and

Nicobar Islands as these areas are now underexploited.

10. A joint Committee may be set up by the Government of India and the Govt. of Sri Lanka to promote greater regional co-operation for the rational exploitation of the holothurians stock in the Gulf of Mannar and Palk Bay.

11. Market survey may be conducted to identify prospective markets for the edible holothurians including non-conventional species for greater consumer preference.

Extension

12. Effective information service in regional languages may be established to educate the fishermen on collection and processing methods and on the need for the conservation of the resource.

13. It is recommended that undersized holothurians caught from the sea are put back in the ecosystem so as to ensure them further growth, reproduction and increased exploitation by number and weight.

NATIONAL WORKSHOP ON *BECHE-DE-MER*

MANDAPAM CAMP, TAMIL NADU

23 - 25 FEBRUARY 1989

PROGRAMME

Venue : Conference Hall of the Regional Centre of CMFRI

22 February 1989, Wednesday

Hours

1500 - 1700 - Registration

23 February 1989, Thursday

0830 - 0930 - Registration

0930 - 1100 - Inauguration

1100 - 1115 - Tea break

TECHNICAL SESSIONS

1115 - 1300	-	**Session I**	:	Resources, Exploitation, Conservation and Management of Holothurians
		Key-note address by	:	Shri K. Sachithananthan
		Chairman	:	Dr. P. S. B. R. James
		Rapporteurs	:	Dr. P. Bensam Dr. N. Kaliaperumal
		Papers	:	Abst. Nos. 1, 2, 3, 4
		Discussion		
1300 - 1400	-	Lunch break		
1400 - 1630	-	**Session II**	:	Systematics, Biology, Ecology and Zoogeography of Holothurians
		Chairman	:	Dr. P. V. Rao
		Rapporteurs	:	Shri P. E. Sampson Manickam Shri P. Livingston
		Papers	:	Abst. Nos. 6, 7, 8, 9
1530 - 1545	-	Tea break		
1545 - 1630	-	Papers	:	Abst. Nos. 10, 11, 12, 13
		Discussion		

24 February 1989, Friday

0930 - 1100	-	**Session III**	:	Culture of Holothurians Hatchery and Pro duction Techniques
		Chairman	:	Dr. D. B. James
		Rapporteurs	:	Shri M. E. Rajapandian Dr. C. P. Gopinathan
		Papers	:	Abst. Nos. 14
		Discussion		
1100 - 1115	-	Tea break		
1115 - 1300	-	**Session IV**	:	Processing, Quality control and utilization of *Beche-de-mer*
		Chairman	:	Shri M. R. Nair
		Rapporteurs	:	Shri N. N. Pillai Shri. A. A. Jayaprakash
		Papers	:	Abst. Nos. 16. 17, 18, 19
		Discussion		
1300 - 1400	-	Lunch break		
1400 - 1530	-	**Session V**	:	*Beche-de-mer* Industry and Export
		Chairman	:	Dr. M. Sakthivel
		Rapporteurs	:	Shri A. Raju Shri V. Gandhi
		Papers	:	Abst. Nos. 20, 21, 22, 23, 24, 25, 26.
		Discussion		
1530 - 1545	-	Tea break		
1545 - 1645	-	**Plenary Session**		
		Chairman	:	Dr. P. S. B. R. James
		Rapporteurs	:	Dr. P. Bensam Dr. D. B. James
		Discussion and Recommendations of the Workshop		
		Vote of thanks	:	Dr. D. B. James

25 February 1989, Saturday

1000 - 1100	-	Lectures in Tamil on commercially important holothurians
1100 - 1115	-	Tea break
1115 - 1300	-	Lectures in Tamil on correct methods of processing
1300 - 1400	-	Lunch break
1400 - 1700	-	Visit to *Beche-de-mer* processing centres and demonstration of improved processing methods.

NATIONAL WORKSHOP ON *BECHE-DE-MER*

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TECHNICAL PAPERS

Bull. Cent. Mar. Fish. Res. Inst., 1994, **46** : 17 - 22

1.1

1. RESOURCES, EXPLOITATION, CONSERVATION AND MANAGEMENT OF HOLOTHURIANS

MANAGEMENT OF *BECHE-DE-MER* INDUSTRY IN INDIA

P. S. B. R. JAMES AND D. B. JAMES*

Central Marine Fisheries Research Institute, Cochin - 682 014

ABSTRACT

Strategies for the management of the *beche-de-mer* industry in India are the extension of fishing to new areas, processing of more valuable species, collection of biological information to regulate exploitation, restriction on size for capture, imposition of closed seasons, farming and sea-ranching and developing the industry in an organised manner which are discussed in detail in this paper.

INTRODUCTION

The *beche-de-mer* industry is very ancient in India and it is essentially a cottage industry. At present it is restricted to a narrow strip on the southeast coast of India along the Gulf of Mannar and Palk Bay on the mainland. It was introduced to India by the Chinese and it is a must for them on festive occasions such as the Chinese New Year which falls in February and the prices normally go up in January. *Beche-de-mer* has no internal market and the whole product is exported. India at present exports *beche-de-mer* worth of nearly one crore rupees per year. James (1987 b) gave an account of the history, present status, problems facing the industry and also future prospects for the industry in India.

HISTORY OF THE INDUSTRY

According to Hornell (1917) the Chinese had trade with Southern India and Sri Lanka for the past one thousand years. He is of the opinion that *beche-de-mer* and pearls figured among the Indian products in exchange for porcelain, silk and sweetmeats. Custom records are available for the export of *beche-de-mer* from 1898 onwards from the Madras Presidency. The history of the industry is of great functions on the mainland. According to Mannadiar (1977), in Lakshadweep the industry flourished once, but there is no industry there now. Kloss (1902) stated that Andaman is known for *beche-de-mer* in olden days which later died down. In recent years it is revived by persons from Tamil Nadu who are processing chiefly around Port Blair. James (1981, 1987 a, 1988) gave an account of the resources, processing, utilization, problems and prospects of *beche-de-mer* industry in the mainland and Andaman and Nicobar Islands.

LOCATION OF THE INDUSTRY

There are more processing centres and higher magnitude of fishing along the Palk Bay than on the Gulf of Mannar. The important centres on the Palk Bay side are Rameswaram, Devipatnam, Tirupalakudi, Karangadu, Mullumonai, Thondi, Pasipatnam, Pudupatnam, Kottaipatnam, Ammapatnam, Kattumavadi, Sethubavachatram and Mallipatnam, and Pamban, Mandapam, Seeniappa Darga, Pudumadam, Muthupettai, Periapatnam, Kilakkarai and Tuticorin along the Gulf of Mannar. In the Andaman and Nicobar Islands processing is chiefly done around Port Blair and also at Rangat in Middle Andamans, Mayabunder

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and Diglipur in North Andamans, to some extent.

CRISIS FACING THE INDUSTRY

Beche-de-mer industry is not an organised one. Since the holothurians are sluggish and harmless, they are indiscriminately fished and the stocks are alarmingly depleted. Also the whole fishing pressure is restricted to a narrow zone due to the concentration of the divers in particular places and due to ignorance, the whole fishing effort is directed towards a single species. This has resulted in overfishing which is clearly indicated in recent days by the fall in the size of the specimens fished and also in the decrease in the catch per unit of effort. At this juncture the Government of India has rightly imposed a ban on the export of processed material below 3" in length in 1982 as a measure of conservation. The industry which was already facing difficulties in procuring adequate number of holothurians was hard hit by the ban since it could not export the smaller forms which formed the bulk of its catch due to overfishing, restored to clandestine methods to dispose off the material on hand. Their problems were further aggravated since the material has no internal market and also cannot be retained for longer periods due to its hygroscopic nature. With these problems on hand the industry brought in pressure on the Government to scrap the ban by putting forward many arguements. The fishermen stated that (i) it is not possible to estimate the size of holothurians under water, (ii) the material once removed from water cannot be put back to sea as they die and (iii) the Palk Bay holothurians do not grow beyond a particular size. All these were not found to be tenable. They also argued that while there is ban on exporting material below 3" size there is no ban on fishing small holothurians and there is heavy demand only for smaller forms in foreign markets. Government of India recently constituted a Committee to examine the problem and give recommendations. The matter is still pending as can be seen from the nil figures for sizes between 2-3" and below 2" from 1984 onwards given in Table 1. Even material between 3-4" size formed over 80% from 1984 onwards.

TABLE 1. *Size-wise export of* beche-de-mer *in kg (Percentage in parenthesis)*

Size	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
4"-6"	7031 (16.9)	4756 (14.21)	2054 (3.06)	3596 (7.48)	3051.5 (3.8)	2851 (18.52)	2123 (19.5)
3"-6"	13987 (13.7)	9332 (27.89)	6986 (10.4)	19192.5 (39.93)	22643 (28.22)	12545 (81.48)	8765 (80.5)
2"-3"	18301 (44.0)	15867 (47.42)	45675 (66.59)	22370.5 (46.54)	39021 (48.64)	- -	- -
Below 2"	2182 (5.25)	3502 (10.46)	13373 (19.95)	2906 (6.04)	15495 (19.31)	- -	- -
Total	41501	33457	67088	48065.0	80210.5	15396	10888

Source : Data compiled from the invoices registered in the MPEDA Regional Office, Madras.

The ban did not have the desired effect as there is ban to export material less than 3" length, but not for catching of small forms. Also there is some demand for smaller forms at much lower rates in countries like Taiwan as shown below.

4 to 6" (Large size 25-35 per kg) US $ 17 per kg.

3 to 4" (Medium size 35-50 per kg) US $ 15 per kg.

2 to 3" (Small size 90 to 100 per kg) US $ 7 per kg.

Added to the above two problems, due to the ethnic disturbances in Sri Lanka the Export of *beche-de-mer* practically stopped since 1985. So more pressure was put on India for material and the only way left out to the fishermen was to indulge in smuggling small forms from the country thus depriving the valuable foreign exchange.

STRATEGIES FOR THE MANAGEMENT OF THE INDUSTRY

Extension of fishing activities to new areas

The export figures from 1898 to 1916 and again from 1963 to 1987 speak out for the erratic nature of the industry. The first world war had its impact on the exports and again in recent times the ban imposed by the Government of India had an effect on the exports (Table 2). The Government imposed ban in 1982, but permitted the export the undersized material on hand and this accounts for the high export figure during 1987. The exports picked up due to the extra effort put by the industry to procure material from various places due to the higher price of *beche-de-mer*.

TABLE 2. *Export figures of* beche-de-mer *(kg) and value (Rs) during 1898-1987*

Year	Weight	Value
1898-1899	25,601	15,380
1899-1900	1,260	1,140
1900-1901	-	-
1901-1902	-	-
1902-1903	-	-
1903-1904	-	-
1904-1905	14,523	15,203
1905-1906	30,845	24,300
1906-1907	3,125	3,100
1907-1908	9,992	8,460
1908-1909	12,758	7,020
1909-1910	8,609	5,039
1910-1911	1,222	655
1911-1912	2,820	800
1912-1913	504	596
1913-1914	1,360	600
1914-1915	-	-
1915-1916	2,167	1,426
1963	3,049	7,529
1964	1,275	2,550
1965	24,974	21,125
1966	21,886	39,631
1967	38,422	43,672
1968	64,535	1,03,820
1969	69,051	5,77,898
1970	58,293	5,48,444
1971	57,614	3,66,003
1972	37,089	2,44,761
1973	29,255	2,47,911
1974	67,871	6,51,077
1975	91,268	20,71,561
1976	62,578	18,96,777
1977	66,934	19,46,633
1978	24,537	10,76,560
1979	31,231	15,22,941
1980	34,013	18,72,314
1981	47,841	26,28,757
1982	37,143	17,23,558
1983	71,853	36,96,765
1984	20,715	17,97,948
1985	11,933	11,68,213
1986	32,864	38,03,858
1987	53,755	79,37,977

The industry has to be extended to areas such as the Lakshadweep where there is no processing today and where first grade holothurians are available for processing (James, 1989). It is significant to note in this connection that there is an industry in Maldives. James (1989) has estimated 1882 tonnes at Kadamath, 209 tonnes at Chetlat, 172 tonnes at Kiltan and 165 tonnes at Ameni for *Holothuria* (*Microthele*) *nobilis* which is the best holothurian for *beche-de-mer*. Estimates for other valuable species such as *Actinopyga mauritiana* are also made. Other valuable species are *A. echinites* and *Thelenota ananas*. These have to be exploited in a rational manner. In 1968 a person from Madras came to Androth and processed nearly seven tonnes of *Holothuria* (*Microthele*) *nobilis* by paying a royalty of Rs. 1 per kg to the Administration. He purchased specimens paying

five or ten piase for each specimen. He processed *beche-de-mer* at Kavaratti also. Fisheries Department restricted the collection of specimens below 150 mm size. After two years he wanted to return to Lakshadweep, but the Administration did not give him permission.

In Andaman and Nicobar Islands also hardly any industry worth the name exists. Some processing is done chiefly around Port Blair for *Holothuria (Metriatyla) scabra* leaving other valuable species like *Actinopyga mauritiana* and *A. echinites*.

Even on the mainland it is restricted to only some places like Tirupalakudi, Devipatnam, Kilakkarai and Periapatnam. There is no reason for the absence or limited quantity of the holothurians between widely separated curing centres, since the nature of the bottom and the hydrographical conditions are the same all along the Palk Bay and the Gulf of Mannar. A point to prove this fact is the introduction of the industry at Tuticorin which was not there some 18 years ago. Not a single holothurian was fished and people were not even aware of this resource. Today it has a flourishing industry and during peak season holothurians worth of Rs. 10,000 to 15,000 are auctioned on a single day. The main reason for processing the holothurians at particular centres is due to the availability of divers at those places. Devipatnam, Tirupalakudi, Karangadu and Mullimonai from the core area for the divers and these divers go to other places when the season is favourable. More fishermen should be trained in skin diving for holothurians. Local fabrication of the masks has given a new impetus to diving. In recent years divers are using Aluminium plates as 'flippers' to give them greater mobility under water. With these 'flippers' they are able to cover greater areas and collect more material.

Processing of other species

In an export trade like this it is always desirable to go in for diversification. Market trends change with the tastes. If we specialise only on one or two species there is a possibility of closing down the industry when the demand for a particular species falls, as it has happend in Australia for *Thelenota ananas* which once commanded highest price. James (1973, 1986 a) gave an account of *beche-de-mer* resources of India. At present on the mainland of India *Holothuria (Metriatyla) scabra* and *Holothuria (Thelothuria) spinifera* are processed the former accounting for more than 90% of the specimens fished. In Andamans *Holothuria (Metriatyla) scabra* is exclusively fished so that the fishing pressure falls on a single species and the stocks are depleted due to overfishing. In recent years due to the high price offered for *beche-de-mer* at the rate of US $ 18/- per kg, people have taken to processing another species *Bohadschia marmorata* especially at Kilakkarai. Yet another species is also tried in the Palk Bay. Because of the high price they started processing even *Holothuria (Halodina) atra* which is not a very valuable species for *beche-de-mer* preparation. The tragedy is that the more valuable species in the Andaman and the Lakhsadweep Islands are left untouched due to ignorance. Some samples of *beche-de-mer* of *Actinopyga* sp. were shown at Kilakkarai, but the trade seems to be a mystery as they are not willing to reveal the actual value of the species. They neither know the value nor the correct processing methods for these species. Therefore the people have to be taught about the value and processing methods for these species.

Need for biological information to regulate exploitation

If the industry has to survive, the resources should be judiciously exploited without over fishing the same. This becomes all the more important since we are ignorant of several aspects of their biology such as age and growth, longevity, spawning and fecundity, recruitment, distribution, size at first maturity and other aspects. Unless these aspects are known it is not advisable to exploit the species indiscriminately. In case of holothurians, over exploitation can easily take place as the animals are defenceless with sluggishness and offer no resistance when caught.

Restriction on size for capture

To conserve the resource regulation regarding the size at collection should be insisted. This can be strictly implemented as the

Tamil Nadu Fisheries Department does in the case of chanks. Since the area of fishing is same for both this can be easily monitored. The landing centres for holothurians are also limited and therefore it can be easily regulated. Material below the size of 200 mm in length may be banned from catching. Even if they are caught and brought to the shore they can be put back into the sea since they live out of water for a long time.

Imposition of closed seasons

There should be closed seasons for the collection of holothurian especially during the peak spawning months in July and October. The diving should be closed down by the end of June. The water in the Palk Bay also becomes somewhat turbid and rough preventing the divers to conduct their operations effectively. In fact the season in the Gulf of Mannar starts from October when the sea is calm. From November onwards the NE monsoon sets in and drying becomes a problem and therefore the processing is not in full swing. It is worth mentioning that the Lakshadweep Administration took the first conservation measure for holothurians when it restricted the collection of *Holothuria (Microthele) nobilis* below the size of 150 mm when processing was done during 1968 at Androth and Kavaratti Islands.

Farming and sea-ranching to be stepped up

Apart from the size restrictions and closed seasons which have to be strictly adhered, attempts should be made to culture the species in enclosed areas to augment production and boost up export. James (1983) made an attempt to culture *Holothuria (Metriatyle) scabra* at Port Blair by collecting juveniles and stocking them in enclosed areas. In this type of work the first step is to locate the beds where juveniles are in large numbers. One such area could be Kundagalgut near Pamban where juveniles of *Holothuria (Metriatyla) scabra* were seen buried during low tide.

Another important step to sustain the industry is the sea-ranching of seeds in large scale. Success has been achieved recently by James *et al.* (1988) at the Tuticorin Research Centre in inducing *Holothuria (Metriatyla) scabra* to spawn in the laboratory to produce viable seeds. Now intensive seed production has to be taken up and when once the larvae settle down to the bottom as Pentactula stage and grow to 20-30 mm size they can be sea-ranched.

Development of organised beche-de-mer *industry*

As mentioned earlier the *beche-de-mer* industry is not in an organised manner. *Beche-de-mer* processing factories can be opened on the Gulf of Mannar and Palk Bay side. Hornell (1917) mentioned about a Government factory at Tirupalakudi with economics worked out. He suggested that another factory can be opened at Vedalai. In Sri Lanka a *beche-de-mer* factory was opened in 1974 at Mannar under the Fisheries Co-operative Society. Paramananthan (1974) has given the advantages of processing *beche-de-mer* in a factory and has also given the cost analysis. He has also clearly shown that in order to run the factory successfully they have to process atleast 1.2 tonnes of *beche-de-mer* per month. The processing by selected and trained staff to ensure uniformity, hygenic conditions, greater care for better standard and quicker production are primary requisites for the success of the industry. Bad weather conditions will not affect the processing, individual suppliers of raw material will find continuous employment, society can afford to expand and improve operations and finally society can pursue action for promoting better sale in quality and quantity. James (1986 b) suggested several methods to improve the quality of *beche-de-mer*. It is worth making an effort under co-operative sector by opening one or two factories along the Gulf of Mannar and Palk Bay. The *beche-de-mer* industry can thus be managed in a better and organised manner.

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1.2

CONSERVATION AND MANAGEMENT OF SEA-CUCUMBER RESOURCES OF INDIA

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ABSTRACT

Conservation measures such as size regulation, closed seasons, sea-ranching for sea-cucumbers are described in detail. The management policies for sea-cucumbers are also outlined.

INTRODUCTION

Sea-cucumbers being defenceless creatures with very limited movements neither offer resistance nor attempt to escape at the time of capture. For these reasons they have been indiscriminately fished. During low tide time, women and even children are engaged in collecting them in the intertidal region. Certain species of sea-cucumbers are fished for the preparation of highly priced export product known as *beche-de-mer*. The *beche-de-mer* industry in India is very ancient having been introduced by the Chinese. Hornell (1917) believes that *beche-de-mer* is one of the commodities taken to China during the last one thousand years when trade existed between South India, Sri Lanka and China. According to Eys (1986), one of the factors that discouraged the development of sea-cucumber industry is over exploitation. Trinidad-Roa (1987) reports that most of the collection areas are stripped of holothurians due to over exploitation in Philippines. James (1987, 1988) made observations on the resources, exploitation, conservation and management of sea-cucumbers in India.

There is no doubt that the sea-cucumbers are over exploited along the Indian Coast. This is clearly indicated by the small size of the sea-cucumbers fished and also in the poor returns per unit of effort. Apart from their vulnerability for fishing, the whole fishing pressure is on one or two species in a narrow strip of sea bed. On the main land of India, fishing is conducted in the Gulf of Mannar and Palk Bay for *Holothuria (Metriatyla) scabra* and *Holothuria (Theelothuria) spinifera*. James (1985) has already pointed out that *Holothuria (Metriatyla) scabra* and *Holothuria (Theelothuria) spinifera* are likely to be depleted unless conservation measures are taken up. Silas *et al.* (1985) reported on the depletion of *Holothuria (Metriatyla) scabra* populations in the Gulf of Mannar. This should apply to Palk Bay resources also. Due to the high price offered for *beche-de-mer* in recent years, other species such as *Bohadschia marmorata* are also fished thus releiving the fishig pressure to some extent. The urgent need of the hour is to conserve and manage the sea-cucumber resources of India in a rational manner.

CONSERVATION MEASURES

Unfortunately upto now no studies were made in India on the stocks of sea-cucumbers. Conand (1986) conducted studies on the stock assessment of *H. scabra* at New caledonia. Production of *Holothuria (Metriatyla) scabra* from the Northwest of Sri Lanka (Palk Bay, Gulf of Mannar and Kalpitiya) is estimated to be around 100-150 tonnes per annum and there is no information on the yield (Anon., 1984). Although sea-cucumbers are fished in large numbers round the year from the Gulf of

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Mannar and Palk Bay from a number of centres, no data are available on the landings of sea-cucumbers. Without data on catch and effort it is not possible to estimate the potential yield, yield per recruit, maximum sustainable yield and the standing crop. This lacuna is now being filled up. The Central Marine Fisheries Research Institute has devised a Proforma and supplied to all survey staff along the Gulf of Mannar and Palk Bay to collect data on landings of sea-cucumbers. Trinidad-Roa (1987) mentions about dried samples as small as 4 to 5 cm and there are signs of overfishing in Philippines also. He is of the opinion that the most practical method is to regulate the sizes of dried sea-cucumber allowed for export as it is easier to monitor considering thousands of kilometres of coast involved. The Government of India did exactly the same thing by banning the export of *beche-de-mer* below 75 mm length in 1982 as a measure of conservation, but this has not been effective. Some of the conservation measures are given here.

Size regulation

Size regulation is the most important measure for conservation. Durairaj *et al.* (1984) stated that the percentage of shrinkage ranged from 56 to 60% for dried *beche-de-mer*. Therefore the *beche-de-mer* of 75 mm corresponds to nearly 190 mm length in the fresh condition. At this length *Holothuria* (*Metriatyla*) *scabra* is immature. It is essential to allow the animals to spawn at least once in their lifetime to replenish the stocks. If this is not done the populations will be depleted drastically as it happened in and around Tirupalakudi in the Palk Bay. The average size of the sea-cucumbers collected from Tirupalakudi is only 155 mm. At Tuticorin the industry has started recently and the average size of the holothurians fished is 217 mm which is above the safe level. In this connection, it is pertinent to note that the *beche-de-mer* of *Holothuria* (*Metriatyla*) *scabra* exported from East Africa, Indonesia and Singapore is 10 - 18 cm in length. Therefore it is not desirable to fish them before they breed and propagate. While there is a ban to export dried product below 75 mm, there is absolutely no ban on fishing small forms. This ban should be enforced strictly by the Tamil Nadu Fisheries Department as they are doing for the chank fishery. Holothurians are usually brought along with chanks during the diving season. Therefore it is easy to monitor and regulate the catch. Sea-cucumbers live out of water for a long time and therefore the undersized specimens brought to the shore can be put back into the sea for further growth and propagation. The Lakshadweep Administration took some laudable steps to restrict the collection of *Holothuria* (*Microthele*) *nobilis* below the length of 150 mm when a person from Madras processed at Androth and Kavaratti some years back. Unfortunately the Andaman and Nicobar Administration completely banned the collection of holothurians under provision 11 of the Andaman and Nicobar Shell Fishing Rules, 1978. Considering the vast number of islands with very good resource of holothurians, this does not appear to be a wise move since the holothurians are short lived species and if they are not exploited they will die and decompose. Instead, the Administration can regulate the fishery by marking out various areas and limiting the material to be exploited as they have done in case of the shells *Turbo* and *Trochus*. In this way the country will not be deprived of the valuable foreign exchange. James (1981, 1987 b) has given an account of the resources, problems and prospects of *beche-de-mer* industry of Andaman and Nicobar Islands.

Closed seasons

On the mainland of India, holothurians are fished round the year in the Palk Bay and the Gulf of Mannar. In Palk Bay the fishing starts in March and extends upto October, the peak season being April to May. The fishing season starts in the Gulf of Mannar in October and extends upto March. The peak season in the Gulf of Mannar is during December and January. March and October are the transition months when they shift the operation from the Gulf of Mannar to Palk Bay and from Palk Bay to Gulf of Mannar. *Holothuria* (*Metriatyla*) *scabra* which forms the main stay for the industry breeds round the year with two spawning peaks one in July and the other in October (Krishnaswamy and Krishnan, 1967). It

is better not to fish in October which is a fag end of the season for Palk Bay and beginning of the season in the Gulf of Mannar when conditions for fishing are settling down. After the peak season during April to May in Palk Bay, they can give respite during June/July which is again the peak breeding season. The populations in the Palk Bay are more affected than in the Gulf of Mannar since the fishing pressure is more and also during the peak breeding season the fishing is in full swing in Palk Bay. The industry should concentrate their efforts during the summer months for two reasons. The first reason is that it can be quickly dried in the sun during January to May. Secondly sun dried material is preferred over smoke dried material in the export market. Smoke dried material also involves additional expenditure by way of fuel. The third reason is that in summer there is no breeding peak. The collection of the material in Palk Bay during July and in the Gulf of Mannar during October may be regulated if it is not possible to ban the collection altogether.

Sea-ranching programme

One of the ways to replenish the stocks in the sea is to sea-ranch the juveniles in large numbers on the holothurian beds. Such work is now being done in Japan for *Stichopus japonicus*. In India, a breakthrough was achieved for the first time when James *et al.* (1988) successfully induced *Holothuria (Metriatyla) scabra* to spawn in the laboratory. They reared them through various stages and obtained the juveniles. In Japan it is found that it is advantageous to sea-ranch them rather than to culture them in farms (Rao, per. comm.). Intensive seed production should be taken up to launch the sea-ranching programme in a big way. The very high fecundity and high rate of survival of *Holothuria (Metriatyla) scabra* are the factors responsible to sustain the fishery despite the pressure on fishing. One female liberated nearly a million eggs in the hatchery.

MANAGEMENT POLICIES

If the industry has to survive and grow, in addition to the conservation measures suggested, the following management policies also have to be strictly adhered. The industry has to diversify in space and species. The industry has to be managed on scientific lines. Industry has to be extended to other areas. This has to be urgently extended to the Lakshadweep and the Andaman and Nicobar Islands. James (1973, 1986 a) advocated the introduction of the industry to the Lakshadweep. This is very important since the best grade holothurian *Holothuria (Microthele) nobilis* is found in abundance in the Lakshadweep. James (1989 made some estimates of this species from some of the islands of Lakshadweep. The industry existed there once and this has to be now revived. The total ban on fishing for sea- cucumbers in Andaman and Nicobar Islands has to be lifted and regulated so that this valuable resource can be exploited judiciously over large areas. Another important management policy is to improve the quality of the product so that it can fetch better price in the foreign market. At present Japanese and Korean products are sold at a premium whereas the Indian product processed under unhygenic and improper conditions fetches poor price. James (1986 b) gave several suggestions to improve the quality of the product.

It is ironical that the least preferred and least valued holothurian *Holothuria (Metriatyla) scabra* is processed in India ignoring other valuable species. This is chiefly due of the ignorancce of the value and also the processing methods for otner species. From Lakshadweep, *Holothuria (Microthele) nobilis*, *Thelenota ananas*, *Actinopyga mauritiana* can be processed since the resource is good and from the Andaman and Nicobar Islands, in addition to *Holothuria (Metriatyla) scabra*, *Actinopyga mauritiana* and *A. echinites* can be processed. In Lakshadweep, *Bohadschia argus* and even *Stichopus chloronotus*, though of lesser value can be processed since the resource is abundant.

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1.3

HOLOTHURIAN RESOURCES FROM INDIA AND THEIR EXPLOITATION

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ABSTRACT

In the seas around India nearly 200 species of holothurians are known, of which about 75 species are from the shallow waters within 20 m depth. Of these, about 15 species are of commercial value. At present processing is restricted only to the Gulf of Mannar and Palk Bay on the mainland. Here *Holothuria (Metriatyla) scabra* is mainly used. The other species exploited are *Holothuria (Thelothuria) spinifera* and *Bohadschia marmorata*. *Holothuria (Halodeima) atra* which occurs in large numbers can also be tried. At present there is no exploitation in the Lakshadweep. In Lakshadweep, *Holothuria (Microthele) nobilis* which yields first grade *beche-de-mer* occurs in abundance followed by *Bohadschia argus* and *Stichopus choloronotus*. Exploitation is stopped in Andaman and Nicobar Islands. *Holothuria (Metriatyla) scabra* and species of *Actinopyga* are important from the Andaman and Nicobar Islands.

INTRODUCTION

The seas around India are rich in holothurian resources for *beche-de-mer*, but information on them and their exploitation is limited. Hornel (1917) wrote a classical paper on the history and revival of the *beche-de-mer* industry in India. James (1973, 1983) has given for the first time an account of the holothurian resources of India chiefly based on the intensive surveys along the Gulf of Mannar and Palk Bay and the Andaman and Nicobar Islands. Soota *et al.* (1983) had listed some holothurians used in the *beche-de-mer* industry in Andamans. The latest information on holothurian resources from India have been published by James (1986). The holothurian resources of the Lakshadweep have been studied in greater detail after conducting a planned survey to all the 10 islands in the Lakshadweep by James (1989 a, 1989 b).

SPECIES EXPLOITED AT PRESENT

There are over 650 species of holothurian known from the various parts of the world. In the seas around India nearly 200 species of holothurians are known, of which about 75 species are from the shallow waters within 20 m depth. Of these about 10 species are of commercial value. Large size holothurians with thick body walls are used in processing. There are special methods of processing holothurians such as *Stichopus variegatus* (Pl. I A) and *S. chloronotus* which become gelatinous and disintegrate when kept out of water. At present in India the most common species for exploitation is *Holothuria scabra* (Pl. I B) commonly known as sandfish. This contributes to more than 90% of the processed material. Next is *Holothuria spinifera*. This species fetched once high price, but at present does not fetch high price. This species is not seen in the intertidal region, but it often found on clean sand and in slightly deeper waters. Due to the high price offered for *beche-de-mer* in recent years, *Bohadschia marmorata* is also processed to-day.

SPECIES FOR EXPLOITATION

Beche-de-mer prepared from holothurian *Microthele nobilis* (Pl. I C) popularly known as the "teat fish" commands the highest price in the world to-day. This species is abundant in some of the islands of the Lakshadweep. It grows to a size of 400 mm, weighing from 2 to 3 kg in live condition. Body wall is very thick

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10 to 15 mm, it occurs in two colour forms - white and black. The white one which is more valuble sometimes referred to as *M. fuscogalva*. The white variety is found on clean sand and near sea-grass. Young white forms live among turtle-grass plants. Black form is found in shallow water of about 3 m on clean sandy bottom where there is live coral. *Actinopyga* is a very valuble genus for *beche-de-mer* preparation. Four species are known from the Indian seas, two of them occur in somewhat good concentrations. Unfortunately this genus is not utilised at present in India due to ignorance of the value and the procesing methods. The most common and important species of the genus is *Actinopyga mauritiana* popularly known as Surf red-fish. It is found at places where the surf breaks on the outside of the reef. The tubefeet are firmly attached to the rocks to prevent the animals being carried away by waves. It is distributed in Andaman and Nicobar Islands and Lakshadweep. Live weight varies from 0.5 to 1 kg. Colour in the living condition is brick red above and white below. This species is not exploited at present, but has a good export market. Next in importance in this genus is *Actinopyga echinites* commonly known as deep water red-fish. It occurs between 3 and 30 m depth on sandy bottom among live corals. Sometimes it also found in the intertidal region. It grows to a size of 300 mm length and the live weight varies from 0.5 to 1 kg. The body is wider in the middle and tapers towards the ends. The dorsal surface is wrinkled with fine sand settling over it. Colour in living condition is uniform brown. It occurs both at Andamans and the Lakshadweep. It is somewhat common in Andamans. Another species under this genus is *Actinopyga lecanora* commonly known as stone fish. It grows to a size of 400 mm in length, colour in live condition is brown with a lighter ash grey colour around anus. It occurs 2 to 10 m depth on the underside of large stones. It is active during nights. This species is somewhat rare at Andamans. The last species under this genus is *Actinopyga miliaris* commonly known as black-fish. It is found mainly in water less than 2 m depth on reef flats among live corals and on algal beds. It grows to about 300 mm and live weight varies from 0.5 to 2 kg. It is black in colour with a dark brown underside. It yields a good quality *beche-de-mer*.

Thelenota ananas (Pl. I D) commonly known as prickly red-fish was once considred as a prized species for *beche-de-mer* processing. This species is found of a depth of 2 to 30 m on clean sandy bottoms. They are also found in the lagoon in the Lakshadweep feeding exclusively on the calcareous alga *Halmeda* sp. and grows to a massive size of 700 mm in length, live weight varies from 3 to 6 kg. It is occasionally found in the lagoons of Lakshadweep. In living condition it is reddish orange with teats darker in colour. The Lakshadweep specimens were brown on the dorsal side and bright orange on the ventral side.

Potentially Important Species

The genus *Bohadschia* qualifies for *beche-de-mer* preparation, because of its large size and thick body wall. The presence of Cuvierian tubules in large numbers however hamper and hinder processing operations since these tubules stick to the hands on contact. *Bohadschia marmorata* is the most common species, found in the lagoon often covered by a coating of fine sand. It grows to a size of 400 mm. In the living condition it is yellowish brown with black spots. It is now processed at Kilakarai and Vedalai. It occurs in the Gulf of Mannar and Palk Bay, the Andaman and Nicobar Islands and the Lakshadweep. *Bohadschia argus* is another species popularly known as Leopard-fish or Tiger-fish. It lives freely in the lagoon on coarse sand. A few coral piece and sand particles are found attached to the body. It occurs from 2 to 6 m depth. Body is cylindrical with very smooth surface and on slightest disturbance white stickly threads are thrown out. It grows to a size of 600 mm in length and 1 to 2 kg in weight. Colour in living condition is brown or black with distinctive eye-like spots all over the body which are encircled with light yellow, white or grey. In Lakshadweep the specimens are black in colour and are abundant.

The most abundant holothurian in the seas around India is *Holothuria atra* commonly known as Lolly-fish grows to a size of 600 mm in length on the outer edge of the reef. Specimens on the reef flat reach a size of 200 to 300 mm in some areas, 10 to 15 specimens are found in 25 sq. m area. It occurs usually

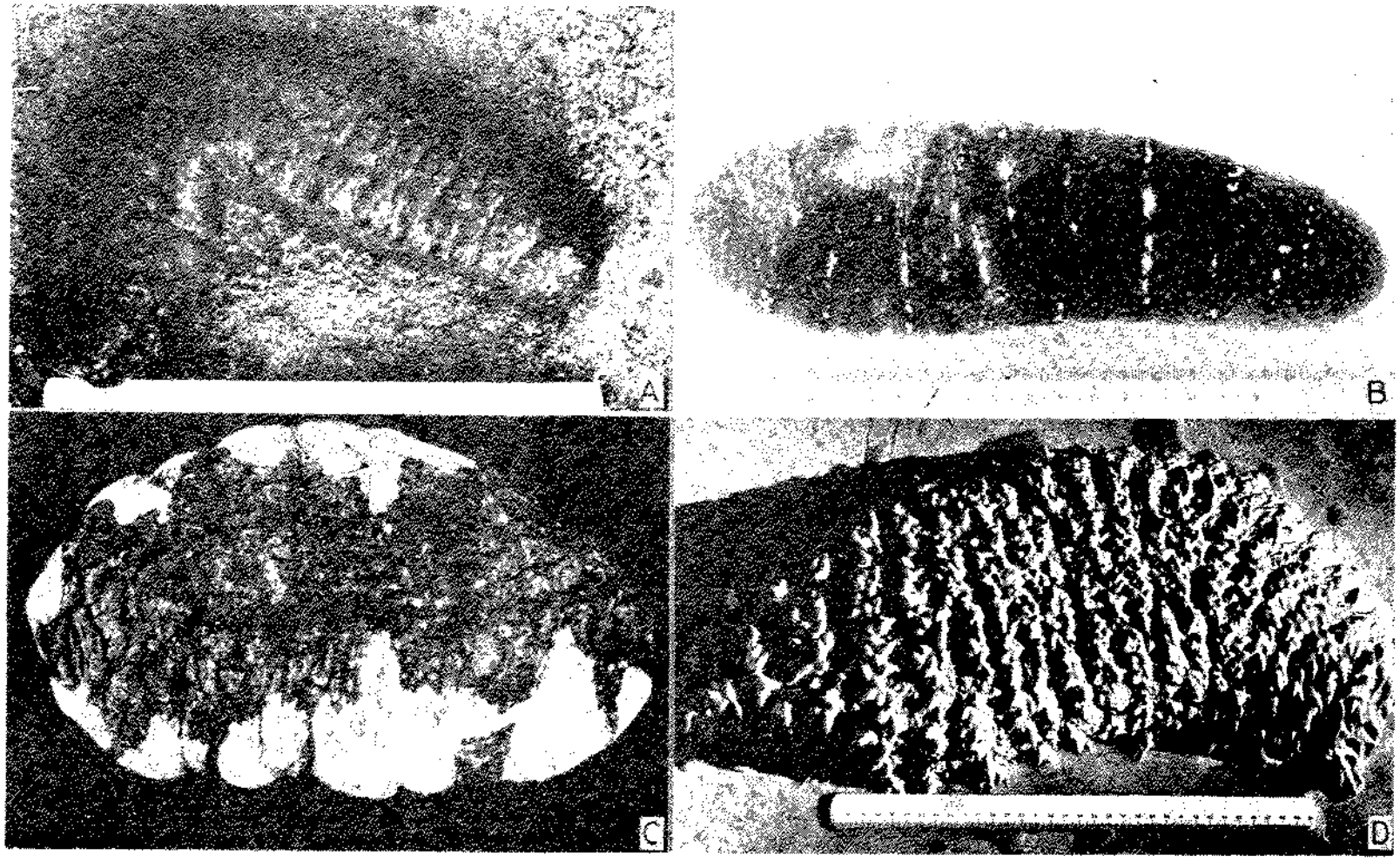

PLATE I A. *Stichopus variegatus*, B. *Holothuria scabra*, C. *Holothuria nobilis* and D. *Thelenota ananas*.

on the dead coral reef flats with sandy or muddy patches. It prefers areas where calcareous alga *Halmeda* sp. is abundant and it feeds on it. When the body of this holothurian is rubbed a red fluid stains the hand. The red fluid is a toxin known as *holothurin*. Boiling the specimens while processing breaks down the toxin. James (1981) reported that this species was processed in small quantities in Andamans for the first time in 1976. On the mainland also, it is often processed along with *H. scabra*, but due to its small size and thin body wall, the processed material is very less. Therefore this species is not preferred for processing in large scale, although it occurs in abundance in the Gulf of Mannar and Palk Bay. It is extensively processed in Philippines today and commands fairly high price in the international market.

As stated earlier the genus *Stichopus* grows to larger size with body disintegrating and becoming gelatinous when taken out of water. It needs special treatment for processing. *Stichopus chloronotus* most abundant in some of the lagoons of Lakshadweep, occurs freely in shallow water in the lagoons. It lies out in the open without making any attempt to conceal its body. Gravely (1927) reported this species as abundant in Rameswaram, but today not a single specimen is seen anywhere. This species is dark green in colour which appears black under certain light conditions. *Stichopus variegatus* grows to a large size of 900 mm in live condition. It is dark yellow with irregular brown patches and pink tubefeet. Massive forms occur in deeper waters in Andamans. It is found on algal beds and on clean sand bottom between depths of 3 to 30 m. Hornell (1917) experimented on processing the species by keeping them in sea water. To process the above two species same methods as those employed for *Stichopus japonicus* in China should be adopted.

Areas of Exploitation

At present sea-cucumbers are caught and processed from the Palk Bay and the Gulf of Mannar. Palk Bay being relatively shallow with extensive areas, has higher resource potential. Consequently the number of processing centres along the Palk Bay are also more in number. Devipattinam, Tirupalakudi, Thondi, Karangadu, Mullimonai, Kottaipattinam, Kattumavadi and Sethubavachatiram are some of the important centres along the Palk Bay. Due to intensive fishing during the last several years, the size of the animal is now less. The processing along the Gulf of Mannar are fewer in number. Vedalai, Periapattinam, Kilakarai and Tuticorin are the main centres of processing along the Gulf of Mannar. The processing of sea-cucumbers at Tuticorin is carried out during the last 20 years.

Potential Areas for Exploitation

As stated earlier the Andaman and Nicobar Islands and the Lakshadweep have valuble sea-cucumber resources for exploitation, which are much more valuble than the species processed on the mainland. In Andamans *Holothuria scabra*, *Actinopyga mauritiana*, *A. echinites* are abundant. In the Lakshadweep best grade sea-cucumber *Microthele nobilis* is found in abundance in some of the islands. Another valuble species in the Lakshadweep is *Thelenota ananas*. *Actinopyga mauritiana* also occurs fairly in good numbers in some of the islands. On the mainland important potential area for exploitation is from Kilakarai to Tuticorin which remains untouched now. *Holothuria scabra* and *Holothuria spinifera* area available in this area for exploitation.

Methods of Collection

The most common and efficient method for the exploitation of sea-cucumbers is by skin diving. The introduction of face masks have helped a good deal in locating and collecting sea-cucumbers due to the clarity of vision it offers. Earlier days face masks were rare and all of them were imported. Now these are locally fabricated and sold at cheaper rates to enable the fishermen to purchase and use them. Another innovation in this line is the use of aluminium plates as 'flippers' in the last years. The use of 'flippers' gives a diver greater mobility and manoeuvr under water increasing his efficiency to collect more material. The introduction of mechanised fishing in early sixties has some effect upon the fishery since sea-cucumbers regularly enter accidentally into the bottom trawlers. In fact at some of the

places like Mandapam where hundreds of trawlers are operated, the *beche-de-mer* industry is sustained by the material collected by the trawlers. In recent years another important gear locally known as *Thalluvalai* has been introduced in the Gulf of Mannar and Palk Bay to primarily cach juvenile prawns. Sea-cucumbers regularly enter these nets accidentally and they are made use in processing. During the low tide vast areas of muddy flats get exposed. During such time women and children are engaged in the collection of sea-cucumbers lying half buried.

CONCLUSIONS

The holothurian resources in the seas around India are varied and diversified in species. We have excellent habitats for sea-cucumbers such as muddy flats, reef flats and lagoons. The Gulf of Mannar and Palk Bay are well known for the richness of marine fauna particularly the sea-cucumbers. *Holothuria scabra* and *Holothuria spinifera* are the two important species in the Gulf of Mannar and Palk Bay. In the Andaman and Nicobar group there are more than 550 islands offering excellent habitats for sea-cucumbers. *Holothuria scabra* is found to be distributed in the Andaman group of islands where some dilution takes place. Species of *Actinopyga* abound on the coral reefs. In the Lakshadweep the most prized holothurian *Microthele nobilis* is abundant in the lagoons of some of the islands. *Thelenota ananas* a massive holothurian is also a dweller of the lagoons. *Bohadschia argus* and *Stichopus chloronotus* are exceedingly abundant in some of the lagoons in the Lakshadweep. If proper exploitation and the utilisation is restored, India can export huge quantities of *beche-de-mer* by introducing the industry to the Andaman and Nicobar Islands and Lakshadweep.

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1.4

ASSESSMENT OF SEA-CUCUMBER RESOURCES OF INDIA

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ABSTRACT

Holothurian resources are of great importance, because of their export potential. Due to their restricted distribution, it is feared that these resources are over-exploited and hence size restriction has been imposed on processed material exported. This has affected the *beche-de-mer* industry in India very much. The need for collecting basic data on catch, effort and biological details of these resources, in order to assess their resources potential, availability and level of exploitation for obtaining MSY, is emphasised.

INTRODUCTION

Resources assessment is a pre-requisite for planning and development of any endeavour for the judicious exploitation of the resource. In case of non-living resources, which are non-renewable, their precise assessment at one point of time is enough for planning their exploitation. In contrast, for living resources, they being renewable, constant monitoring of the resources is a must. Fishery resource being dynamic, all the more needs constant and vigilant monitoring.

CHARACTERISTICS OF THE FISHERY RESOURCES

Among the living resources, fishery resources particularly capture fishery resources are distinct demanding special attention. They are extremely dynamic in their mobility over space and time. There are a number of species constituting the fishery resources and their availability in numbers vary over space and time. In each species, size compositions vary widely over the seasons. In tropics high fecundity, continuous spawning, fast growth and short life span make their biological investigations more complex. In addition fishery resources are affected by independent factors such as currents, temperature and salinity, the impact of which on the stocks is not easily discernible. Fishery dependent factors such as method of fishing and intensity of fishing also affect the fish stocks. These factors contribute to the variability in the availability of fishery resources and hence the variability becomes multi-dimensional the magnitude of which is not encountered with any other resource. To comprehend all these factors fishery resources are beyond our visual horizon and what is below a sheet of water is anybody's guess. Consequently assessment of capture fishery resources remains complex.

MODE OF ASSESSMENT

To assess a resource, either a census of it is taken or sampling is restored. For the reasons mentioned above census of fishery resource is out of question. Only sampling has to be done to assess it. As precision of an estimate depends on the sample size which is linked to the variability, assessment of fishery resource, having multi-dimensional variability, demands careful planning in development of a suitable sampling design and comprehensive schedules for collection of data. This being a specialised field needs biological and statistical know how. Well trained field staff are exclusively required for collection of data.

ROLE OF CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

As the nodal organisation of India in marine fisheries research, the Central Marine Fisheries Research Institute has stock aassessment of commercially important species

as one of its main objectives. For this purpose estimates of exploited fish stocks are basically required. Basing on its vast experience in the field over four decades the Institute has developed a universally acclaimed and well suited stratified mutlistage random sampling design for assessing exploited marine fishery resources of India. The Institute has also developed suitable schedules for collection of sea-cucumber catch statistics along with the effort expended.

Regarding the resources of holothurians, however, no estimates are available on the exploited as well as potential stocks since data on their landings are not collected at present in a systematic manner by any agency in India.

Status of Holothurian Fishery in India

As these resources have export potential an urgent need has arisen for identifying the areas of their availability for estimating their resources potential, for studying their biological characteristics such as growth, mortality and fecundity and for evolving judicious exploitation schedule so as to reap sustainable yields. Expertise available with CMFRI may profitably be used in these areas.

It is well known that these resources are available in the Gulf of Mannar and Palk Bay on the mainland. Holothurians are also available in Andaman and Nicobar Islands and the Lakshadweep. Regarding the rest of the regions no information is available on the occurrence of these resources. Hence a pilot survey has to be undertaken immediately to assess the availability of commercial species all along the Indian Coast. Wherever exploitation takes place and attempts may be made to collect data on catch, effort and biology of the exploited resources on a systematic and regular basis.

To assess the level of exploitation for reaping sustainable yields, data on growth, mortality, fecundity, etc. are required. For this purpose location based biological studies are required using the available facilities and data collected systematically on continuous basis for estimating vital parameters required for stock assessment studies. Since length of holothurians cannot be reliably measured, the weight is used as a unit to estimate age and growth. Instead, any hard part of the holothurians which is expected to give information on growth and that could be easily measured may be considered in growth studies. For this purpose a special project may be thought of for meeting the man power requirements.

To sum up, catch and effort data and biological information on the presently exploited stock, resource potential of known regions and information of new regions with their resource potential are to be obtained for the rational exploitation and judicious management of the holothurian resources of India.

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2. SYSTEMATICS, BIOLOGY, ECOLOGY AND ZOOGEOGRAPHY OF HOLOTHURIANS

ZOOGEOGRAPHY AND SYSTEMATICS OF HOLOTHURIANS USED FOR *BECHE-DE-MER* IN INDIA

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ABSTRACT

Although holothurians have wide range of distribution in general, they are restricted to certain regions and also have localised distribution in some cases. *Holothuria (Metriatyla) scabra* is distributed in the Gulf of Mannar and Palk Bay and also at Andaman and Nicobar Islands, but not represented in the Lakshadweep. *Holothuria (Theelothuria) spinifera* has a localised distribution in the Gulf of Mannar and Palk Bay. *Holothuria (Microthele) nobilis* is abundant in the Lakshadweep, but absent in the Gulf of Mannar and Palk Bay. Species of *Actinopyga* occur in the Lakshadweep and the Andaman and Nicobar Islands, but not on the Indian side of the Gulf of Mannar and Palk Bay. Brief notes on the taxonomy of commercially important holothurians are given.

INTRODUCTION

The zoogeography of sea-cucumbers is interesting due to their relatively sedentary habits, the brevity of the larval life and usually a restricted bathymetrical distribution. Sea-cucumbers remarkably suitable as material for studying changes in shore lines in relation to land masses. Thus a study of zoogeography is very important. Although there are number of contributions on the systematics of sea-cucumbers from different parts of India, informations are very limited on zoogeography of this group.

ZOOGEOGRAPHY

James (1986) studied the zoogeography of the shallow water echinoderms of the Indian Seas. The studies clearly revealed that the faunal composition of Sri Lanka and the Indian shores of the Gulf of Mannar and Palk Bay are different. Despite the close proximity of India to Sri Lanka there is a marked difference in the species composition along the respective coasts. This is rather difficult to explain since most of the holothurians have a wide range of distribution in the Indo-Pacific region. As many as 49 species are known from Sri Lanka whereas only 24 species are known from the Gulf of Mannar and Palk Bay along the Indian Coast. It is interesting to note that the genus *Actinopyga* is not recorded on the Indian side of the Gulf of Mannar and Palk Bay whereas five species are recorded under the genus from Sri Lanka. Only *Bohadschia marmorata* is reported from the Indian side whereas from Sri Lanka four species of *Bohadschia* viz., *B. argus*, *B. marmorata*, *B. tenissima* and *B. vitiensis* are known. This difference in distribution could be due to the role played by currents and it indicates the presence of a barrier which does not favour movements of holothurians from Sri Lanka to the Indian side. Another important factor is the 'area effect' referred to by Price (1982). The Sri Lankan Coast is far more extensive than narrow coast line of the Gulf of Mannar and Palk Bay on the Indian Coast. Therefore a corresponding increase in species diversity is apparent.

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Holothuria nobilis the most valuble species for the *beche-de-mer* preparation, is found in large numbers on some of the islands of the Lakshadweep. It is also found in Andaman and Nicobar Islands. *Holothuria scabra* the most commercially important species from India, is well distributed in the Gulf of mannar and Palk Bay, right from Sethubhavachatiram in the north to Tuticorin in the south. It was also recorded on the west coast from Malvan by Parulekar (1981). Detailed surveys for this species has to be conducted from the other places along the Indian Coast. *Holothuria scabra* is also extensively distributed in Andamans. It is however totally absent from the Lakshadweep and the Maldives. Another commercially important species *Holothuria spinifera* has a somewhat restricted and localised distribution. It is known only from the Gulf of mannar and Palk Bay in Indian region. It is also known from the Red Sea, Persian Gulf, Sri Lanka, North Australia and Philippines. It is totally absent in the Andaman and Nicobar Islands and in Lakshadweep. The distribution of another valuble genus *Actinopyga* is interesting. It is totally absent from the mainland of India. But it is distributed both in Andaman and Nicobar Islands and the Lakshadweep. Species of *Bohadschia* are also distributed in Sri Lanka. The zoogeography of the genus *Bohadschia* is more or less similar like *Actinopyga*. *Bohadschia marmorata* is found in the Gulf of Mannar and Palk Bay, Sri Lanka, the Andaman and Nicobar Islands, and the Lakshadweep. *Bohadschia argus* is found abundantly in some of the islands of Lakshadweep. The massive commercially important genus *Thelenota* is restricted to the lagoons of the Lakshadweep and the Maldives. The record of *Thelenota* sp. as *Stichopus* sp. by Tikader *et al.* (1986) needs to be verified. Now coming to potentially important genus *Stichopus* it is noted that *Stichopus variegatus* is found in the Gulf of mannar and Palk Bay, the Lakshadweep and the Andaman and Nicobar Islands. This species occurring in Andamans is massive and reaches a size of 600 mm in length. The other species *Stichopus chloronotus* is found in large numbers in some of the islands of the Lakshadweep. At present it is not seen in the Gulf of Mannar and Palk Bay though Gravely (1927) reported them to be abundant in inshore areas at Rameswaram. *Holothuria atra* which grows to a size of 600 mm in length is distributed in the Gulf of Mannar and Palk Bay, in the Andaman and Nicobar Islands, and the Lakshadweep. The value of this species for *beche-de-mer* remains to be explored from India though Wainiya (1988) reported as commercially important from Thailand.

SYSTEMATICS

Nearly 200 species of holothurians are known from the seas around India, of which about 75 species are from the shallow waters within 20 m depth. Of these about 10 species are of commercial value. A study of the systematics of holothurians is interesting as not much information is available. As a result of the efforts of the author several species are brought to light from the Indian Coast for the first time. Parulekar (1981) recorded *Holothuria scabra* from Malvan. The holothurians of the Gulf of Mannar and Palk Bay are somewhat better known. Thurston (1984) reported 10 species of holothurians from Rameswaram and neighbouring islands. Of these only *Bohadschia marmorata* has some commercial value. Gravely (1927) recorded 13 species of holothurians from Krusadai Island in the Gulf of Mannar. Of these *Holothuria scabra* is the most important species. James (1986) listed 23 species from the Gulf of Mannar and Palk Bay. Daniel and Halder (1974) reported 32 species of holothurians from Andaman and Nicobar Islands based on earlier reports. Soota *et al.* (1983) reported some holothurians from Andaman and Nicobar Islands. James (1983) recorded *Holothuria spinifera* and *Bohadschia marmorata* from Madras. The holothurians of Andamans are now fairly well known due to the efforts of the author who listed 37 species from the Andaman and Nicobar Islands. The holothurians collected by Gardiner from Maldives and Minicoy Islands have been dealt in a cursory manner by Pearson (1913, 1914). James (1969) listed 14 species of holothurians from the Lakshadweep. Nagabushanam and Rao (1972) recorded 16 species from Minicoy Atoll. Daniel and Haldar (1974) recorded 23 species of holothurians from Lakshadweep. Mukhopadhyay and Samanta (1983) reported 12 species of holothurians from the islands of Androth, Kalpeni and Minicoy. James (1989) reported 25 species of holothurians from the Lakshadweep. *Holothuria nobilis* and *Actinopyga mauritiana* are the most important species commercially.

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2.2

ECOLOGY OF COMMERCIALLY IMPORTANT HOLOTHURIANS OF INDIA

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ABSTRACT

A knowledge of the ecology of holothurians is important for proper exploitation of the resource. Species like *Holothuria (Metriatyla) scabra, Holothuria (Thelothuria) spinifera* are distributed on sandy beds with algae in shallow waters. Species of *Actinopyga* live among coral reefs, while species like *Holothuria (Microthele) nobilis, Bohadschia argus, Stichopus choloronotus* occur in the lagoons. Details on the concentrations of holothurians in different zones are described in detail.

INTRODUCTION

Although there are about 200 species of holothurians belonging to more than sixty genera in the seas around India, only about 75 species occur from the shallow waters. Of these only a dozen species are commercially important. All holothurians are benthic in habit with a very few pelagic species. The commercially important holothurians are found from the intertidal region to a depth of 20 m depth. The habitats of the holothurians are diverse and vary from sand, coral and mud. Very little information is available on the ecology of commercially important holothurians. James (1982) gave a general account on ecology of intertidal holothurians from the Indian region.

HABITAT

Sandy area

Holothuria (Metriatyla) scabra and *Holothuria (Theelothuria) spinifera* live chiefly in sand. The former species is distributed from the intertidal region to a depth of 20 m. During the low tide specimens which live buried inside the sand, come out and they lie in the half buried condition. When they are buried the posterior end of the body is always kept on the surface of sand. Small specimens are very rarely encountered. On a particular occasion at Port Blair nearly 500 juveniles were collected from the intertidal region. They were seen lying freely on the bottom during low tide. At some places 2-10 specimens were found in an area of 5 sq.m. Specimens kept in the Aquarium tanks lie either freely on the bottom or in the half buried condition. In the Gulf of Mannar and Palk Bay specimens of 300-350 mm are found to be distributed in 5-10 m depth of water.

Holothuria (Theelothuria) spinifera though occupies the same habitat like the previous species, occurs in slightly deeper water. This species is never encountered in the intertidal region. This species is much more rarer than the previous one. More number of this species are landed in the Gulf of Mannar than the Palk Bay, because of the greater depth of operation. The distribution in the sandy substratum depends on the size of the sand particles and the content of organic matter.

Coral area

Species of the genus *Actinopyga* are essentially coral dwelling forms. They live in the intertidal region on the coral reef. Clark (1971) mentioned some of the coral dwelling echinoderms. *Actinopyga mauritiana* is a surf loving species being found very near the low water mark. In some of the islands in the Lakshadweep,

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Actinopyga spp. occur in moderately large numbers on the reef flats. Another potential species for *beche-de-mer Holothuria pyxis* occurs on the reef flats in Andaman Islands. This species always live under stones. The long and narrow anterior end is kept out and is seen in constant movement. It is impossible to pull the holothurians without damage. On lifting the stones, it is found to have a bulged posterior end and a very long narrow anterior end. *Actinopyga mauritiana* lies fully exposed near the low water mark. It often attaches itself to the rocks by tubefeet arranged in four bands on the ventral side. Often on lifting the specimens small pieces of coral stones and such other objects are found attached to the ventral side. In *A. echinites* the dorsal body wall is wrinkled with sand settling in the depressions. Often it is found attached at the base of big rocks by curving its body. Species of *Bohadschia* also live on the coral flats. *Bohadschia vitiensis* lives on the reef flats and lies exposed during the low tide. A thin coating of fine mud is found on to the body.

Mud flats

Muddy flats are by far the best habitats suitable for sea-cucumbers as they are detritus feeders live on the organic matter present in the mud. *Holothuria* (*Metriatyla*) *scabra* is characteristic of muddy flats. During the low tide a number of them can be seen in half buried condition. When they are buried the posterior end of the body is always kept outside. Small forms (50-90 mm in length) are also seen to be lying freely on the muddy grounds during low tides. At some places there are 2-10 specimens distributed in an area of 5 sq.m. Species living in muddy flats are also found on sandy habitat.

Lagoon

The lagoons especially in the Lakshadweep offer excellent habitats for the holothurians. Here the waters are calm with very little disturbance. The most prized holothurian for *beche-de-mer Holothuria* (*Microthele*) *nobilis* is characteristic of the lagoons. There are two colour forms in this species the white variety is usually found in deeper waters between 3 to 20 m. It is most abundant on clean sand in reef passages and near turtle-grass. The black variety is typically found in shallow waters at about 3 m depth on clean sand bottoms where there is living coral and free movement of water. *Bohadschia argus* is a very common species found in the lagoons of Lakshadweep. They lie freely exposed. Often a few small pieces of shell and some sand grains stick to the surface of the holothurian. Another important species from the lagoons of the Lakshadweep is *Stichopus chloronotus*. It was found to be extremely abundant in the lagoon of Kiltan Island. It lies out in the open without making any attempt to conceal its body under corals. *Holothuria* (*Halodeima*) *atra* is one of the most common holothurians around Indian seas. It is always found fully exposed in the shallow waters on sandy bottoms during the low tide where water remains as a pool. This species is never encountered under stones. Specimens measuring from 110 to 230 mm in size were found in lagoon with sand coated on them. Specimens collected on the outer side of the reef are found to have the alga *Halimeda* inside the alimentary canal. The suspended matter like mud and sand in the water settle on the surface of the body as a fine coating. Often there are paired rows of round spots free from the sand or mud. This is due to the presence of two rows of dorsal papillae.

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2.3

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

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ABSTRACT

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

INTRODUCTION

Information on the biology of holothurians is limited. This is particularly so concerning the Indian holothurians. Despite its economic importance, *Holothuria scabra* did not receive much attention, this is rather surprising. From India, some work has been done on the *Holothuria scabra* by Krishnaswamy and Krishnan (1967, 1970 a, 1970 b); Krishnan (1968) and Mary Bai (1971, 1978, 1980). Recently James *et al.* (1988) described induced spawning and rearing of the holothurian from Tuticorin.

Mortensen (1937) reported on the spawning of *H. scabra* on the Egyptian Coast of the Red Sea between April and June 1936. Hardy and Cowan (1980) reported the pearl-fish *Encheliophis vumricularis* from *H. scabra*.

Chopra (1932) and James and Mahadevan (1966) reported a pea-crab from *H. scabra*. James (1976) described an early juvenile of *H. scabra* from Palk Bay.

Since the information on the biology of the most important holothurian *H. scabra* is very scanty, this work was taken up to fill up the gaps in the knowledge of its life history.

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MATERIALS AND METHODS

For the study of biology regular samples were collectd from Tuticorin and Kilakarai in the Gulf of Mannar and from Tirupalakkudi and Rameswaram in Palk Bay. Samples were transported to laboratory. After recording length and weight, specimens were dissected; gut and gonads were carefully taken out for examination.

For gut content analysis, guts were preserved in 1% formalin. Gut contents were carefully removed and dried in oven at 65°C for 24 hrs. Gut contents were seggregated into different size grades by passing through standard sieves of 90, 125, 250, 500, 700, 1003 and 1630 μ sizes. Each fraction was weighed and expressed as percent of total gut content weight. The amount of total organic carbon in the gut contents were estimated (Walkey and Black, 1932).

To determine the size frequency of *H. scabra*, the body length of each individuals was measured to the nearest 5 mm dorsally from mouth to anns by means of flexible tap allowing the animal to relax and resume its normal condition, and total weight to the nearst 5 g. The length of the holothurian was measured from the commercial landing centres, when the individuals are in turgid condition and the eviscerated individuals were eliminated. Nearly 1200 individuals of different sizes were measured.

For reproductive biology, the gonads were carefully removed, weighed and examined macroscopically. Sex was determined by microscopic examination, a part of gonad was fixed in 10% NBF for histological studies. In female, oocyte diameter were measured by using occular micrometer.

Results and Discussion

Food and feeding habits

The holothurian takes fine particles of sand and mud into their mouth by means of tentacles.

TABLE 1. *Maturity stages in* Holothuria (Metriatyla) scabra (*Jaeger*)

Maturity stages		Macroscopic feature	Microscopic feature
Undetermined sex			
I Immature		Single tuft of tubules, tubules short.	Sex indistinguishable.
II Maturing		Gonadial tubules elongated partly, yellow in colour.	Germinal cells are seen.
III Early Mature			
	Male	Gonadial tubules large, yellow in colour, branched having small round saccules.	Some spermatozoa can be seen from a portion of the tubule.
	Female	Gonadial tubules yellowish red, branched with round saccules.	Oocytes are growing and without modal size (Dia. 120 μ).
IV Late Mature			
	Male	Gonadial tubules long, pale yellow, having 2-3 ancillary branches, saccules more elongated.	Numerous spermatozoa are found, yellow in colour.
	Female	Tubules pale red, elongated with swollen round saccules, having 2-3 ancillary branches.	Oocytes are polymodal in shape (Dia. 120-165 μ).
V Spent			
	Male	Number of tubules decreasing; tubules shortening pale yellow in colour.	Yellow coloured spermatozoa are present.
	Female	Gonadial tubules shorter and wider, pale red in colour.	Few oocytes of dark yellow coloured cells (Dia. 152-197 μ).

In the case of *H. scabra*, the gut cotents were analysed and observed mud, sand, shell debris, molluscan shells, bivalves and algae. The percentage of occurrence of different particles were seived, weighed (Fig. 1). From this it is clear that the percentage of individuals feeding muddy particles were 9.07% in 90 μ; 15.48% in 125 μ; 42.08% in 250 μ; 8.86% in 500 μ; 14.15% in 710 μ; 6.16% in 1003 μ and 4.2% in 1680 μ.

H. scabra takes muddy particles mostly with particle size of 125-250 μ. This shows that *H. scabra* prefers muddy substratum than the sandy bottom. The amount of organic matter estimated from the different regions of the gut *viz.* oesophagus, stomach and intestine are 2.06%; 2.26% and 1.7% respectively. This shows

that absorbtion takes place more in the stomach region than in the intestine. Tokuhica (1915) commented that the holothurian extract organic matter out of sand or mud taken together. Clark (1954) also noted that holothurian and the bottom animals generally extract organic matter out of sand or mud which pass through their intestine. *H. scabra* is not a continuous feeder, the oesophagus and stomach remains empty in most of the individuals, but the intestine is filled with sand or mud particles.

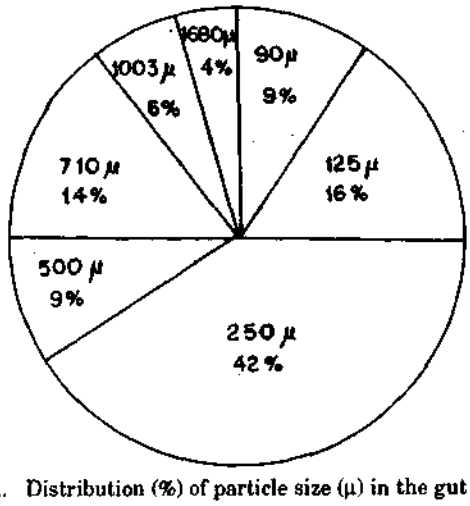

FIG. 1. Distribution (%) of particle size (μ) in the gut content of *Holothuria scabra*.

Size frequency distribution

The size frequency distribution for *H. scabra* shows a single mode (Fig. 2 a). The smallest individuals recorded was 90 mm long and the largest was 370 mm with an average 230 mm. Conand (1981) has observed similar

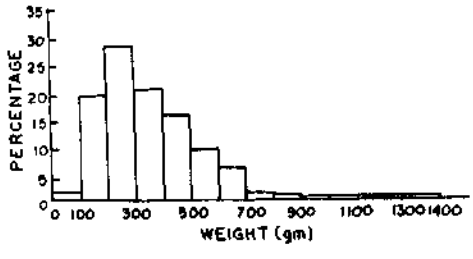

FIG. 2 a. Length frequency distribution of *Holothuria scabra*.

unimodal in the *Thelenota ananas* and *Microthele fuscogilva* and they reveal the phenomenon of 'one class in a locality' (Bakus, 1973). Tyler *et al.* (1987) have recorded the same structure in *Cherbonniera utriculus*.

The total weight of *H. scabra* ranged from 100 to 1400 g (Fig. 2 b). The weight depends on the amount of coelomic water and sediment in the alimentary canal.

Reproductive biology

Gonads : Gonads are yellow in colour, composed of single tuft of tubules, each of which generally has 2 to 3 branches attached to the left side of the dorsal mesentary. From this gonoduct proceeds anteriorly along the mesentary and opens externally on the mid-dorsal line.

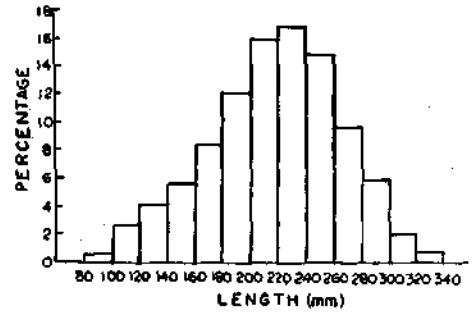

FIG. 2 b. Weight frequency distribution of *Holothuria scabra*.

Maturity stages : Five stages of maturity are recognised and they are presented in Table 1 and illustrated in Fig. 3. Stage I & II comprise

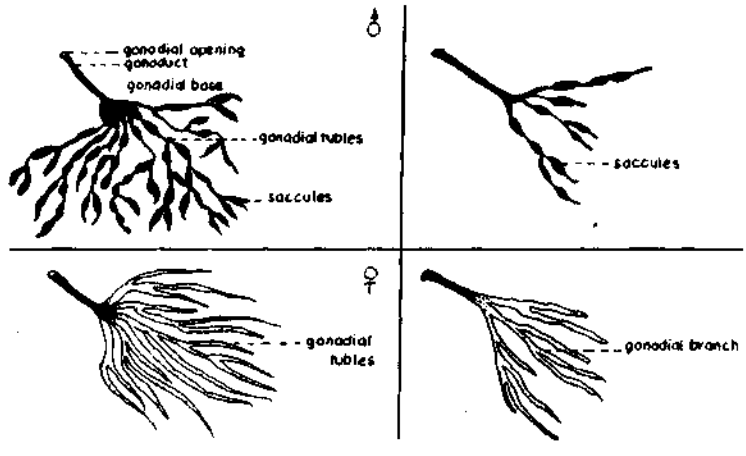

FIG. 3. Gonad structure of *Holothuria scabra*.

individuals of undetermined sex. Stage I corresponding to immature individuals and stage II to the maturing ones. Stage III corresponds to the early mature; the sexes can

therefore be distinguished by a microscopic examination. Stage IV becomes evident by the increased volume of the gonads and includes late mature. Stage V is the spent and the residual riped oocytes or spermtozoa may be observed.

The gonadial tubules are shorter and wider in females, whereas in males the tubules are longer having succules.

Tanaka (1958) who has studied the changes in the maturity stages of *Stichopus japonicus*, observed five stages such as resting, recovery, growing, mature and shedding stage. Conand (1981, 1982) observed five stages in *Thelenota ananas*, *Microthele nobilis*, *M. fuscogilva* and *Actinopyga echinites* and described the stages such as immatre, resting, growing, mature and post-spawning. Krishnamurthy and Krishnan (1967) have given an account of the reproductive cycle. Fish (1967) and Rutherford (1973) have also recorded five stages.

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2.4

STUDIES ON REGENERATION IN THE HOLOTHURIAN *HOLOTHURIA (METRIATYLA) SCABRA* JAEGER

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ABSTRACT

The histological studies made on regeneration of *Holothuria (Metriatyla) scabra* revealed that the alimentary canal regenerates as a thickening from the original mesentery through mitotic proliferation. The presence of groups of morula cells at the anterior and posterior remnants, during regeneration suggests their possible role in the process of wound healing. The circular muscle is formed by the de-differentiation and reorganization of the circular muscle fibres that are already present. The haemal rudiment is formed within three days as a projection of the mesenterial thickening. The respiratory tree originates as a solid rudimentary protrubarance from the ruptured end of the respiratory tree. The rate of regeneration, in all the tissues studied, seems to be more rapid when compared to that of temperate forms.

INTRODUCTION

Echinoderms have long been known to be interesting forms for the study of regeneration. Experimental studies on regeneration of different organs are on record (Hyman, 1955; Nichols, 1964; Swan, 1966; Bakus, 1973). In holothurians, evisceration has been observed as a response to external stimuli (Kille, 1931, 1935). However, there are records of definite occurrence of this process seasonally also (Bertolini, 1932; Kille, 1936; Mosher, 1965; Swan, 1961). Even though detailed investigations on regeneration in holothurians have been carried out in temperate forms, no information is available for tropical forms except for the preliminary report in *Holothuria (Metriatyla) scabra* (Semper, 1868). Further the earlier works have failed to describe in detail the histology of the early stages in regenerative process. Anderson (1965) pointed out that a study of events in visceral regeneration in holothuroids with particular attention to histological details, localization of mitotic activities and cellular differentiation will provide a valuable contribution for comparative purpose. In the present report, therefore, attempts were made to study the evisceration and regeneration of different systems in the holothurian *Holothuria (Metriatyla) scabra* using histological techniques.

The author wishes to express her sincere thanks to late Dr. S. Krishnaswamy, Professor and Head, Department of Biological Sciences, Madurai University, Madurai for suggesting the problem and for his guidance. She is also thankful to Dr. S. Krishnan, National Institute of Oceanography, Goa, India, for his help during this work. The award of a scholarship from the Madurai University for carrying out this investigation is gratefully acknowledged.

MATERIAL AND METHODS

Method of collection and maintenance : The holothurians *Holothuria (Metriatyla) scabra* used in the present studies were collected from an area of 14 sq. km near Pamban (09° 16' N, 79° 13' E), around Krusadai Islands, 97 miles away from Madurai. Forth to fifty animals were collected at weekly intervals for a period of two years and dissected for the presence of complete viscera. Sampling was made at random by hand picking from the same location. They were transported to the laboratory in well oxygenated polythene bags.

For the experimental studies in the field, the holothurians were maintained inside a pen covering an area of 100 sq. m at Pamban, where the sea water never recedes below the depth of one metre.

In the laboratory, they were maintained at room temperature (28° - 30° C) in cement concrete tanks of 120 - 150 litres capacity. Arrangements were made to aerate and circulate the sea water continuously. This system mainly consisted of an air-lift siphon operated with compressed air and an alkathene, or glass cylinder of 60 cm long with a diameter of 7 cm filled with shore jelly plugged with glass wool. Water pumped by the air-lift recirculates through the glass wool and pebbles and becomes cleared of the debris and excreta of the animals (Fig. 1).

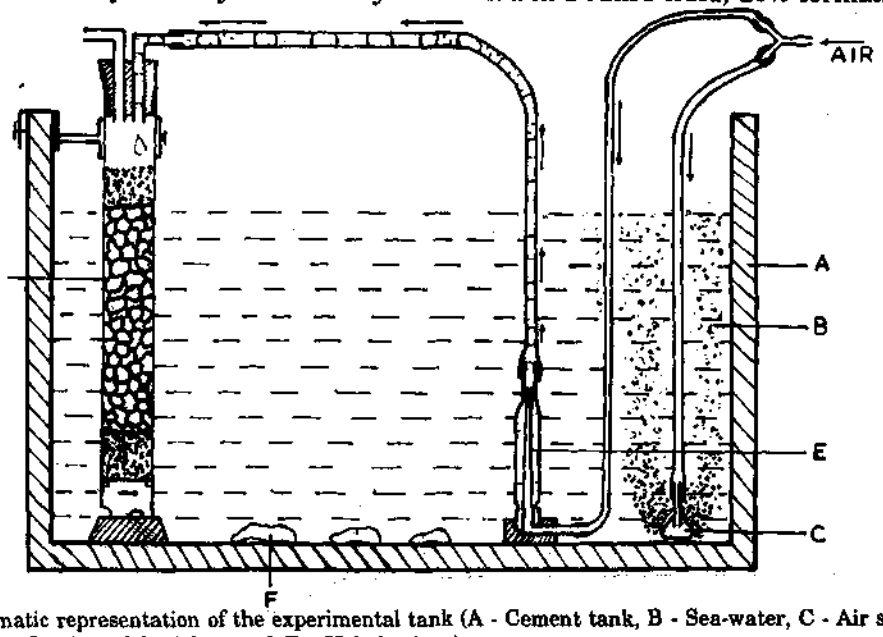

FIG 1. Diagrammatic representation of the experimental tank (A - Cement tank, B - Sea-water, C - Air stone, D - Filtering apparatus, E - Air - lift siphon and F - Holothurians).

Evisceration

Evisceration of the internal organs in holothurians weighing 80 - 200 gms, was induced by injecting 10 - 100 ml of distilled water into the coelom following the method of Dawbin (1948 a). After evisceration the animals were returned to the experimental pen. In the laboratory they were maintained in cement cisterns as described earlier.

Histology

For histological studies, the regenerated tissue samples of 2 cm long were taken to study from five different regions; the junction of the remaining original constriction and the anterior portion of regenerating alimentary canal, the posterior end of the dorsal mesentery, the middle portion of the lateral mesentery, the end of the ventral mesentery at the junction with the cloaca and respiratory tree. The tissues were fixed in Bouin's fluid, 10% formalin, Susa's fluid (all made with sea water), Zenker-formal and Helly's fluid, cleared in oil of winter green and embedded in paraffin wax. Sections of 5 μ thickness were cut and stained with Heidenhein's iron hematoxylin, Mallory's triple strain (MTS), Heidenhein's azan (HA) and Masson's trichrome strain (MT).

RESULTS

The observations on the morphological details of the evisceration and regeneration of *Holothuria (Metriatyla) scabra* have been reported by Mary Bai (1971).

The closure of the anterior and posterior ruptured ends

As a result of evisceration, the coelomic cavity was left in open communication with the exterior through the cloaca. However, the ruptured ends at the anterior and posterior regions of the gut were closed within 24 hours after evisceration. The closed ends consisted of an outer layer of peritoneal epithelium and an inner layer of connective tissue with morula

cells and muscle fragments (Pl. I A). As a result of contraction of muscle fibres, the villi of the lining epithelium were drawn together, thereby obliterating the lumen (Pl. I B). Groups of morula cells were observed in the connective tissue and in the lining epithelium of the 'constriction' (anterior to the cut end) and the cloaca (Pl. I C).

On the second day, the important change noticed at the anterior cut end, was the histolysis of the epithelium. The villi of the 'constriction' were disorganised and their size was reduced (Pl. I D). Inside these villi, pynotic phagocytic cells and morula cells were seen (Pl. I E). Changes like histolysis and disorganisation of the lining epithelium noticed at the anterior ruptured end were not seen at the posterior ruptured end.

In the 'constriction' histolysis of the lining epithelium continued on the third day also. The villi started diminishing in numbers on the third day and by the end of the fourth day they disappeared completely (Pl. I F). As a result, a reduction in the thickness of the wall of 'constriction' was noticed. The number of fragmented muscle fibres found on the first and second day at the closed end were reduced on the third day (Pl. II A) and by the fourth day these were completely missing.

Regeneration of the alimentary canal

After 24 hours of evisceration : There was no change in the course taken by the mesentery. The torn edge of the mesentery was, however, healed and slightly thickened. This thickening which was uniform throughout its length consisted of an outer peritoneal epithelium and an inner mass of mesenchyme with spindle - or oval - shaped de-differentiated muscle fragments and morula cells (Pl. II B).

After 48 - 72 hours of evisceration : There was a distinct increase in the mesenterial thickening. Histological examination revealed that the mesenterial thickening consisted of an inner mass of mesenchyme with de-differentiated muscle fibres and morula cells (Pl. II C, D). Further the cells of the epithelium of the peritoneum were mitotically active.

Four and five days after evisceration : The primordium of the alimentary canal was a rod-like straight thickening along the entire length of the mesentery. The circular muscle fibres have become differentiated on the fourth day (Pl. II E). The cells of mesenchyme and peritoneal epithelium showed evidence of proliferation. On the fifth day the closed end of the alimentary canal became fused with the mesentary.

Six days after evisceration : A complete tubular alimentary canal was formed by the formation of a lumen in the mesenterial thickening, connecting antero-posteriorly the old and regenerating alimentary canal. The newly formed alimentary canal consisted of an outer peritoneal epithelium, a thin layer of circular muscle fibres, a connective tissue layer with amoebocytes and morula cells and a lining epithelium (Pl. II F).

An antero-posterior differentiation in the structure of the alimentary canal was noticed on the seventh day of regeneration. Three distinct changes *viz.*, 1. the peritoneal and lining epithelium had acquired columnar structure, 2. the muscle layer had increased in thickness and 3. the connective tissue was differentiated into an outer thick and inner fluid-like mass so characteristic of the normal intestine, were observed (Pl. III A).

Eight days after regeneration : By the eighth day, the alimentary canal showed evidence of normal functioning, like pulsation and movements. Further, mud and bottom material were seen in the alimentary canal. Faecal pellets were also found indicating that the normal feeding activities had started. Even though the lining epithelium of the anterior part was well organised with secretory glands and goblet cells in the villi (Pl. III B), the differentiation of the mid and posterior region was incomplete. From the seventh to ninth day there was an extensive growth in the regenerating alimentary canal, leading to the formation of intestinal loop (with ascending and descending limbs), simulating the condition in the normal animal.

Nine days after regeneration : On the ninth day, the cells of the lining epithelium of the middle region were columnar and simple (Pl. III C).

Mucus secretion was noticed in both the anterior and middle parts (Pl. III D). From tenth day onwards, there was a gradual thickening of all the layers of the alimentary canal and by 23rd day the structure of the anterior part resembled that of the normal one (Pl. III E).

Changes in the descending small intestine during regeneration : Even though a functional alimentary canal was formed by the ninth day, the differentiation of the posterior region had not completed as mentioned earlier. From fourteenth to thirty-second day, great changes were seen in the descending small intestine. A gradual development of the villi from its simple form to normal complicated and elongated structure was noticed. On the thirty-second day the descending portion of the small intestine had assumed its normal form.

Changes seen in the ascending small intestine : From fourteenth to thirty-second day, increase in the thickness of the different tissue layers were seen. Further, the development of the villi was accompanied by the formation of secretory glands in the lining epithelium. On the thirty second day, the ascending small intestine showed histological details resembling normal intestine (Pl. IV A).

Changes seen in the large intestine : The large intestine which started as a straight tube on the ninth day showed progressive lengthening and changes in the structure. The normal form was attained on the thirty-second day.

Regeneration of haemal system

During evisceration the entire haemal system except the haemal ring and the anterior part of the haemal system were expelled. The ruptured end of the ventral haemal vessel was closed at the end of 24 hours after evisceration. This closure was brought about by the fusion of the epithelial cells of the peritoneum of the adjacent region. A mass of connective tissue with morula cells and muscle fibres were also seen next to the layer of epithelial cells (Pl. IV B). On the third day the rudiment of the ventral vessel appeared as a projection consisting of an outer peritonial epithelium covering a mass of mesenchymal tissue with de-differentiated muscle fibres and a few morula cells at the free edge of the mesenterial thickening (Pl. IV C). The circular muscle fibres were noticed on the fourth day. Mitotic activity was seen in the mesenchyme and peritoneal epithelium of the haemal rudiment of five day regeneration (Pl. IV D). The dorsal haemal vessel developed as a mesenterial thickening at the junction of the alimentary canal and mesentary. The wall of the vessel is composed of a layer of peritoneal epithelium over a layer of connective tissue with morula cells. The process involved in the formation of lumen of both the dorsal and ventral vessel, is similar to that of the alimentary canal. On the eighth day the dorsal haemal vessel started branching. Both the dorsal vessel and the branches consisted of an outer columnar epithelium, a layer of thin circular muscle fibres and a layer of inner connective tissue. Morula cells and amoebocytes were also present (Pl. IV E). With the development of the intestine, the haemal vessels adjacent to the descending small intestine became differentiated into the main dorsal vessel. The haemal vessels close to the ascending small interesting became heavily branched and gave rise to *rete-mirable*. By the end of twelveth day both the dorsal and ventral haemal vessels assumed the normal structure (Pl. IV F). The haemal system attained its full development by the thirty second day.

Regeneration of respiratory tree

The ruptured end of the respiratory tree was covered by the fusion of peritoneal epithelium by the end of 24 hours after evisceration (Pl. IV G). On the second day a layer of connective tissue with morula cells covered by a layer of peritoneal epithelium as a protuberance from the healed end was noticed (Pl. IV H). On the fourth day the regenerated part assumed a tubular form as the result of the formation of lumen connecting it with the main vessel. The respiratory tree was made up of a layer of thin peritoneal epithelium. From sixth day onwards there was a general thickening of the different tissue layers. There was an elongation of the respiratory tree from the seventh to the eighteenth day after the evisceration. Three main branches, measuring 3.5 mm in length, were formed. The respiratory tree entered into the coelom making contact

with *rate-mirable* by the nineteenth day. Further development continued until the thirty second day by which time the normal structure and shape had been attained.

Discussion

In *Holothuria* (*Metriatyla*) *scabra* it was reported that evisceration does not occur in nature either spontaneously or seasonally (Mary Bai, 1971).

Regeneration of alimentary canal : While looking into the origin of the alimentary canal during regeneration two different views have been expressed. Torelle (1909), Bertolini (1932) and Kille (1936) are of the opinion that the alimentary canal is formed by the growth of blind tubular elements, one growing from the anterior, and the other from the posterior end. Later they unite in the middle forming a continuous structure. Conversely, Scott (1914), Bertolini (1930), Kille (1935), Dawbin (1949) and Mosher (1956) have shown that the alimentary canal regenerates as a thickening from the original mesentary, and the anterior and posterior fragments apparently have no influence on the regeneration of the intestine. The histological studies made on consecutive days of regeneration in *H.* (*M.*) *scabra*, have revealed that the latter method of regeneration (namely from the mesenterial thickening) appears to be true in this species as in *Stichopus mollis* (Dawbin, 1949).

The closure of wound at the anterior and posterior ruptured ends is provisional and by muscular contraction of the gut remains, as described by Needham (1952) and Smith (1971).

It is interesting to note that in *H.* (*M.*) *scabra* mitotic activity is encountered in the peritoneal epithelium and mesenchyme cells of the mesenterial thickening, even as early as 72 hours after evisceration. This is indicative of the rapidity with which regeneration takes place. In the other holothurians, in *Holothuria* sp. (Bertolini, 1930 a), in *Thyone briareus* (Kille, 1935) and in *Actinopyga agassizi* (Mosher, 1956) the authors failed to make clear whether mitotic activity is involved or not. However, in *S. mollis* (Dawbin, 1949) noticed distinct mitotic figures in mesenchymal cells lining the lumen and the peritoneal epithelium, only after 4 days of regeneration.

While looking into the regeneration of muscle fibres in the gut, Dawbin (1949) has reported that these fibres in the regenerating gut of *S. mollis* originate from the mesenchyme cells 80 days after regeneration. However in *H.* (*M.*) *scara* it was found that the muscle fibres are formed by de-differentiation of already existing muscle fibres in the mesentary, followed by re-differentiation.

Even though the lumen of the regenerating gut is formed within the mesenterial thickening, there seems to be divergence in the process in different genera. For instance, in *S. mollis* the lumen is shown to have developed by extension and fusion of cleft-like structures in the mesenterial thickening and the lining epithelium is formed later by differentiation of mesenchymal cells (Bertolini, 1931; Dawbin, 1949). In *Thyone briareus* (Kille, 1935) and in *Holothuria* sp. (Bertolini, 1932), the lumen is shown to have formed as a result of the secondary invasion of tubular ingrowth from one or both ends of mesenterial thickening. Mosher (1956) has described in *A. agassizi* that the epithelium of the mesenterial thickening proliferate followed by folding of the surface of the rudiment resulting in the inclusion of blind lumina within the connective tissue core. The lumina later fuse into a single continuous lumen. The present observations on *H.* (*M.*) *scabra* reveals that a hollow space in the middle protion of the mesenterial thickening is formed by the reorganisation of mesenchyme cells. The lumen appears without any constant relation in the position along the regenerating alimentary canal. These finding are in agreement with that of Dawbin (1949) and Bertolini (1931 b) who report the similar features in *S. mollis* and *S. regalus* respectively.

As reported for *S. mollis* by Dawbin (1949), the formation of alimentary canal as a straight tube at an earlier period of regeneration and the antero-posterior differentiation of different layers in *H.* (*M.*) *scabra* may enable the animal to start its feeding earlier and to supply the nutritive material for its further regeneration.

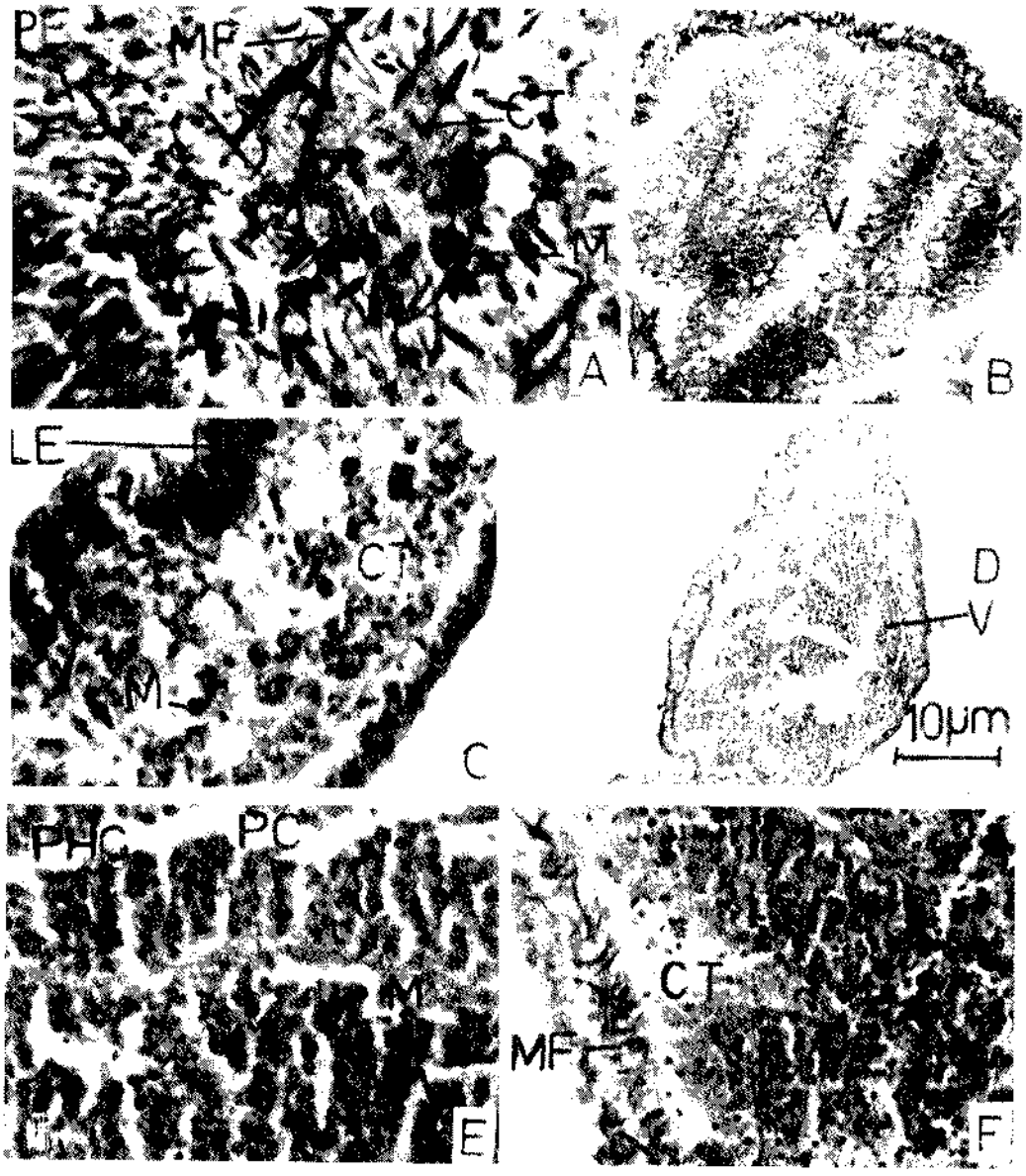

Plate I A. T.S. of the closed end at 'constriction' 24 hours after evisceration showing outer peritoneal epithelium (PE), inner connective tissue (CT) with morula cells (M) and muscle fibres (MF) X 320; B. T.S. of the 'constriction' 24 hours after evisceration. Note the villi (V) are drawn closer together obliterating the lumen X 80; C. T.S. of the cloaca 24 hours after evisceration showing the morula cells (M) in the connective tissue layer (CT) and lining epithelium (LE) X 320; D. T.S. of the 'constriction' of 48 hours after evisceration showing the disorganisation of the villi (V) X 80; E. Portion of T.S. of the 'constriction' showing the presence of Pycnotic cells (PC), Phagocytic cells (PHC) and morula cells (M) X 320 (A-E. Heidenhains iron haematoxylin) and F. T.S. of the 'constriction' 72 hours after evisceration showing the diminution of villi (V) X 320 (Masson's trichrome).

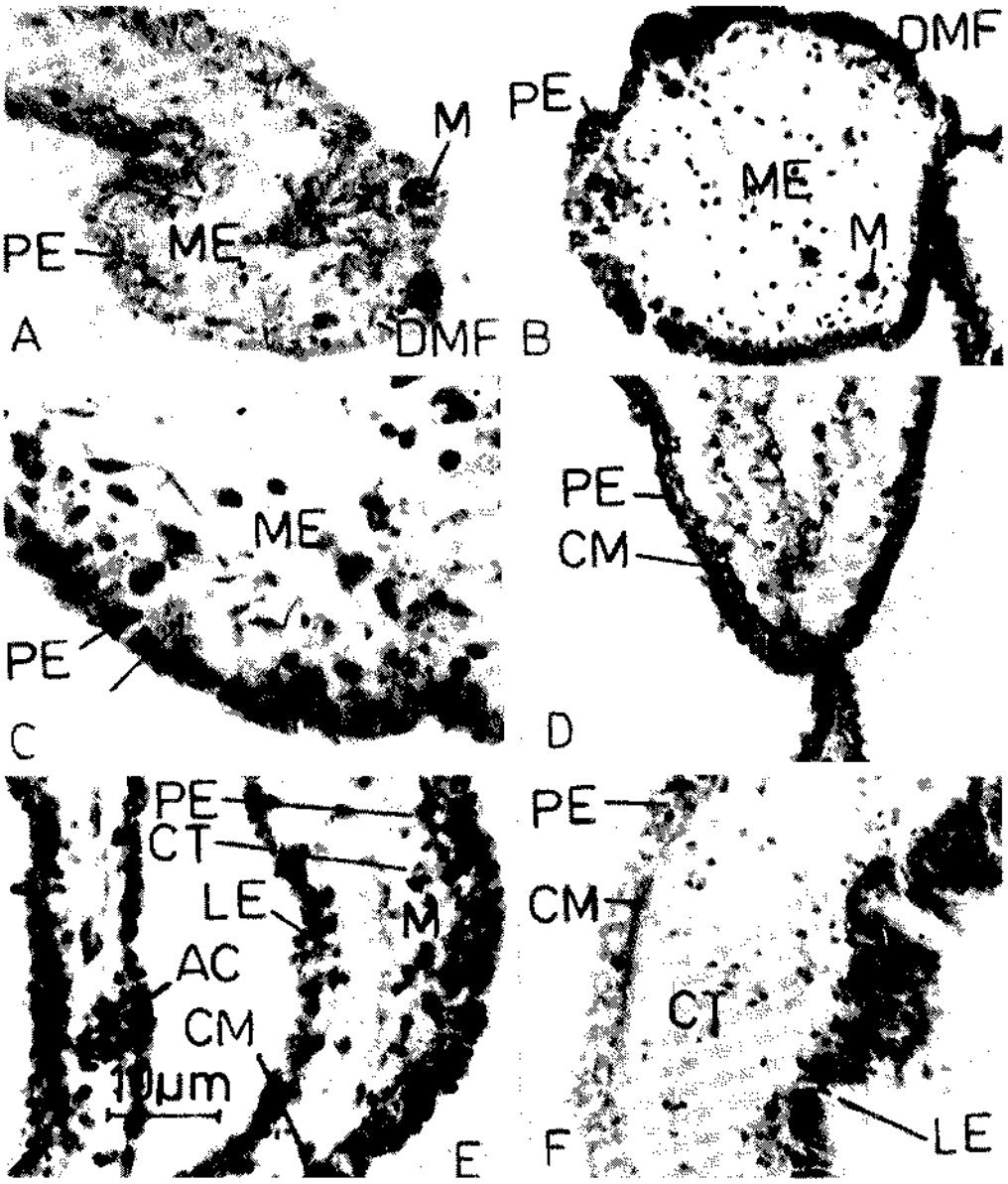

Plate II A. Plate II A. T.S. of the anterior closed end 72 hours after evisceration showing the reduction of muscle fibres (MF) in the connective tissue (CT) X 320; B. T.S. of the mesenterial thickening at the anterior region 24 hours after evisceration showing outer peritoneal epithelium (PE) and an inner mass of mesenchyme (ME) with de-differentiated muscle (DMF) and morula cells (M) X 320; C. T.S. of the mesenterial thickening 48 hours after evisceration showing an outer peritoneal epithelium (PE) inner mass of mesenchyme (ME) with de-differentiated muscle fibres (DMF) and morula cells (M) X 320; D. T.S. of the mesenterial thickening 72 hours after evisceration showing the mitotic activity in peritoneal epithelium (PE) and mesenchyme. The arrow indicates the dividing cells X 800; E. T.S. of the mesenterial thickening 3 days after regeneration. Note the circulatory muscle fibres (CM) are rearranged under peritoneal epithelium (PE) X 320 and F. T.S. of the intestine of 6 days regenerate showing the outer peritoneal epithelium (PE), thin circular muscle layer (CM), connective tissue layer (CT) and inner lining epithelium (LE) X 320 (All in Heidenhain's iron haematoxylin).

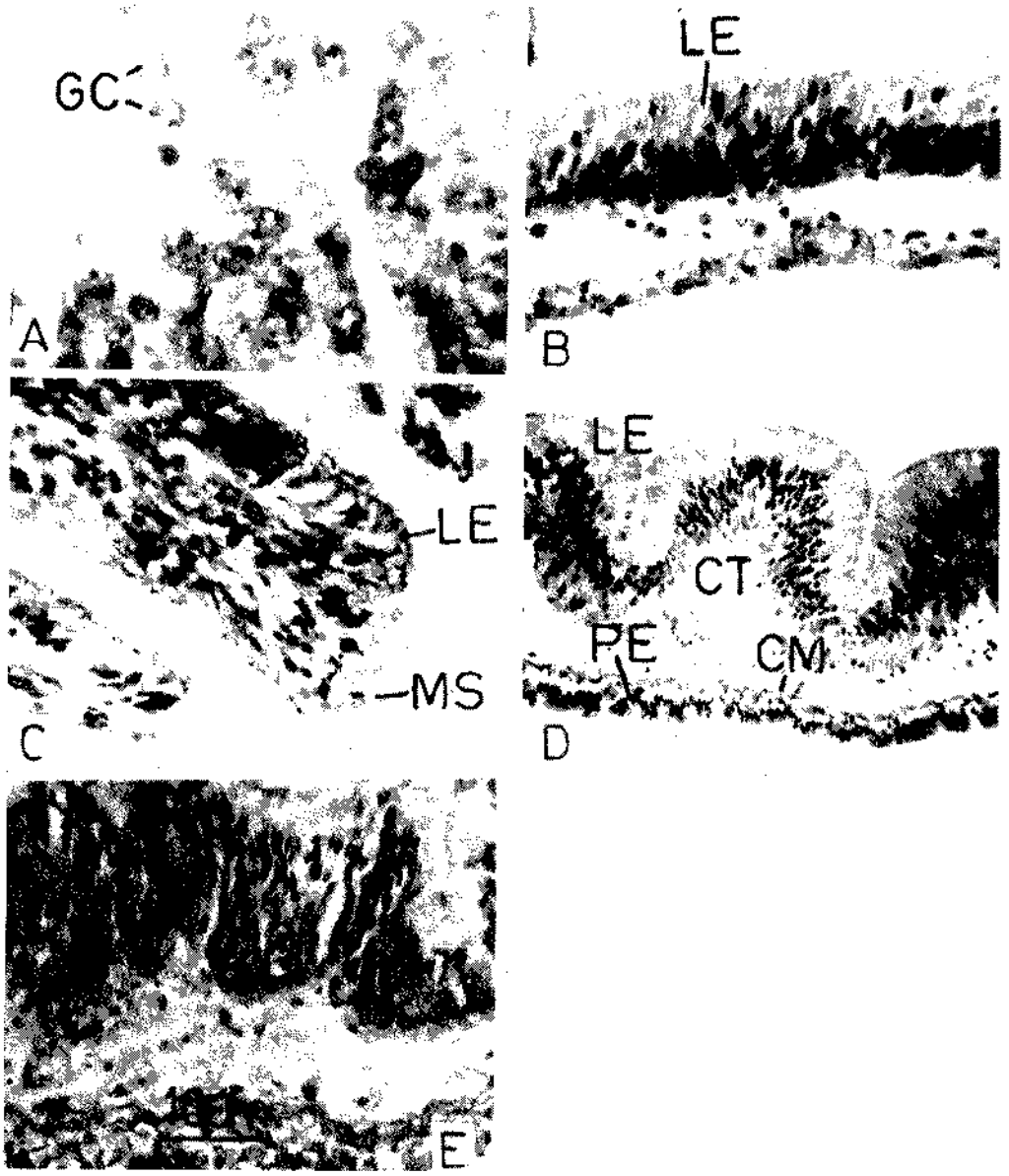

Plate III A. T.S. of the anterior part of intestine 7 days regenerate. Abbreviations as in Pl. II F. X 320 (Masson's trichrome); B. T.S. of the anterior part of the intestine 8 days regenerate. Note the presence of goblet cells (GC) and secretory glands in the lining epithelium X 800 (Heidenhain's iron haematoxylin); C. T.S. of the middle part of the intestine of 9 days regenerate. Note that the lining epithelial (LE) cells had become columnar X 320 (Heidenhain's iron haematoxylin); D. T.S. of the anterior part of intestine of a 9 days regenerate showing the presence of mucus secretion (MS) in the lining epithelium (LE) X 320 (Mallory triple stain) and E. T.S. of the anterior part of the intestine of 23 days regenerate, showing the outer peritoneal epithelium (PE) the muscle layer of circular fibres (CM), connective tissue layer (CT) and inner lining epithelium (LE) X 320 (Heidenhain's iron haematoxylin).

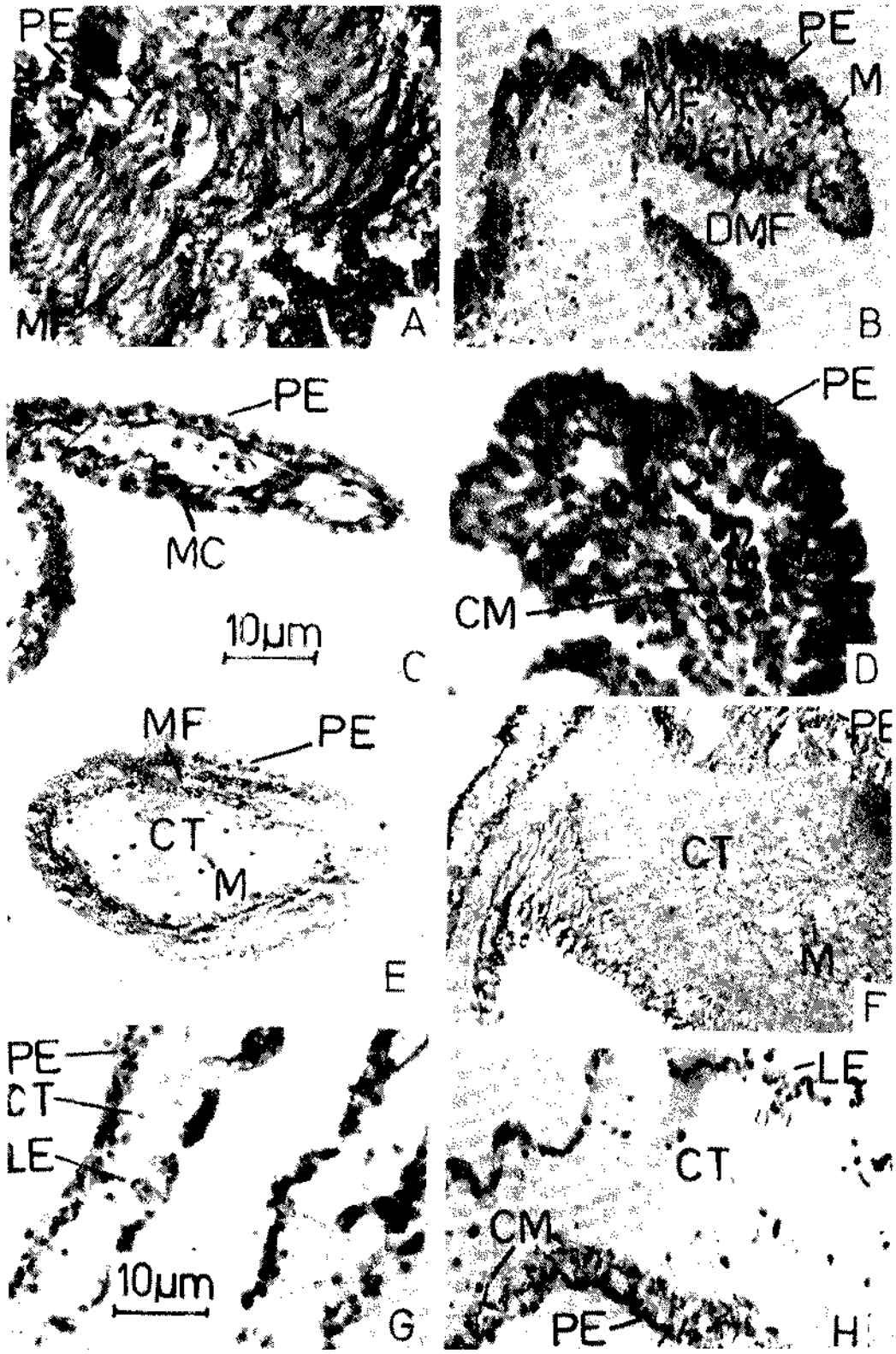

PLATE IV A. T.S. of the ascending small intestine of 32 days regenerate, showing that all the layers have attained the normal structure X 80 (Heidenhain's iron haematoxylin); B. T.S. of the closed end of the ventral haemal vessel showing the outer peritoneal epithelium (PE) and connective tissue (CT) with morula cells (M) and muscle fibres (MF) X 320 (Mallory's triple strain); C. T.S. of the ventral haemal rudiment after 3 days regeneration showing an outer peritoneal epithelium (PE) and inner mesenchyme (MC) with morula cells (M) and de-differentiated muscle fibres (DMF) X 320 (Heidenhain's iron haematoxylin); D. T.S. of the dorsal haemal rudiment after 5 days of regeneration showing the mitotic activity (arrow mark) in peritoneal epithelium (PE) and mesenchyme cells (MC) X 320 (Heidenhain's iron haematoxylin); E. T.S. of the dorsal haemal vessel after 8 days of regeneration showing that the outer peritoneal epithelium (PE), thin circular muscle layer (CM) and inner connective tissue with morula cells (M) and amoebocytes (A) X 320 (Heidenhain's iron haematoxylin); F. T.S. of the dorsal haemal vessel after 12 days of regeneration showing that the haemal vessel has attained the normal structure. X 80 (Heidenhain's iron haematoxylin); G. T.S. of the closed end of the respiratory tree, 24 hours after evisceration showing outer peritoneal epthelium (PE) and inner connective tissue (CT) with muscle fibres (MF) and morula cells (M) X 80 and H. T.S. of the respiratory tree rudiment (RTR) 48 hours after evisceration showing an outer peritoneal epithelium and an inner mass of connective tissue (CT) with morula cells (M) X 80 (Mallory's triple stain).

Regeneration of haemal system : Although investigations have been carried out on the regeneration of different organ systems of holothurians our knowledge of regeneration of haemal plexus is scanty. The earlier observations made by Kille (1935) reveal that this system is formed as a crescent-shaped membrane within the first major loop of the intestine. Even though the above author has not clearly traced out the origin, it can be said from his interpretation that it originates from the intestine. But later Dawbin (1949) has shown in the holothurian, *S. mollis* that the origin of haemal plexus is from the mesentary. Results obtained during the present studies support the view of Dawbin (1949). It is interesting to note both in *Stichopus mollis* and *Holothuria (Metriatyla) scabra* that the ventral haemal vessel appears first as an outgrowth from the mesenterial thickening while the dorsal haemal vessel appears later at the point where the mesentery attaches with the alimentary canal. However, there is a slight difference in that the formation of this system takes a longer time in *S. mollis*.

Regeneration of respiratory tree : Both the alimentary canal and respiratory tree undergo wound healing on the first day itself. The gut takes its origin from the mesentery, the respiratory tree on the other hand starts regeneration from the already existing rudiment of original one. This is because the intestine is lost as a whole during evisceration, whereas, the respiratory tree found on the left side alone is usually expelled out along with the alimentary canal. But for these differences, the other process of de-differentiation and re-arrangement of tissue has been observed to be the same in the gut and in the respiratory tree. The respiratory tree starts regeneration only after 25 days in *S. mollis* (Dawbin, 1949) whereas *H. (M.) scabra* the regeneration starts even after the first day as soon as the wound healing is completed.

Role of coelomocytes : The role of coelomocytes during wound healing has been shown in the different groups of echinoderms (Nusbaum and Oxner, 1915; Cuenot, 1906; Kindred, 1921; Bookhout and Greenburg, 1940; Reichenberger, 1912; Dawydaff, 1901 - as referred by Hyman, 1955). It has been reported that in all these animals the wound is first covered by a delicate membrane, consisting of a layer of epithelium and an underlying connective tissue with coelomocyts. The occurrence of coelomocytes facilitating wound healing has been demonstrated in the echinoid *Psammechinus milaris* by Willi (1966). In the holothurian *S. tremulus* it has been shown by Rollefsen (1965) that a special type of coelomocyte, 'morula cells' play a distinct role in the wound healing process. The accumulation of such morula cells in large numbers at the anterior as well as posterior remnants and closed ends in *H. (M.) scabra* suggests their important role in the process of would healing. Since the major portion of the coelomic fluid is lost during the process of evisceration, with consequent reduction in the number of free coelomocytes in the coelom, the coelomocytes already present in the tissues may have moved to the region of the healing sites. Such a movement of coelomocytes from the tissue, during regeneration has been reported for the asteroid *Henricia leviuscula* by Anderson (1962) and for the holothurian *Leptosynapta crassipatina* by Smith (1971).

It has been shown that in echinoderms, the nutritive materials for the regenerating structure are transported by the amoebocytes (Anderson, 1962; Hyman, 1955). In the holothurians, however, it is thought that this function is taken up by the morula cells. Dawbin (1949) after observing these morula cells (which he calls as wandering cells), in the mesenchyme of regenerating alimentary canal of *S. mollis*, also has concluded that these cells are the carriers of nutritive reserves which are available in the body wall. Since the amoebocytes and morula cells are found accumulated in the regenerating tissues of *H. (M.) scabra*, it is presumed that these may be the carriers of energy source for the maintenance of metabolism during the period of enforced starvation.

Rate of regeneration : The rate of regeneration varies in differentt species of holothurians ranging from 15 to 120 days. Bertolini (1930 b) states that in *S. regalus* the whole process is completed within 15 days. However, a longer period of 25 - 27 days for the completion of regeneration has been shown by Mosher (1956 for the holothurian *A. agassizi*. In *Thyone briareus* regeneration is completed within 32 - 40 days (Scott, 1914; Kille, 1935). Among the

available reports, *S. mollis* is the only form which is known to take 110 days for the regeneration of lost parts. When compared to other species regeneration of lost parts is very rapid in *H. (M.) scabra* in that the animals start feeding even after seven days of regeneration. The high temperature prevailing in Pamban area (27° C) from the where the animals were collected could have induced the process of regeneration quickly.

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2.5

TOXICITY EVALUATION OF THE HOLOTHRIAN *HOLOTHURIA (MERTENSIOTHURIA) LEUCOSPILOTA* (BRANDT) AND THE EFFECT OF TOXIN ON THE PRAWN *CARIDINA RAJADHARI*

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ABSTRACT

The evaluation of lethal and sublethal concentrations is an important step for further studies on behavioural and physiological changes in the animal. In the present investigation toxicity evaluation was done using computational procedure for critical analysis of the regression line relating probits and log dose.

In the present study five size groups of the prawn *Caridina rajadhari* namely juveniles, immature females, immature males, mature females and mature males were used and the LC_{50} values were calculated upto 96 hrs. It was observed that the percent mortality of the five size groups increased progessively upto 96 hours in all concentrations of holothurian toxin and the LC_{50} values decreased with increasing exposure period. The size and sex dependent toxicity indicated that LC_{50} values followed by immature male, immature female, mature male and mature female. It was observed that males were found to be more tolerant than females in both immature aand mature stages. It was also observed that mature females were most susceptible and the juveniles are more tolerant among the test animals.

INTRODUCTION

The holothurians have certain poisonous substances in the mucous secretions of their skin, which affords excellent protection against enemies. Also, many holothurians, when attacked, can distract their attacker by ejecting their digestive tract, and in particular the Cuvierian tubules. These tubules are white, pink or red in colour. If the sea-cucumber is irritated, the Cuvierian tubules are emitted through the anus. Upon contact with the water, the tubules swell and elongate into sticky slender threads which serve to entangle any predator that attempts to annoy it. Only few of the tubules are emitted at any one time and the autotomized tubules are soon replaced by new ones. The organs of Cuvier are quite toxic, containing large concentrations of holothurin. The role of these tubules is not completely known, but they are believed to serve as a protective mechanism for sea-cucumber.

The present investigation was undertaken to study the toxicity to prawn *Caridina rajadhari* after exposing to sea-cucumber *Holothuria leucospilota* toxin.

MATERIAL AND METHODS

The freshwater prawns *Caridina rajadhri* were collected from Kham River, near Aurangabad in Maharashtra. The prawns were maintained in large glass aquaria, containing aerated tap water. The other conditions were kept constant to their minimum range (temperature 25 ± 2° C; pH 6.5 - 7.0; dissolved oxygen 5.0 ± 1.0 ml/l). They were acclimatized for seven days to laboratory conditions before subjecting them to experiments. The water in the container was changed everyday. After three days the prawns were fed with green algae. During the experimental period they were not fed.

Intermoult prawns of five different groups based on size and sex (Immature male - 18 mm, immature female - 20 mm, mature male - 23 mm, mature female - 28 mm, juvenile - 15 mm) were used measured from the tip of the rostrum upto the end of telson. Series of static bioassays were conducted under laboratory conditions as described by Finney (1971). For each experiment 20 animals approximately of similar size were exposed to 5 to 10 different concentrations of

sea-cucumber toxin. Care was taken to dechlorinate the tap water before supplying it to the experimental prawns. No artificial aeration was provided to the animals during the exposure period. Different concentrations of sea-cucumber toxin were prepared in two litres of test medium.

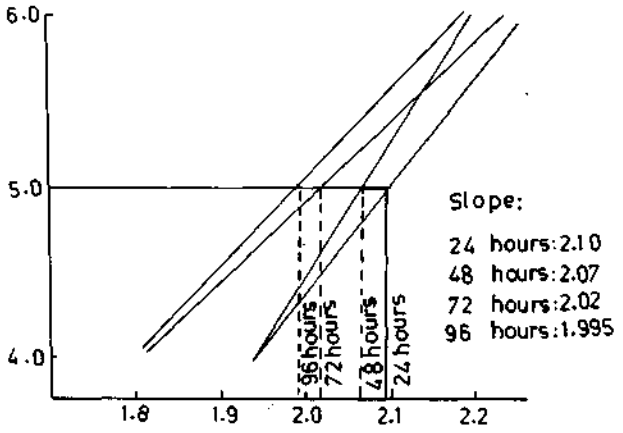

FIG 1. The effect of sea-cucumber toxin in juveniles of *Caridina rajadhari*.

The test medium was changed at every 24 hours to maintain the toxin concentration. The resulting mortality was noted to be in the range of 10 to 90% for each concentration for the durations of 24, 48, 72 and 96 hours. Individuals which were motionless and did not respond to the needle prick were regarded as dead and were removed immediately from experimental containers, because such mortality in static bioassay might deplete DO (dissolved oxygen) and affect other animals. A control set was maintained with similar number of animals and toxin free tap water. No mortality was observed in the control troughs. Each experiment was repeated thrice to obtain constant results with the toxicant.

Sea-cucumber toxin, which was used in this experiment was collected from *Holothuria leucospilota*. The specimens were collected at Ratnagiri in the west coast. The specimens were brought to the laboratory and toxin was extracted by Ferlan and Leebez (1974) method as follows.

The body wall of the sea-cucumber along with Cuverian tubules was separated from alimentary canal. The tissue was cut into small pieces and to this a small amount of water added. The suspension was kept at 4° C for 5 to 6 days. The tissue was homogenised by adding sea water and passed through a thick nylon screen. To the screened suspension distilled water was added and centrifuged. Acetone was added to the supernatant to obtain a precipitate.

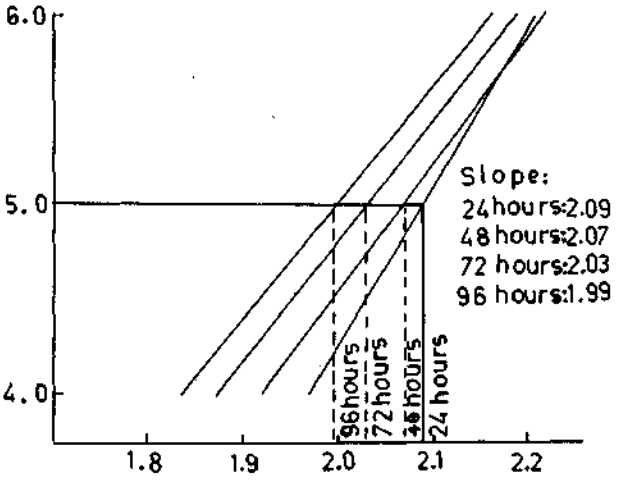

FIG. 2. The effect of Sea-cucumber toxin in immature males of *Caridina rajadhari*.

The precipitate was dissolved in distilled water, this solution is used as toxin. The data collected is elaborated statistically by means of the probits method which, by transforming the toxicity curve (% mortality/concentration) into regression lines (Mortality in probits/concentration) (Finney, 1952) which allow the "average lethal concentration" or LC_{50} to be calculated for 24, 48, 72 and 96 hours.

RESULTS

Effect of sea-cucumber toxin has been studied in five different developmental groups *viz.* juveniles, immature male, immature female, mature male and mature females to determine lethality of a prawn *Caridina rajadhari*. The LC_{50} values, along with the standard deviation, 95% fiducial limits and homogenity of all the five groups are shown in Tables 1 and 2 (Figs. 1 to 5). The safe concentrations of SCT to different stages of prawns are presented in Table 3.

Order of toxicity according to tolerance for SCT is : juveniles > immature male > immature female > mature male > mature female.

TABLE 1. *Calculation of log dose/probit regression line for some experiments in which immature male prawn* Cardina rajadhari *were exposed to different concentrations of sea-cucumber* (Holothuria leucospilota) *crude toxin in Busvine/Nash technique for a period of 48 hours*

Con. of crude toxin (ml)	No. of prawns used (n)	% dead	Corr. % kill P	log (+1) dose x	Experi-cal probit	Expected probit Y	Working probit y	Weight-ing coeffici-ent	Weight W	Wx	Wy	Wx^2	Wy^2	Wxy	y'
9.0	20	20	20	1.95	4.13	4.15	4.15	0.471	9.42	18.36	39.02	35.81	162.23	76.23	4.20
10.0	20	30	30	2.00	4.48	4.50	4.47	0.581	11.62	23.24	51.94	46.48	232.11	103.88	4.53
11.0	20	40	40	2.04	4.75	4.80	4.74	0.627	12.54	25.58	59.43	52.18	281.74	121.25	4.80
12.0	20	50	50	2.07	5.00	5.00	5.00	0.637	12.74	26.37	63.70	54.84	318.50	131.85	5.00
13.0	20	60	60	2.11	5.25	5.30	5.25	0.616	12.32	25.99	64.68	54.84	339.57	136.47	5.27
14.0	20	70	70	2.14	5.52	5.50	5.52	0.581	11.62	24.86	64.14	53.21	354.06	137.26	5.47
15.0	20	80	80	2.17	5.84	5.75	5.83	0.532	10.64	23.08	62.03	50.10	361.64	134.60	5.67
									80.90	167.48	404.94	347.20	2049.91	841.54	
									SW	SWX	SWY	Swx^2	Sw^2	Swxy	

Calculation of working pobit : Y = Yo + Kp

1. Y = 3.41 + 0.0376 x 20 = 4.16
2. Y = 3.62 + 0.0284 x 30 = 4.47
3. Y = 3.72 + 0.0256 x 40 = 4.74
4. Y = 3.75 + 0.0251 x 50 = 5.00
5. Y = 3.68 + 0.0262 x 60 = 5.25
6. Y = 3.54 + 0.0284 x 70 = 5.52
7. Y = 3.27 + 0.0320 x 80 = 5.83

Calculation of x and y

$$\bar{x} = \frac{Swx}{Sw} = 2.0702$$

$$\bar{y} = \frac{Swy}{Sw} = 5.005$$

Calculation of 'b'

$$b = \frac{Swxy - x\,Swy}{Swx^2 - x\,Swx} = \frac{3.23322}{0.483} = 6.6940$$

Calculation of regression equation

$$Y = (\bar{y} - b\bar{x}) + bx$$

$$Y = -8.852918$$

Calculation of improved expected probit Y'

$$Y' = (\bar{y} - b\bar{x}) + bx$$

Y' = -8.852918 + 6.6940 x 1.95 = 4.20
Y' = -8.852918 + 6.6940 x 2.00 = 4.53
Y' = -8.852918 + 6.6940 x 2.04 = 4.80
Y' = -8.852918 + 6.6940 x 2.07 = 5.00
Y' = -8.852918 + 6.6940 x 2.11 = 5.27
Y' = -8.852918 + 6.6940 x 2.14 = 5.47
Y' = -8.852918 + 6.6940 x 2.17 = 5.67

TABLE 2. *LC_{50} values calculated for different stages and sexes of freshwater prawn* C. rajadhari *after exposure to sea-cucumber* (Holothuria leucospilota) *toxin for periods of 24, 48, 72 and 96 hours*

Exposure period in hours	Regression equation $y = (\bar{y}-b\bar{x}) + bx$	LC_{50} values ml	Variance	Chi-square value	Fiducial limits upto 95% confidence	
					M1	M2
Juvenile						
24	-9.5838689 + 6.93355 x	12.685	0.00025644	-0.1921016	11.680831	13.786
48	-11.6840 + 8.0458 x	11.847	0.05227898	3.0303835	10.823883	12.638
72	-4.2701355 + 4.5864 x	10.500	0.0057873	3.0780055	9.0695746	11.849
96	-5.5475 + 5.3061 x	9.723	0.000443419	1.5612474	8.7378723	10.816
Immature male						
24	-12.52799 + 8.3860 x	12.306	0.000190042	1.1122421	11.554387	13.0975
48	-8.852918	11.734	0.0466457	1.5421789	10.798963	12.740892
72	-7.4966 + 6.1541 x	10.730	0.00032239	1.0655537	9.7793927	11.73894
96	-5.0146 + 5.0466 x	9.647	0.00048529	1.5455749	8.5883219	10.782834
Immature female						
24	-9.1127 + 6.8032 x	11.869185	0.000301674	-0.5895264	10.740091	12.789347
48	-7.1124 + 5.8909 x	11.379429	0.000374252	7.3302916	9.9973453	12.204756
72	-5.7404 + 5.347 x	10.201822	0.00044812	0.780883	8.9576432	11.22007
96	-8.0086 + 6.5962 x	9.3785451	0.000301021	19.188214	8.5611095	10.155246
Mature male						
24	-7.2877 + 5.9109037 x	11.99	0.000352592	4.5440398	10.959073	13.255589
48	-7.2812 + 6.1488 x	10.00	0.000321242	-18.9828	9.123652	10.880281
72	-3.1344 + 3.1285865 x	6.0	0.00123272	0.0878551	4.9641308	7.00686132
Mature female						
24	-8.30 + 6.705188 x	11.55	0.000280274	11.578083	10.771694	12.762654
48	-5.2761 + 5.1629902	9.78	0.000462467	13.583486	8.6891869	10.831154
72	-3.4202 + 4.4823 x	7.56	0.000624215	-1.35077	6.6454271	8.5244643
96	-0.5664 + 3.1721 x	5.89	0.0123777	0.2908994	4.7771907	0.7719131

From the observed data it appeared that freshwater prawn *C. rajadhari* in all the developmental stages is sensitive to SCT. From

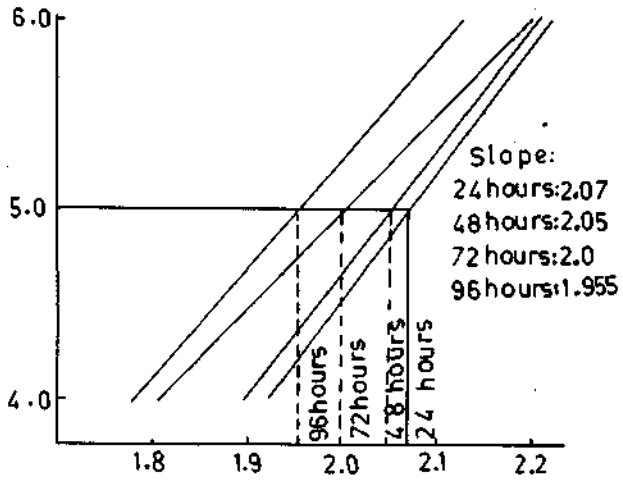

FIG. 3. The effect of sea-cucumber toxin in immature female of *Caridina rajadhari*.

the LC_{50} values observed, it was clear that 24 hours LC_{50} values in all the cases were the highest, followed by 48, 72 and lower for 96 hours among all exposure periods. The percentage mortality of all the five size groups increased progressively upto 96 hours in all concentrations of SCT. The LC_{50} values decreased with increasing exposure periods.

TABLE 3. *Safe concentration of sea-cucumber* Holothuria leucospilota *toxin calculated for freshwater prawn* Caridina rajadhari

Stage	Safe concentration
Juveniles	3.100027
Immature males	3.2005579
Immature females	3.1376557
Mature males	2.0868099
Mature females	2.1036518

From the data it seems the toxicity of SCT ranged from 5.0 ml to 14.0 ml/L for the five groups of the prawn *C. rajadhari*. The results in relation to size and sex indicated that LC_{50} values decreased as the size of animal increased. Juveniles had the highest LC_{50} values being the most tolerant stage among all the five groups of the prawn tested. They were followed by immature males, immature females, mature males and mature females. In this study, males were found to be more tolerant than females in both immature and mature stages. It was also observed that mature females were the most susceptible to SCT.

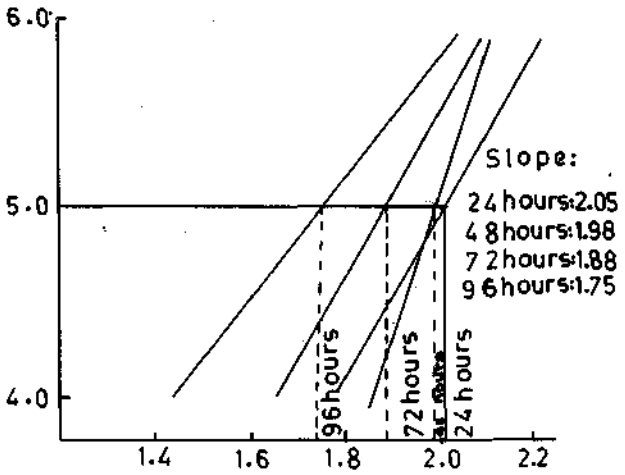

FIG. 4. The effect of sea-cucumber toxin in mature male of *Caridina rajadhari*.

Thus the above results indicate that mature prawns were the most susceptible as compared to other groups. The juveniles are more tolerant among the test animals.

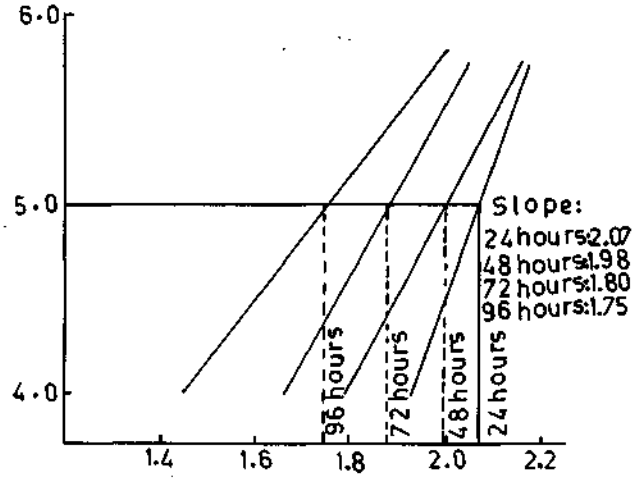

FIG. 5. The effect of sea-cucumber toxin in mature female of *Caridina rajadhari*.

DISCUSSION

Mortality of test organism is a more sensitive measure of toxicant. The physiological responses are dose dependent, the evaluation of LC_{50} concentration of sea-cucumber toxin is an

important step before carrying further studies on physiological changes in the animals. Unless and until the lethal and sublethal concentrations of SCT are known, it becomes difficult to choose the concentration, which may be effective at physiological levels and enable to study the physiological responses of the prawn to SCT. The bioassay tests in the present study have been carried out under static laboratory condition. The laboratory bioassays provides quickest and the most reliable information about the toxicity of SCT in respect of several life history stages of prawn *Caridina rajadhari*. The effect of toxin depend upon their concentration in specific target organs and tissues of the prawn. The study of the toxicity to various developmental stages exposed to SCT indicated that LC_{50} values decreased as the time of exposure increased and also the percent survival rate of the prawns decreased with the increasing concentrations. There was not much difference between 24 to 96 hours LC_{50} which indicates culmination of the acute mortality with first 96 hours. The comparative tolerance in the various developmental stages of prawn *C. rajadhari* to SCT reveals that juveniles show more tolerance among all the five groups. They were followed by juveniles, immature male, immature female, mature male and mature females. Mature females are more sensitive.

The present investigation on *C. rajadhari* indicates that juveniles are most tolerant than the adult animals. It was observed that the smaller animals show higher metabolic rate than that of larger animals. Thus due to the rapid metabolism SCT may be metabolized and excreted in larger amount and as such the SCT residues are lesser in the body of smaller prawn. In mature prawns most of the energy is utilized for reproductive purpose and comparatively less for metabolic rates (Prosser, 1973). It was also observed that like-size dependence there is a sex dependent tolerance phenomenon of SCT in *C. rajadhari*. Males are more tolerant than the females in both immature and mature groups. It may be concluded that SCT is not metabolized in mature prawns as rapidly as in the immature and juveniles and is accumulated in large amounts in the body. This may be the causative factor for the greater sensitivity of mature or larger prawns than that of immature or smaller prawns. The data in the present investigation is insufficient for a comparison, because adequate information on toxicity is not available. However the results show that the sea-cucumber toxin is poisonous to the prawn *C. rajadhari*.

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2.6

REPRODUCTION IN *HOLOTHURIA (MERTENSIOTHURIA) LEUCOSPILOTA* (BRANDT) FROM ANJUNA, GOA

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ABSTRACT

Holothuria (Mertensiothuria) leucospilota spawns more than once in a year *i.e.* during the postmonsoon (October to January) and in monsoon periods (June to September). An increase in the gonad index is observed during September and December 1985 and again during April and May 1986. The macroscopic and microscopic features of gonads have been described. The tubules are found to be longer and narrower in males when compared to the females. The ripe oocytes measured upto 220 μ. The spawning of *Holothuria (Mertensiothuria) leucospilota* appeared to be influenced by low temperature and salinity. The relationships between the gonad index, temperature and salinity are not significant during the study period.

INTRODUCTION

Sexes are separate and there is no sexual dimorphism. The gonad usually consists of numerous tubules united into a single tuft attached to the left side of the dorsal mesentery. Except for the dorsal attachment the gonad hangs freely in the coelom (Hyman, 1955).

Spawning of holothurians indicates that each species breeds during one or more months at a definite time during a year. Usually, it is during spring and summmer in temperate latitudes (Selenka, 1876; Clark, 1889; Ludwig, 1898; Clark, 1899, 1910 a; Remiers, 1912; Ohshima, 1918; Runstroms, 1921; Courtney, 1927; Mortensen 1937, 1938). Nyholm (1951) and Edwin (1948) have suggested that the holothurians usually spawn in the late afternoon or in the evening or at night, a response to dimlight. Temperature also plays a significant role in influencing spawning. The general tendency in holothurians from temperate waters is to spawn during summer and during spring and it was related to an increase in temperatures (Hyman, 1955).

The present knowledge on reproduction and breeding of tropical echinoderms is scanty. Though holothurians display diverse reproductive habits (Hyman, 1955; Krishnaswamy and Krishnan, 1967; Bakus, 1973; Emson and Wilike, 1980), much needs to be done on reproductive pattern. Important contribution on the reproductive seasonality of tropical holothurians have also been made (Krishnaswamy and Krishnan, 1967; Conand, 1981; Harriott, 1985). Spawning was confirmed by data on the histological status of the gonads (Harriott, 1985).

During the present investigation the reproductive cycles of *Holothuria leucospilota* (Brandt) have been studied. An attempt was made to see if any correlation existed between the reproductive cycle, and the temperature and salinity.

MATERIAL AND METHODS

The animals were collected from the intertidal area at Anjuna. Every month 35 to 40 animals were collected from August 1985 to October, 1986. The gonads were preserved in buffered formalin (AR) (7% dilution). The method used for classifying sexual stages in fishes (Conand, 1975) was employed in the present study. This method was earlier followed

for some holothurians like *Thelenota ananas*, *Microthele nobilis*, *Microthele fuscogilva* (Conand, 1981), *Holothuria atra*, *Holothuria edulis* and *Holothuria impatiens* (Harriott, 1985). The method employs the macroscopic characteristics, gonad form, colour and consistency and the microscopic features of the preserved gonad in formalin. A part of the gonad was spread on a slide and examined for sex. For females, the oocyte diameters were measured by using an ocular micrometer and their frequency was noted.

Gonads and sexual stages

In *Holothuria leucospilota* the ovaries and testes are composed of one tuft of tubules (Pl. I A, B). In the females the gonadial tubules are shorter and wider, whereas in males they are longer and narrower. The Stage I and II corresponded to individuals with undetermined sex, with tubules 1 to 5 cm long and 0.5 mm to 0.8 mm in diameter. Stage III corresponded to the growing stage. In Males, the tubules 10 to 15 cm long and 1 mm in diameter were considered under this stage. Female tubules 5 to 12 cm long and 1 mm to 1.5 mm in diameter also represented this stage. Stage IV represented a stage when the male gonadial tubules were 15 to 25 cm long and with 2 to 5 mm diameter. In the same stage, the female gonadial tubule was 10 to 15 cm long and 12 mm in diameter. In Stage V, male gonadial tubules ranged from 15 to 18 cm in length and from 1 to 1.5 mm in diameter; the female tubules ranged from 8 to 12 cm and from 6 to 9 mm respectively.

The microscopic features in *Holothuria leucospilota* revealed that Stage I and II comprised the undetermined stage. The germinal cells were not distinguishable. The germinal cells had a diameter of 50 μm. In Stage III, the oocytes had diameters ranging from 140 to 159 μm (Pl. I C, D). Numerous spermatozoa were present in males. In females, dark brown coloured spherical oocytes with diameters of 150 to 220 μm were observed in the mature stage (Stage IV) (Pl. II A). Yellowish cells of a few spermatozoa in males and in females, a few oocytes of dark brown colour (diameter 120 to 200 μm) were present in post spawning stage V (Pl. II B, C).

The gonad index (GI) is expressed as the ratio of wet gonad weight to the total drained wet animal weight (Geise, 1959). The mean value of gonad index was calculated separately for the males and the females. Temperature and salinity of the sea water, from where animals were collected were recorded. Correlations, if any, between the gonad index, and temperature and salinity were examined based on regression and correlation analysis.

RESULTS

Male gonad index showed in increase during September (0.25), November (0.17) and December 1985 (0.29). There was a decline in the gonad index during October 1985 (0.10), January (0.05), February (0.03) and March 1986 (0.06). The gonad index in males increased again during June (0.13), July (0.16) and August 1986 (0.19).

The female gonad index values showed an increase in September (0.32), December (0.38) 1985 and April (0.26) 1986. During October (0.16), November 1985 (0.1) and January 1986 (0.11), a decrease in the gonad index was recorded. The variations in the gonad index values are high in Septmber 1985 (0.435), December 1985 (0.475) and May to July 1986 (0.16, 0.14 and 0.14 respectively). This indicated the high variations in the gonad state of the holothurian maturity. The decline in the gonad index from February to May 1986 (0.25 to 0.16) suggested that the animals might have attained the spent or the resting phase.

The monthly percentage of male, female and animals with undetermined sex were obtained by microscopic observations of gonads. The undetermined individuals sampled during January, February and March 1986. Males and females of *Holothuria leucospilota* represented 35.9% and 43.5% respectively. Maturing individuals were found (Stage III) only during August and September 1985 and 1986. They were in large numbers during September 1985. Maturing individuals were found again during April and May 1986. The spawning (Stage IV) period was during October, November 1985 and January 1986 with a maximum in June, July and August 1986. Post-spawning individuals

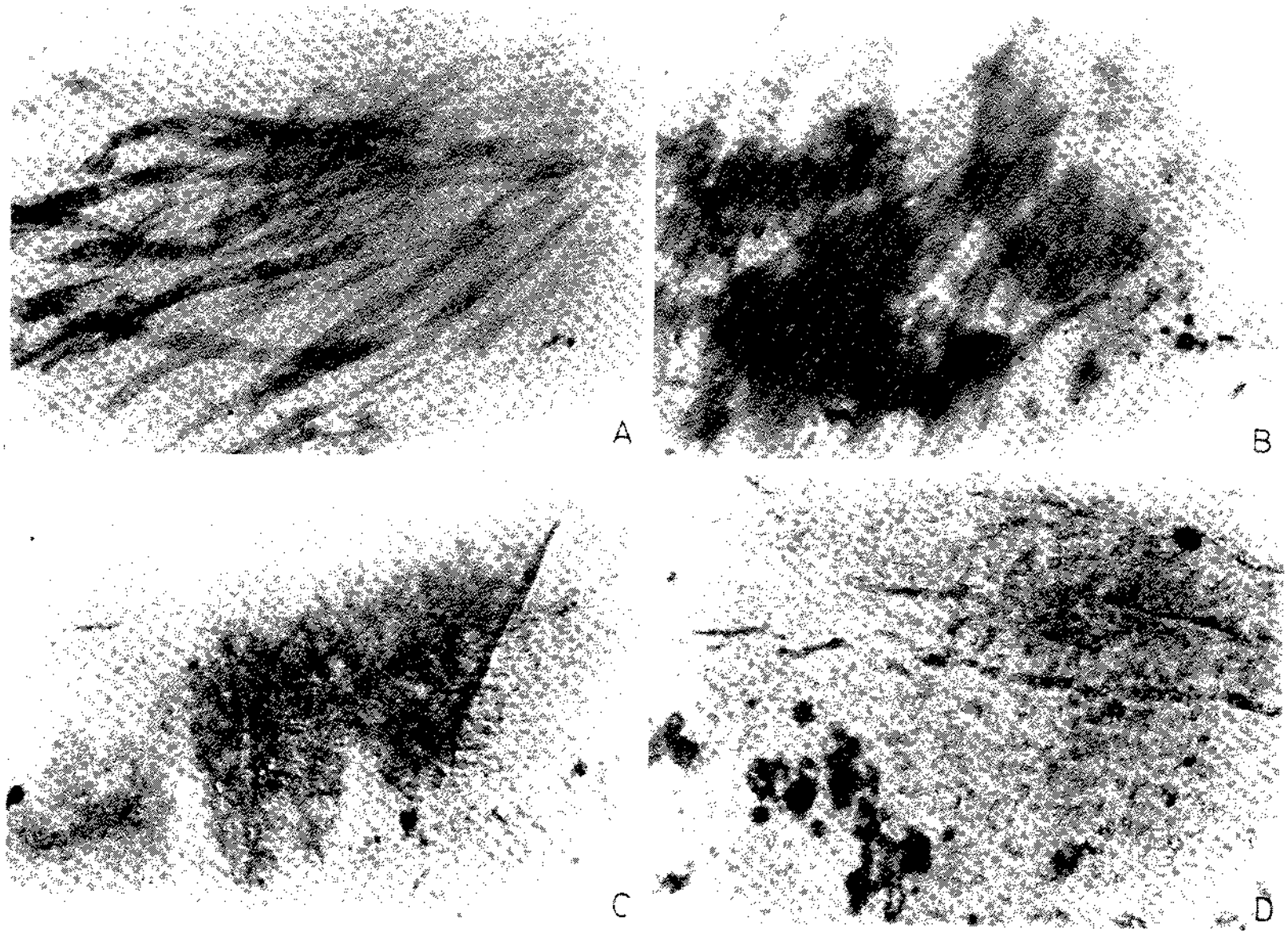

Plate I A and B. Gonadial tubules, and C and D. Germinal cells of *Holothuria (Mertensiothuria) leucospilota*.

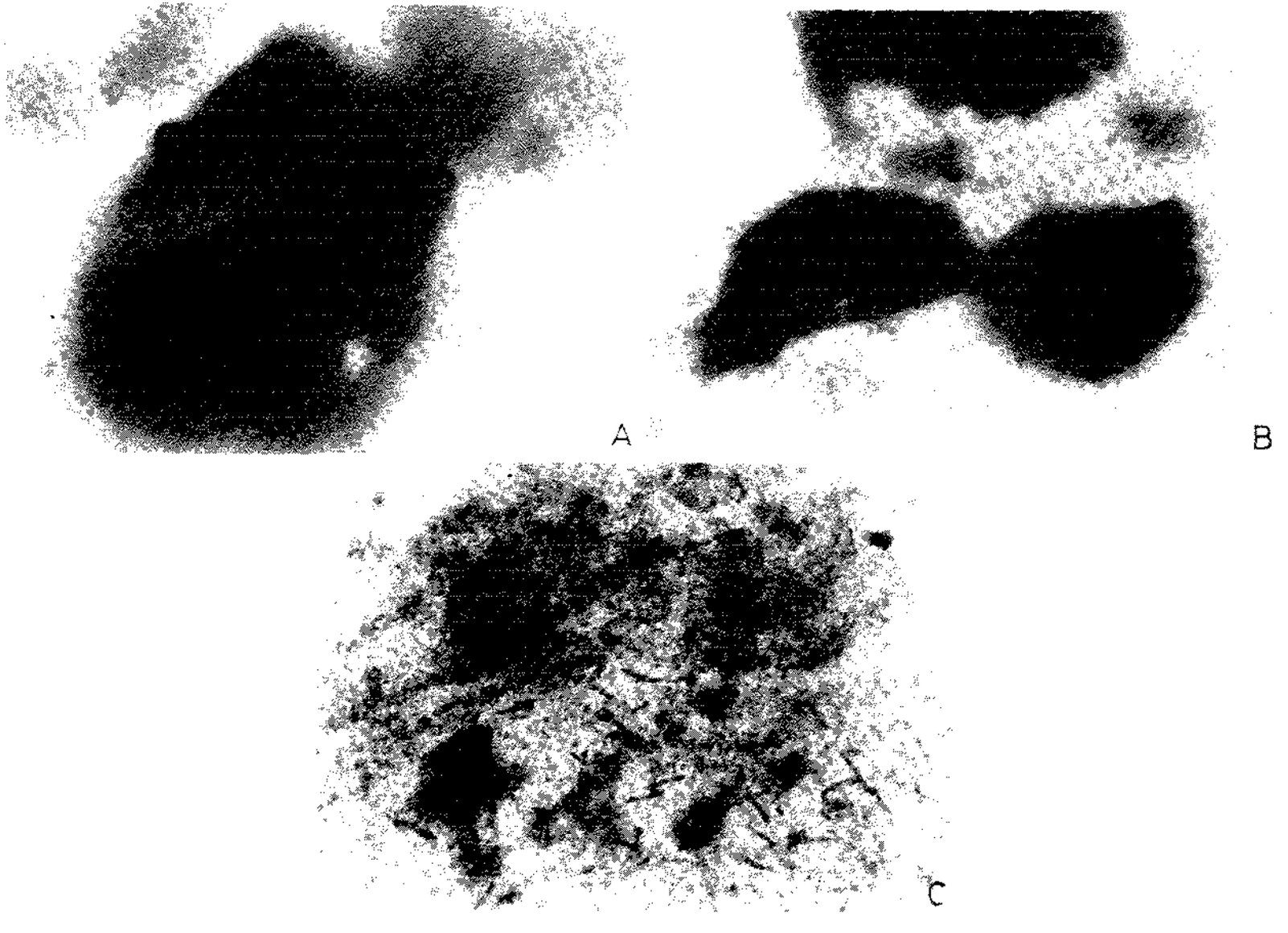

Plate II A - C. Mature oocytes of *Holothuria (Mertensiothuria) leucospilota*.

(Stage V) were found during January (40%) to March 1986 (25%).

During the study period, August 1985 to October 1986, water temperature ranged between 24.0° C and 31.5° C. The maximum temperature was recorded in March 1986 (31.5° C). The minimum temperatures were during August 1985 (24.0° C), July and August 1986 (26.0° and 25.0° C) respectively. The salinity values ranged from 35.1‰ - 23.6‰. The maximum salinity was recorded during October 1985 (35.0‰) and March to May 1986 (34.0 to 35.1‰). The minimum salinity was recorded during February (28.6‰), July 1986 (23.6‰) and November 1985 (29.23‰).

No relation was noticed between temperature and gonad index. The decrease or increase in gonad index did not correspond much with the increase or decrease of temperature. The coefficient of regression was - 0.22. Though not significant a positive relationship was noted between salinity and gonad index. The coefficient of regression ws 0.34.

When the sexual cycles were compared with temperature and salinity, maturation was observed to begin during August to september 1985. Spawning occurred in October to November 1985, followed by post-spawning in December 1985 to January 1986. Resting period occurred in February to March 1986. The reproductive cycle of *Holothuria leucospilota* was correlated with the gonad index variations, the cycle of different maturity stages and with the percentage of undetermined individuals. The period of Stage IV was dissociated into maturity (August 1985 and September 1986), pre-spawning (maximum peak of gonad index) and spawning (October and November 1985; beginning of the decline of the gonad index). The period of Stage V was divided into post-spawning (December 1985 to January 1986) or spent (during the decline of the gonad index) and resting (February to May 1986) corresponding to the maximum percentage of undetermined individuals. During spawning (October - November 1985) the temperature and salinity were 29.5° C, 29.0° C and 35.0‰, 29.23‰, respectively. In post-spawning (December 1985 - January 1986) the temperature and salinity were 28.0° C, 28.5° C and 34.0‰, 33.1‰ and during prespawning period (February to May 1986) the temperature and salinity were 29.5° C to 31.5° C and 28.6 to 35.0‰ respectively. The temperature and salinity during July and August 1986 (26.0° C and 23.6° C, 32.5‰) corresponded to the spawning period of *Holothuria leucospilota*. The variations in temperature (29.0° C to 29.5° C) during spawning period were very small, whereas the variations in salinity (29.23 to 35.0‰) were significant.

Discussion

Krishnaswamy and Krishnan (1967) have shown that *Holothuria scabra* spawned once during July and again during October. Green (1978) had reported bimodal breeding in *Leptosynapta tenuis*. He assumed that gametogenic growth reached a peak within a month either during summer of the fall. Conand (1981) had reported the sexual cycles in *Thelenota ananas*, *Microthele nobilis* and *Microthele fuscogilva*. The ripe oocytes in *Thelenota ananas* measured 200 μm. The ripe oocytes in *Microthele nobilis* measured from 140 to 160 μm and the ripe oocytes of *Microthele fuscogilva* measured 170 μm. In *Thelenota ananas* and *Microthele fuscogilva*, the annual reproductive cycle was represented only by a single spawning period during the warmer season. *Microthele nobilis* reproduced only during the cold season.

In the case of *Holothuria leucospilota*, there was an increase in the gonad index during September (0.40) and December 1985 (0.475). It decreased during January (0.035), February (0.025) and March 1986 (0.035). The gonad index exhibited increase again during April (0.125) and May (0.16). During the monsoon months a slight decrease (0.14 to 0.13) was observed. The macroscopic and microscopic features of the gonads could be correlated with those of the gonad index. The ripe oocytes measured upto 200 μm during August, September, October 1985, May, June, July and in August 1986. When spawning occurred during October and November 1985, (*i.e.* in Stage IV) the gonad index was low. Again during June, July and in August 1986, a decline in the gonad index was noticed. The Stage V (post-spawning period) corresponded to the resting or spent individuals

in January, February and March 1986 which indicates that the *Holothuria leucospilota* spawned more than once a year during the monsoon and post-monsoon season.

The principal environmental factor that induces breeding of animals in temperate forms is generally considered to be the increase or decrease in temperature. This is well established in echinoderms and for other invertebrates (Stott, 1931; Giese *et al.*, 1959; Pearse, 1985; Sastry, 1966). As far as the tropical animals are concerned, it is generally believed that breeding is continuous (Giese *et al.*, 1964; Krishnaswamy and Krishnan, 1967). In *Stomopneustes variolaris*, *Oreaster hedemanni*, *Penaeus indicus* (Subrahmanyam, 1963; Durve, 1964; Giese *et al.*, 1964; Rehman, 1965; Rao, 1965), a well marked breeding season was reported. For holothurians, factors responsible for spawning have not clearly been said so far. Salinity (Krishnaswamy and Krishnan, 1967) and temperature (Tanaka, 1958) were considered responsible. Green (1978) reported that the reproductive cycle of *Leptosynapta tenuis* was regulated by temperature and salinity. The mid-summer spawning was correlated with the high temperatures (Rutherford, 1973). Mc Crary (1989) had suggested that the high temperature influenced spawning in the planktonic larvae of *Leptosynapta tenuis* (Ayres). Correlation was established between temperature and the reproducctive phenomenon in *Arbacia punctulata* and *Paracentrotus lividus* (Moore, 1966). The optimum temperature requirements for reproduction were considered for some tropical species (Yonge, 1940; Pearse, 1968). *Strechinus neumayeri* (Pearse and Giese, 1966), *Odontaster validus* (Pearse, 1965, 1966) and *Stylocidaris affinis* (Holland, 1967) have shown marked reproductive periodicities even though there is very little or no seasonal fluctuation in sea water temperature. Similar examples of little or no direct relation between fluctuations of the sea water temperature and reproduction can be found for other groups of marine animals (Galtsoff, 1961). In *Holothuria leucospilota*, the higher values of gonad index during September (0.435) and December 1985 (0.475) and during May to July 1986 (0.16, 0.14 and 0.14 respectively) suggest that spawning had taken place during these months. The temperatures recorded during above months were 25.0, 28.0, 29.5, 29.5 and 26.0° C respectively. This may imply that the low temperature influenced spawning. The maximum temperature was recorded during March 1966 (31.5° C); the gonad index recorded in that month was 0.03. It was also noted that the variations in temperature during August 1985 to October 1986 did not correspond much with the variations in gonad index during that period.

Orton (1920) stressed upon the influence of temperature over the breeding in temperate marine invertebrates, but the never discounted the role of salinity. The Ceylon Pearl Oyster, *Margaritifera vulgaris* was found to spawn twice in a year. The spawning season coincided with the southwest and northeast monsoons. Based on this, Mal'pas (1933) concluded that the oysters are induced to spawn with the changes in salinity. Similar trend was also reported for *Crassostrea madrasensis* by Hornel (1910). Stephenson (1934) found that the vast majority of species in the Great Barrier Reef spawned during the summer months and when the rainfall was maximum. Panikkar and Aiyar (1939) had suggested that the lowering of salinity, consequent upon the onset of the north-east monsoon, influenced the breeding of animals off the Madras Coast.

Salinity was considered to be the inducing factor for breeding in the tropical regions (Giese *et al.*, 1964; Durve, 1964). Giese *et al.* (1964) have suggested that decrease in salinity may induce breeding in *Stomopneustes variolaris*. Durve (1964) while working on *Meretrix casta* reported that neither an increase nor a decrease, but an optimum salinity is responsible for te breeding. It was presumed that in *Holothuria scabra* (Krishnaswamy and Krishnan, 1967) the salinity was responsible for initiating breeding. Other factors such as increase in the concentration of quantity of food during spawning periods are also to be considered (Jayaraman, 1954).

The ara of present investigation recorded the rainfall of about 3400 mm during the south-west monsoon of 1985. The rainfall recorded during the southwest monsoon in 1986 was 2650 mm. This was reflected in the low salinity values recorded (23.6 to 34.5‰). During October and

November, the heavy fresh water runoff from the land was reflected in the reduced salinities (Sankaranarayanan *et al.*, 1978). During October and November 1985, the salinity recorded was 35.0 and 29.23‰. Thus it may be possible that the low salinity of sea water had influenced the spawning in *Holothuria lucospilota* at Anjuna.

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3. CULTURE OF HOLOTHURIANS : HATCHERY AND PRODUCTION TECHNIQUES

A REVIEW OF THE HATCHERY AND CULTURE PRACTICES IN JAPAN AND CHINA WITH SPECIAL REERENCE TO POSSIBILITIES OF CULTURING HOLOTHURIANS IN INDIA

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ABSTRACT

Pioneering work on the hatchery and culture of holothurians is done by the Japanese. In recent years some work has been done in China. Both in Japan and China work is conducted on *Stichopus japonicus*. It is significant to note that both the countries do not import *beche-de-mer* due to their culture practices. In China transplantation of holothurians is done from north to south to enable them to spawn due to higher temperature. At present in Japan sea-ranching is restored on a large scale. In India *Holothuria (Metriatyla) scabra* has been successfully induced to spawn in the laboratory and there is a good possibility to culture the juveniles in farms.

INTRODUCTION

Culture of holothurians is the monopoly of the Japanese and Chinese. They took up the work on these lines in order to augment the natural populations as food for them. The work on these lines is so well developed and remarkable succes has been achieved. This is reflected by the harvest of good quantities and these two countries do not import any *beche-de-mer* and they are able to meet their requirements through culture. India can follow these countries in culture of sea-cucumbers, so that the *beche-de-mer* industry which is now facing crisis can once again be well organised.

REVIEW OF WORK

Japan

Pioneering work on the hatchery and culture of holoturians is done by the Japanese. As early as 1937, Inaba has attempted artificial fertilization in *Apostichopus japonicus*. Imai *et al.* (1950) reported the artificial rearing of *Apostichopus japonicus*. The survival rate of Auricularia larvae was found to be 5 to 25%. The mortality in Doliolaria, Pentactula and young stages is found to be very low. The young ones grows to 3 to 4 mm in length in two months. Densely covered eel grass was found to be a favourable nursery ground for the natural propagation of sea-cucumber. Ishida (1979) studied the production of juvenile sea-cucumbers and noted that the thermal stimulation gave good results to induce spawning. Larvae were fed on *Monochrysis* or *Phytocerus*. For mass production in one tonne tank, 5 lakh thousand sea-cucumbers were produced. Dried green algae were used to feed the juvenile sea-cucumbers. The juvenile sea-cucumbers changed their colour and shape according to feeding condition. Yanagibashi *et al.* (1984) studied the rearing procedures for the newly settled young ones of the sea-cucumber *Apostihopus japonicus* with special reference to supply food itms. It was found that the settlement of pelagic larvae is influenced by the presence of their foods, epibenthic diatoms. Those fed on frozen epibenthic diatoms grow two times faster than

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those fed on epibenthic diatoms which adhere to the plates. When they attain 1 g weight two species of *Sargassum* were dried and given. The young ones attained 1 g weight in 6 months time after fertilization.

China

As expected the Chinese have done considerable amount of research on the hatchery and culture of sea-cucumbers, because of their need. Again all the work is done on *Apostichopus japonicus*. Most of the work in China is of recent origin. In fact the earliest work in China is by Chang *et al.* (1957) who gave preliminary report on the artificial rearing and propagation of *Apostichopus japonicus*. During 1972-73 *Apostichopus japonicus* was induced to spawn by thermal stimulation. As a result of this experiment 1.7 lakhs of juveniles were produced. The juveniles were reared in concrete ponds and fed with dried powder of various algae like *Enteromorpha*, *Sargassum* and *Rhodomela*. Green mud scraped from the surface of rocks which is rich in diatoms and organic debris was also given. Sexual maturity reached within two years. A two year sea-cucumber could reach a length of 230 mm and a weight of 248 g. Shuxu and Gongchao (1981) conducted experiments on the southward transplantation and artificial breeding of *Apostichopus japonicus*. The natural habitat of the sea-cucumber *Apostichopus japonicus* is in the northern China Sea. Experiments were carried out to transplant them to southern China for the purpose of culture and artificial breeding. They were able to live in indoor concrete tanks. Both adults and juveniles developed very well at temperature 27° to 29° C in summer. After 4 months the adults attained sexual maturity and they spawne twice in April. The fertilized eggs hatched and developed into more than 20,000 juvenile. A part of them were reared in indoor tanks. By August, juveniles reached a lengh of about 20 mm. Food of the larvae mainly consisted of *Dicrateria shaniangensis*, *Platymonos*, *Nitzschia*, *Bunalcilla* and *Torulopsis* among the *Dicrateria* is the most favourable one. Shui *et al.* (1984) studied the artificial culturing of sea-cucumber seeds and the effect of artifically prepared feed for sea-cucumber larvae. The juvenile sea-cucumbers were fed with powder prepared from *Sargassum thunvergii*. The same authors studied the artificial ripening of *Apostichopus japonicus*. Shui *et al.* (1986) studied the technology for rearing of postlarvae and juveniles of sea-cucumbers in high density tanks.

It is of interest to note that in reent years Russians have also evinced keen interest in the artificial rearing of *Apostichopus japonicus* in Far Eastern Seas. Mokretsova (1973), Levin (1984) and Savvatea (1987) have published papers on artificial rearing and culture of sea-cucumbers from Far Eastern Seas.

Culture Possibilities in India

In India no culture work has been attempted though Nicholson made a mention about sea-cucumber farming in olden days (Anonymous 1917). The author conducted some culture experiments at Port Blair in 1978 on *Holothuria* (*Metriatyla*) *scabra*. About 500 juveniles of this species from 65 to 160 mm in length were stocked in an enclosed area of 1500 sq. m. In seven months time the sea-cucumbers juveniles were found to grow 190 to 290 mm in length. A project was taken up by the Central Marine Fisheries Research Institute in 1987 on the hatchery development of *Holothuria* (*Metriatyla*) *scabra* to augment the dwindling stocks in the natural beds due to over exploitation. Success was achieved in early 1988 by inducing *Holothuria* (*Metriatyla*) *scabra* to spawn in the laboratory for the first time. This breakthrough was achieved for the first time in the country. Specimens were induced to spawn by thermal stimulation by raising the water to 5° C. As a result of this three males and one female spawned in the laboratory. One female liberated nearly one million eggs. The eggs were round and varied from 180 to 200 μ in diameter. It transformed into first Dipleurula and later transformed into Auricularia larvae after 24 hours. The Auricularia larvae were fed on *Isochrisis galbana* and mixed culture dominated by *Chaetoceros* and *Skeletonema*. Some of the Auricularia larvae were transformed into Doliolaria stage on the tenth day. On the thirteenth day some of the Doliolaria transformed into Pentactula stage. At this stage they settled down to the bottom and feed like adults.

Nearly after an year some of them have reached a lengh of 8 mm. In view of the poor growth in the laboratory it is desirable to sea-ranch them in large numbers on natural beds to replenish the stoks as it is now done in China and Japan. India should go in for intensive seed production and large scale sea-ranching programme so that the effect of these studies can be felt in the natural beds. Much more works remain to be done in India on these lines.

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3.2

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

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ABSTRACT

Holothuria (Metriatyla) scabra 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 micro-algae. Details of various stages of larvae are given. The feeding and rearing of juveniles also are presented in this paper.

INTRODUCTION

Export of *beche-de-mer* has earned very good foreign exchange to India and the industry was flourishing very much for sometime. Due to increasing demad for the raw materials, the sea-cucumbers were exploited indiscriminately including undersized animals resulting overexploitation and depletion of stock. It was felt very essential to take measures to preserve the holothurian resources from overexploitation, particularly the smaller size and conserve the resources for judicious exploitation. Hence Government of India imposed ban in 1982 on the export of processed holothurians less than 8 cm in size as a measure of conservation. As a result, the *beche-de-mer* industry is now facing a setback in the country. In view of this, the Central Marine Fisheries Research Institute, initiated a programme on the artificial spawning and production of young Holothurians for culture and propagation at the Institute's Molluscan Hatchery Unit, Tuticorin. The achievement in the experiment is significant which would eventually solve problem presently faced by the *beche-de-mer* industry of India.

The results of the laboratory experiments on artificial spawning and rearing of larvae, and juveniles are enumerated in the present paper.

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MATERIALS AND METHODS

Sea-cucumbers *Holothuria scabra* form a seasonal fishery in Tuticorin. They are collected off Tuticorin in the vicinities of Kaswar and Karaichalli Islands by skin diving. The fishery starts from the late September extends till April. During this period of the year, the water clarity remains to be ideal for gathering the sea-cucumbers from the seabed at depths ranging from 6 - 10 m. Based on the availability of adult *H. scabra* from the commercial landings, experiments on the artificial spawning and production of young Holothurians were carried out.

H. scabra of the size ranging from 250 - 350 mm in length were collected and maintained in the laboratory was broodstock. A total of 50 *H. scabra* have been maintained under healthy conditions in the laboratory for a period of 10 months. The Holothurians were placed on a layer of mud and sand with a thickness of 10 cm in 2 x 1 x 0.5 m fibre-glass tanks. The layer of mud and sand is changed once in a week and the water in the tank is well aerated.

OBSERVATIONS AND RESULTS

Induced spawning

Various methods employed to induce spawning in *H. scabra* have been attempted. Neural extract of the starfish *Pentagaster regulus* were obtained, centrifuged and the extracts was injected into holothurians at different concentrations. This did not induce the Holothurians to spawn. Chemical stimuli such as injecting isotonic potassium chloride into the body of holothurian and treatment of holothurians in water medium containing various levels of concentrations of Cystine did not provide any results. Holothurians placed in different salinity media, above and below ambient levels (35‰) for a period of 3-6 hours did not induce them to spawn.

Successful induction of spawning was achieved by subjecting the holothurians to thermal shock. Twenty numbers of holothurians measuring 300-350 mm and weighing 500 - 600 gms were conditioned for 2 days in water temperature of 25° C which is 2-5° C below the ambient temperature. Three fibre-glass tanks of 30 x 50 x 75 cm (100 l) were taken and filled with filtered seawater at temperature levels of 27° C (normal water temperature), 32° C and 37° C. In each tank, 5 numbers of holothurians were placed. The animals at water temperature of 32° C and 37° C exhibited vigorous movements than the ones in 27° C. In about 90 minutes, two males at 32° C started spawning and subsequently, one male at 37° C spawned. The spawning males were transferred to the normal seawater temperature conditions forthwith. These animals continued to spawn for 15 to 20 minutes. During spawning, the males fully extended the pharyngeal bulb with tentacles and waved back and forth releasing a thin string of spermatozoa from the gonophore. Further, the animals curved and twisted their body while spawning. The spermatozoa were very active and they get dispersed in the water evenly within minutes. On completion of spawning, the sperm suspension in the water was poured to a tank which contained ten numbers of holothurians at normal temperature conditions. Within 15 minutes of time, a single female spawned. The behaviour of the spawning female was similar to that of male, but the eggs were released in spurts which get dispersed in the water. The eggs were visible to naked eye and initially they remained on the surface and gradually sank to the bottom. All the animals in the tank were removed and the sex cells were held in the tank for one hour, to effect the fertilization process. Total eggs spawned by the single female was estimated to be one million.

Early development

The eggs measured 180 to 200 μ and the average diameter was 192 μ. The sequential stages of development of the fertilized eggs have been observed in the following pattern for the first three hours.

12.00 hrs	-	Fertilization
12.15	-	First cleavage
12.20	-	Four celled stage (Radial cleavage)
12.25	-	Eight celled stage
12.30	-	Sixteen celled stage
12.35	-	Thirty two celled stage
12.40	-	Early blastula
13.00	-	Blastula (partly developed)
15.00	-	Blastula fully developed (Pl. I A)

The egg of *H. scabra* has a jelly coating. After fertilization, the cleavage starts and the embryo further develops inside the embryo sac (jelly coating). The blastula stage occurs within an hour after fertilization. It soon develops cilia and begin to rotate inside the sac. The embryo hatches out after 26 hours of fertilization. The larvae assumes typical gastrula stage after 27 hours. The body becomes slightly elongated and moderately curved at the oral end of the larvae. At the end of 48 hours, the larvae assumed Dipleurula stage. The larvae floats and exhibits slight movements with the formation of a single band of cilia running along the sides of the larval body and loops over the pre-oral and aboral aspects of the larvae.

Auricularia stage (Pl. I B)

Dipleurula stage larvae transforms to early Auricularian stage just after 50 hours. The

total number of larvae at early Auricularian stage have been estimated to 0.9 million. The larvae become a transparent and more elongated. The ciliary band assumes more sinuous curves along the body of the larvae which increases the motility of the larvae. The interior of the larvae shows the appearance of a well defined digestive track comprising of foregut, midgut and a narrow hindgut, leading to the larval anus. The larvae start feeding from this stage onwards. The early auricularian stage larvae measures on an average 563 μ. The auricularia grow and on the 13th day, measure on an average 1.1 mm. At this stage, the auricularians metamorphose to Doliolarian larvae or the 'pupa' stage.

***Doliolaria stage* (Pl. I C)**

The larvae reach this stage on the 14th day. The size of the doliolarian larvae is much reduced, almost half the length of Auricularia, and assume the barrel-shape The sinuous ciliary band re-organised into five rings around the body similar to that of the muscular strand of the ascidian *Doliolum*. Rapid changes occur inside the body and all the adult features of the holothurian gradually set in. The larvae measure at this stage 460-620 μ. This stage is a short phase extends to 2-3 days and subsequently transform to a swimming and creeping stage known as Pentactula.

***Pentactula stage* (Pl. I D)**

The young sea-cucumbers with five primary tentacles and one or two podia are termed as Pentactula. The adult characters particularly tube-feet developed all over the body. The pentactula creep over the sides and bottom of the tanks. On th 22nd day, the colour of the pentactula become dark showing greenish-grey tinge. They actively move on the bottom and feed on the benthic algae and other detritus matter. The pentactula measured 600-700 μ and on the 28th day, they become the typical sea-cucumbers, measuring 1.5 to 2 mm.

Larval rearing

The auricularians are reared in one tonne fibre-glass tanks with filtered seawater under proper aeration. The larval density was maintained at 1 larva per 2 ml.

Initially a mixture of live micro-algal feed such as *Isochrysis galbana* (Haptophyceae), *Tetraselmis gracillis* and *Chlorella salina* (Chlorophyceae) were provided. Of these, the larvae preferred the flagellate *I. galbana*. Hence from the 4th day onward till it reaches the Doliolarian stage, pure culture of this flagellate has been provided as feed.

The larvae were fed with *I. galbana*, harvested during the growing phase in the mass culture system. Initially the larvae were provided with *I. galbana* at the rate of 10,000 cells/larva/day. The feeding rate gradually increased to 25,000 to 30,000 cells as the larvae approaches the pentactualar stage.

The filtered seawater in the larval rearing tanks are completely changed once in alternate days on receiving the larvae in filter-heads. On penultimate days, the water is partially changed through filter-heads. The water changes were always effected just before feeding.

Rearing of young holothurians

Young holothurians are reared in tanks on a layer of oven-dried silt and fine sand particles, collected from the intertidal area of Tuticorin Bay. Dried and powdered leafy alga *Ulva lactula* was dusted on the water which gradually settled at the bottom to form the food of the young holothurians. The bottom materials are changed and the operation is repeated once in 2 days.

Brood survival and the growth of young holothurians

A total of 32,559 young holothurians was produced during the rearing process. This worked out to be 3.6% of the initial larval strength. The young holothurians reared in the laboratory registered a growth of 10.28 mm (in total length), initially during end of first month and subsequently 7 mm per month.

Discussion

Mortensen (1937) made observations on the spawning and early larval development of

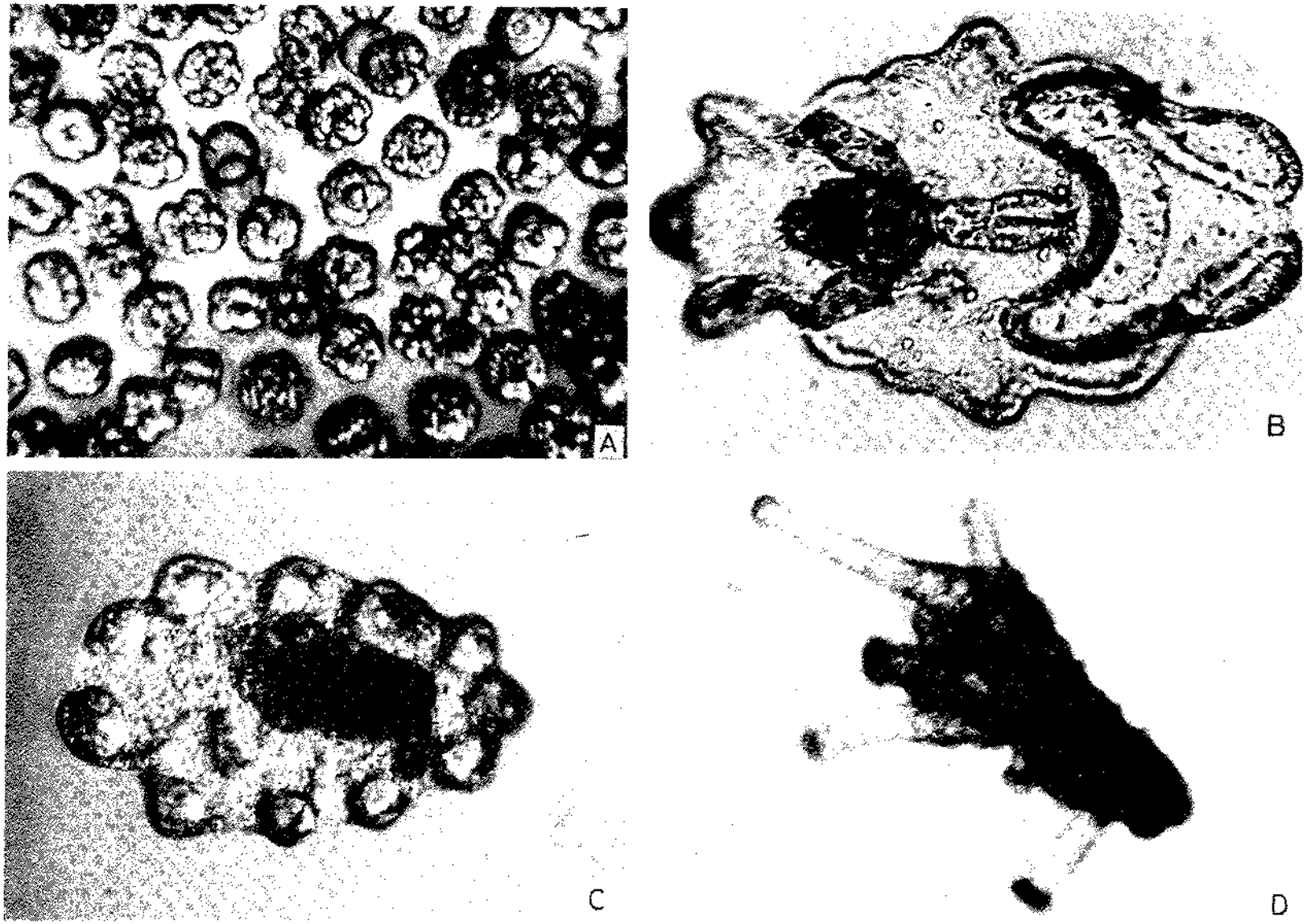

Plate I A. Fully developed blastula. B. Auricularia. C. Doliolaria and D. Pentactula.

H. scabra along the Egyptian Coast of the Red Sea. However, pioneering works have been done by the Chinese and Japanese in breeding and culture of holothurians, particularly on *Stichopus japonicus*. Recently, the Chinese have commercialised the hatchery production of sea-cucumbers and their farming. The present work on the artificial spawning and production of young *H. scabra* is the first attempt in India.

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4. PROCESSING, QUALITY CONTROL AND UTILIZATION OF *BECHE-DE-MER*

IMPROVED METHODS OF PROCESSING HOLOTHURIANS FOR *BECHE-DE-MER*

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ABSTRACT

The value of *beche-de-mer* depends on the quality and method of processing. The present day processing leaves much to be desired. At present holothurians in India are processed in the same manner. The hygenic conditions of processing holothurians are not satisfactory. Improved methods for processing of different species of holothurians are given in the paper.

INTRODUCTION

The value of *beche-de-mer* depends upon the quality. The quality depends on the method of processing. At present there are lot of defects during processing. All species of holothurians in India are now processed in the same manner. The processing in hygenic conditions are not upto the mark and fetch poor price when compared to the material from other countries. Hornell (1917) was the first person who gave several suggestions for the improvement of quality of *beche-de-mer*. Durairaj (1982) and Durairaj *et al.* (1984) evolved quality standards for *beche-de-mer*. Recently James (1986) suggested methods for quality improvement in *beche-de-mer*.

FACTORS CONTROLLING QUALITY

The quality of *beche-de-mer* mainly depends on the species used, size, shape, appearance, colour, odour and moisture content. Many of the above factors can be controlled during processing. Presently the processing is with the hands of unscrupulous profiters who not only process them under unhygenic conditions, but resort to adulteration of the product to make quick money.

The processing has been introduced by the Chinese nearly 2000 years ago and supervised under their watchful care. Slowly in order to make profits, processors restored to short-cut methods at the expense of quality.

Species

Only about ten species are of commercial value from India. Among them the teat-fish *Holothuria nobilis* ranks first, as it commands maximum price. Prickly red-fish *Thelenota ananas* ranks second, black-fish *Actinopyga miliaris* ranks third and the sand-fish *Holothuria scabra* which is the most common species for processing ranks fourth in quality.

Size

Size is the most important criterion to fix the quality and price. The first grade quality is above 12 cm when processed. Though small sized forms have some demand, they fetch very low price Longer, sturdier and stouter ones fetch higher prices than shorter, slender and flexible ones. The sea-cucumbers usually shrink to one third the size on processing.

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Appearance

Price is controlled mainly based on appearance. The appearance of a product should be neat and free from any dirt, sand and also from white chalky deposits. The presence of white chalky deposits is due to improper processing. Such material needs to be re-processed. Those which have tear markings, leisons on the skin fetch low prices. The cut made for degutting should be neat and straight.

Shape

The shape of *beche-de-mer* depends upon the species used. Neat, cylindrical forms are preferred. Some species like teat-fish and prickly-fish have characteristic projections in the end product also. These help in identifying the species of the product.

Colour

Traders prefer darker coloured products since the consumer believes darker ones are the true sea-cucumbers. Unscrupulous persons resort to colouring the material with bark of mangroves. This should be avoided and checked.

Odour

Clean and throughly dried product has no odour at all. Care should be taken to see that moisture content is around 8 to 10%. The product is hygroscopic and absorbs moisture and gives a foul and offensive smell. This can be avoided by thorough drying aand packing in polythene bags. *Beche-de-mer* should never come in contact with fresh water since it spoils the material.

IMPROVEMENT IN HANDLING

Handling the catch on board in a proper manner is foremost in improving the quality of the product, reducing the losses during processing and ensuing cleanliness and hygiene. As soon as sea-cucumbers are brought to the boat (Pl. I A) a slit of 2 to 3 cm is made through the cloaca and the animal is held out of the boat so that eviscerated material falls into the sea. This way the final product also remains neat and clean. The sea-cucumbers should never be kept in palm leaf baskets and net bags since the animals closer to the holes shape into them. It is best to keep the sea-cucumbers in a plastic fish box or trays having a smooth interior surface and drain holes of 1 cm diameter or less. If the holes are larger the animals that are closer to the holes shape into them and the holes get blocked. The box should be cleaned prior to placing of the animals as dirt and sand particles become embeded into the body wall. If coral bits and algal pieces are found attached to the body they should be removed and the animal is cleaned in sea water before placing them inside the box. Sand-fish can be placed one above the other and they flatten out while alive. In case of teat-fish a single layer is preferable. If stacked one above the other the outer skin of the body wall tends to break and after processing these appear as tear marks down grading the product. Prickly-fish needs special care as the tubercles get damanged if handled improprly. After capture the sea-cucumbers should never be exposed to sun as the top layer of the animal dries up and starts peeling off. The surface of the boat makes an imprint on the animals bringing down the quality of the final product. Nets should not be present on the deck of the boats since the animals easily get entangled. As far as possible the animals should be processed soon after they are brought to the shore. If they are kept overnight in fish boxes the animals become weak and this affects the quality of the product. If they are kept in pens leison due to higher temperature form on the outer skin of the body wall leading to breakage of the body wall and softening.

PRECAUTIONS DURING PROCESSING

During processing a number of precautions have to be taken to ensure a high quality product. The sea-cucumbers should not be kept in sea water and then boiled since heating causes both outside and inside water of the animal to boil. Pressure builds up inside and the body wall bursts. The correct method should be first the water should be boiled over high flame and the animals should be introduced one by one. This way the animals are quickly killed in a few seconds. The animal assumes cylindrical shape which is the most preferred one in the market. It is necessary to keep the products well stirred

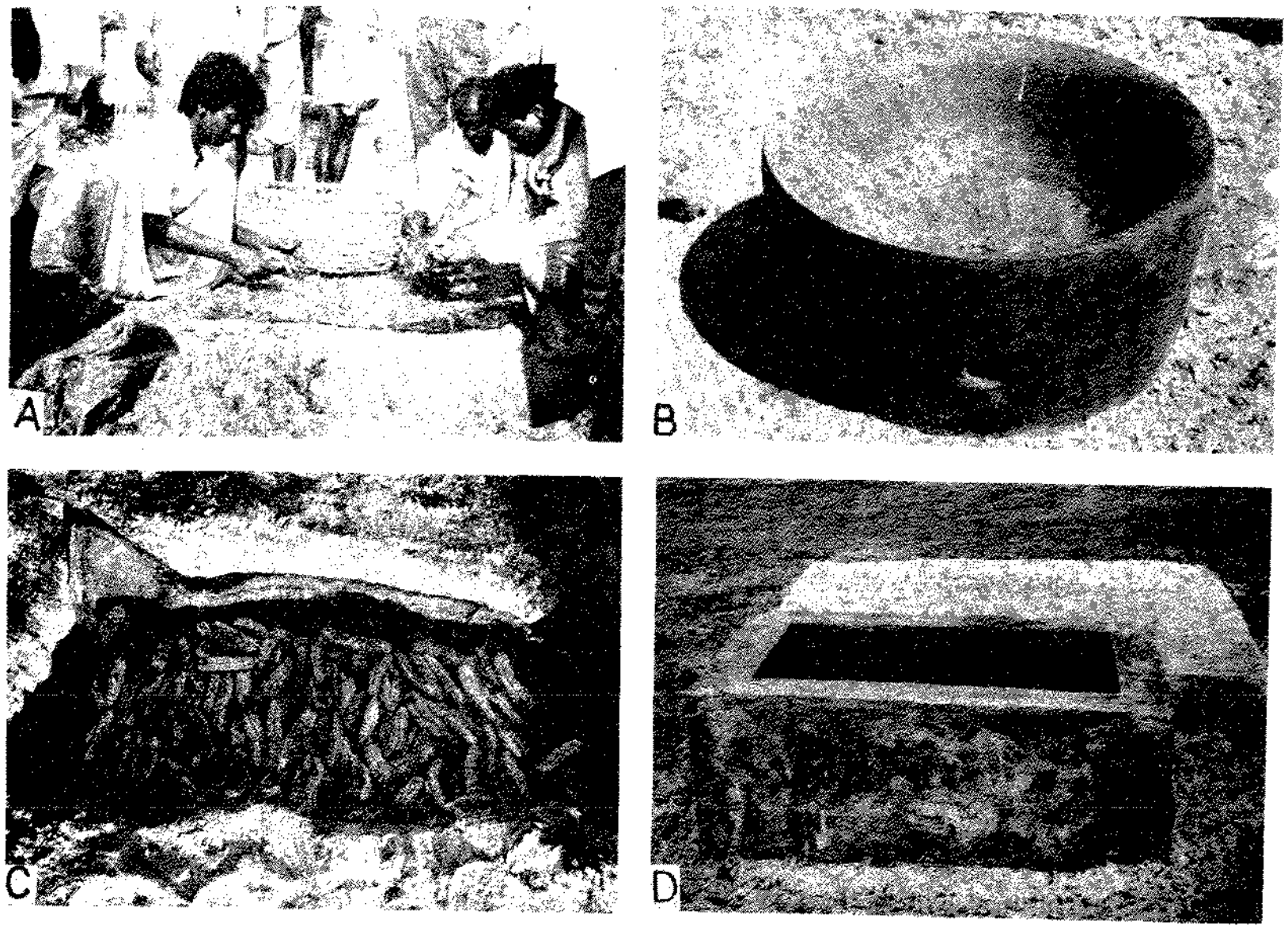

Plate I A. Degutting of holothurians, B. Saucer-shaped cast iron pan for boiling holothurians (back view, the hole seen serves as an outlet for smoke), C. Sea-cucumbers kept in a pit lined with gunny bag and D. Burying pit and drying platform constructed for demonstration purpose.

during boiling. The material should be well rolled during boiling. This makes the product perfectly cylindrical. The shape of the pan used for boiling also determines the quality. A saucer-shaped shallow pan (Pl. I B) made of cast iron is most suitable since it distributes heat uniformly to all animals. Aluminium vessel is also used for hygenic procesing. The most important factor in boiling is to keep intense heat. Slackness or relaxation is detrimental to the product. Eviscerated holothurians should not be added in bulk to the boiling water since it quickly brings down the temperature. They should be slided along the edges of the saucer-shaped pan one by one. Cleaning of the sea-cucumbers after boiling is necessary. Fine mud gets embeded in the outer body wall of the dorsal and lateral surfaces. These have to be removed to have an acceptable product for the market. The traditional method involves bacterial decomposition of the outer layer which scrubbed off to remove the outer mud embeded layer and the pigmented layer. Bacterial decomposition is activated by allowing the bacteria from the sand to odour the sea-cucumber. After boiling, the sea-cucumbers are cooled and kept inside pits lined with gunny bag (Pl. I C) on the beach and covered by sand. Bacteria multiply fast and eventually cover the entire surface of the body and they penetrate inside the body wall. It is just enough if the bacteria penetrate 2 mm or so. Therefore duration of time for keeping the sea-cucumbers inside the pits is an important factor. If kept for longer period the body wall may become too soft for further processing. If the material is not moist at the time of burying, bacterial action may be slow and decomposition inadequate. Proper care should be taken for selecting the site for burial. Most beaches near villages are polluted with faecal matter. Not all beaches are sandy and tidal waters move in and out at certain areas. Therefore clean sandy beaches with little human activity are the best sites. First boiling should be for 45 minutes, stirring should be continued at every 3 to 5 minutes interval. The material removed from the pan should first be allowed to cool on the sand. The pit for burying should be cleaned, sandy beach 100 cm long, 75 cm wide and 30 cm deep and as far as possible with even floor. The sea-cucumbers sould be arranged in single layer and they should be packed densely and covered with jute hessain sac after sprinkling water on the sac the pit is closed with sand and marked. After thorough cleaning those which still have white patches of calcareous deposits are once again boiled and the whole process is repeated. In recent times a de-scummer is designed by Sachithananthan *et al.* (1975) to remove the chalky deposits. About 100 sea-cucumbers can be cleaned in 5 minutes using a de-scummer with a chamber 1 m diameter and 0.45 m in height and the base plate rotating at a speed of 120 revolutions per minute motivated by a 3 H. P. Electric motor. The cleaned product is once again boiled for 45 minutes to kill all the remaining bacteria. The product is now put out for drying on drying platforms or trays in the sun. The product should never be dried on sand since sand particles stick to them and are difficult to remove later and this will bring down the quality of the product. They can also be dried on palmyra mats. The product should never be kept out when drizzling. During rainy season smoke driers can be used since the product is hygroscopic it should be put in the sun now and then to keep the moisture level low. However smoked product is not preferred. Around 8 to 10% moisture content seems to be the best level.

Packing and Forwarding

Packing and forwarding is an important aspect in quality control. The product has to be packed in cardboard box cartons lined by polythene. This will help in extending shelf-life and also it is easy to stock them. This way handling during transport is easy and shipping lines also accept them as hold cargo. If they are packed with jute-hessain sacs lined internally with palm leaves the shipping lines will accept only as deck cargo. The product will absorb moisture and will be spoiled. The shipping lines do not prefer to keep this cargo inside and this is a limiting factor. The internal lining of palm leaf oven mat protects the product when carried in open deck and covered by canvas from sea spray, rain spray, etc. This is not a desirable way of packing. If *beche-de-mer* could be sealed inside the polythene bag after a good day of drying, the chances of moisture absorption is reduced. To prevent tear in the bag it could be kept inside an appropriate box carton. Storage life of the product could be extended this way.

MALPRACTICES TO BE CHECKED

Malpractices have to be checked during processing at any cost. In order to increase the weight of the product, processors often resort to processing smaller forms with sand inside. Apart from getting a low grade product they are often rejected since they are full of sand inside. Processing smaller forms will deplete the stock since the animals do not have any chance to breed even once. In order to increase the weight of the product, the processors sometimes mix up sand-fish with lolly-fish *Holothuria atra*. Lolly-fish has toxin which fortunately breaks down during boiling. In order to make the product free from all white chalky material some persons add hydroxide during second boiling. Such products are dangerous to consume from the health point of view. Also many holes are found in the material to reduce the value of the product is lost. At times the processors resort to colouring the material by using the bark of mangroves since darker material commands higher price. This malpractice has to be checked.

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Bull. Cent. Mar. Fish. Res. Inst., 1994, **46** : 76 - 78

4.2

PROCESSING AND QUALITY REQUIREMENTS OF *BECHE-DE-MER*

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ABTRACT

This paper deals with processing, composition, common quality defects, export specifications, suggestions for improvement in the processing and finally precautions to be taken during processing.

INTRODUCTION

Beche-de-mer is the commercial name for cured holothurians, commonly known as sea-cucumbers. In India, the *beche-de-mer* industry depends almost on a single species *viz. Holothuria scabra* found in the Gulf of Mannar, Palk Bay, Andaman and Nicobar Islands, Lakshadweep and also in the Gulf of Kutch. The animal usually burrows in sandy or muddy bottom and feed on the nutritive material contained in it.

EXPORT OF BECHE-DE-MER

Beche-de-mer industry of India is exclusively an export-oriented industry. Bulk of the export from India goes to Singapore. The export of *beche-de-mer* in 1973 was only 29 tonnes valued at Rs. 2.48 lakhs. From 1974 onwards an increase in the export of this commodity was noticed. Maximum export (Quantity-wise) was noted in 1975 and the maximum earnings by way of foreign exchange was in 1986 (Anon., 1986). Table 1 shows yearwise export of *beche-de-mer* from India.

During recent years, the price of *beche-de-mer* has considerably increased from US $ 2.95 for 17 pc/kg in 1974 to US $ 16.00 in 1985 (James, 1986).

PROCESSING

Processing of *beche-de-mer* is simple and involves the following steps :

1. Thorough evisceration before boiling.
2. Boiling without the addition of water till the animals shrink to half of their length and emit a distinctive cooked odour.
3. Burial in damp sand for 12 to 18 hours.
4. Removal of the chalky external coat.
5. A second boiling in sea water for 20 minutes.
6. Full drying upon wire net trays raised above the ground or half-sun drying.

Size : Size is the most important criterion to fix the quality. The first grade quality is above 12 cm when processed. Longer and stouter ones fetch higher prices than shorter and leaner ones. Sea-cucumbers usually shrink to one third of their original size during processing.

Appearance : The appearance of the product should be neat and free from dirt and sand and also from white chalky deposits. Those which are having markings and leisons on the skin fetch low price.

Shape : This depends upon the species used. Neat and cylindirical forms are preferred.

Colour : If dark coloured products are matched against light coloured products, traders pick the former in preference to the latter as consumers believe that darker ones are the true sea-cucumbers.

Odour : Clean and thoroughly dried product has no odour at all. Care has to be taken to maintain

moisture content around 8 to 10%. The product is hygroscopic and absorbs moisture thereby emitting a foul and offensive smell. This can be avoided by thorough drying and packing in polythene bags.

The proximate composition of *beche-de-mer* is given below :

	Durairaj (1982)	Shenoy (1977)	Jacob (1973)
Moisture %	15	27	22
Crude protein %	65	43	35 - 82
Ash %	11	21	15 - 30
Fat %	1	2	Traces
Insoluble ash %	Below 0.5	7	-

COMMON QUALITY DEFECTS

Sandy *beche-de-mer* : The external sand sticking to *beche-de-mer* is below 0.5%. But, due to faulty processing, sand content goes upto 50 to 60%. Such specimens are called sandy *beche-de-mer*.

Imperfect removal of chalky external coat.

Careless and inadequate sun-drying.

Absorption of moisture during storage and action of fermentative micro-organisms.

The quantity of *beche-de-mer* inspected and rejected by the Export Inspection Agency (Madras) is given below (private communication).

Year	Quantity inspected Kg	Quantity rejected Kg
1986	51817	3046
1987	32213	1155

Reasons for the rejection are (i) Non-conformity with declaration, (ii) mixing of under-sized grades and (iii) excess of white pigment.

EXPORT SPECIFICATIONS FOR *BECHE-DE-MER*

Dried *beche-de-mer* is a notified fish item which comes under the purview of Export (Quality Control and Inspection) Act of 1963. However, as processing of *beche-de-mer* is even now carried out on a cottage industry level, a detailed inspection is not undertaken at the moment. The specifications prescribed by Export Inspection Agency are given below :

Size grades : 10 cm and above
7.5 cm to 10 cm
5 cm to 7.5 cm
Below 5 cm

Specifications

Size : Export of size grades below 3 inches is banned.

Colour : Dark brown to black on the dorsal side and pale white on the ventral side.

Odour : Characteristic odour of the species and shall be free from any off odour.

General characteristics : Dried *beche-de-mer* shall be prepared from the species *Holothuria scabra*. The material shall be properly dried and free from fungal, insect and mite infestation. It shall be free from visible contamination. The product shall have characteristic shape.

SUGGESTIONS FOR IMPROVEMENT

Handling the catch on board is foremost in improving the market value of the product. James (1986) has given certain suggestions to improve the quality of *beche-de-mer*.

Improvements in handling

a. As soon as the sea-cucumbers are taken onboard a slit of 2 to 3 cm is made near the cloaca and eviscerated properly. This enables the final product to remain neat and clean.

b. The sea-cucumbers shall not be kept over palm leaf woven baskets and net bags in order to avoid marks and impressions on the outer flesh. It is best to keep sea-cucumbers in a plastic fish box having a smooth interior surface and drain holes of 1 cm diameter or less.

c. After capture, the sea-cucumbers should not be exposed to sun since the top layer of the animal dries up and starts peeling off.

d. As far as possible, the animals shall be processed soon after they are brought to the shore. Delayed processing may result in the development of leisons on the outer skin of the body wall.

Precautions During Processing

A number of precautionns have to be taken during processing to ensure a high quality product (James, 1986).

1. If the animals are kept in sea water in boiling pans and heated, the animals first consume water and become swollen. It has the capacity to close its mouth and cloaca while being heated and effectively seal both the openings. Heating causes both the outside and inside water of the animal to boil. Pressure builds up inside the body and the body wall bursts. On the other hand, if the animals are introduced after the water boils, they are killed quickly in a few seconds. Bursting can thus be avoided and the resultant product will have a cylindrical shape which is the most preferred in the market.

2. Cleaning after cooking is very important. Fine mud get embedded into the outer body wall of the dorsal and ventral surfaces. These have to be removed to have an acceptable product for the market.

3. Duration of keeping the sea-cucumbers inside pits is an important factor. If kept for a longer period, the body wall may become too soft for future processing. If the material is not moist at the time of burying, bacterial action may be slow and decomposition may be inadequate.

4. Proper care is necessary in selecting the site for burial. Most beaches near the villages are polluted. Therefore, clean sandy beaches with little human activity are the best sites.

5. Drying of the product shall be on raised platforms and shall be dried to a moisture content of 8 to 10%.

Conclusions

Considering the resources available in the country and the demand for dried *beche-de-mer* in overseas markets, there is good scope for further improving the export trade of this commodity. For a steady export market, there is the need for improving the curing practices of *beche-de-mer* to produce better product. There is every scope for formulating an Indian Standard Specification for dried *beche-de-mer*.

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Bull. Cent. Mar. Fish. Res. Inst., 1994, **46** : 79 & 80

4.3

A SMALL-SCALE UNIT TO PROCESS SAND-FISH *HOLOTHURIA (METRIATYLA) SCABRA*

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ABSTRACT

This paper deals with the design, details of a small-scale unit to process *Holothuria (Metriatyla) scabra* in a fishing village to improve the quality and storage life of the product.

INTRODUCTION

Sand-fish *Holothuria (Metriatyla) scabra* is one of the most abundantly exploited holothurian in the Indo-Pacific region. Most countries export processed sand-fish to Singapore and Hong Kong. Processing of the sand-fish is carried out in stages to preserve as much of the muscular body wall as possible. Because of the rural backdrop of the processing area, the method of processing is simple and is accessible to fishermen. The final product is generally clean and wholesome. Processing of this species is dealt in detail by Hornell (1917), Sachithananthan (1986) and James (1989).

Sand-fish like many other holothurians have a simple anatomy with a muscular body enclosing a viscera consisting of alimentary canal, the respiratory trees and the gonads. Sometimes a symbiotic crab occupies the wider portion of the respiratory trees. Because of its habitat - the sea bottom, the body wall is usually covered with a scum of sediments. The upper side is black with yellow cross bands and the lower side is milky white. The body wall of holothurians tend to disintegrate when exposed to unusual conditions.

PROCESSING

Processing involves the removal of the viscera, arresting of the degenerative process of the body wall, removal of the outer scum and the pigmentation and the preservation of the body wall musculature. A slit of 20 mm is made with the knife at the anal region followed by squeezing from the oral to anal region facilitates complete evisceration. Introducting the sand-fish into boiling sea water initially provokes quick and simultaneous contraction of the longitudinal and circular muscles of the body wall. The animal is also killed with all its body wall as it is without further post-harvest degeneration. Exposure to limited decomposition of the external layer of the body wall helps in the rubbing off of the scum-ladden outer upper layer and the white pigmented outer lower layer. Thus the sand-fish becomes clean. Introducing again into boiling water arrests any further bacterial encroachment into the body wall. Sun drying removes the water in the product and the moisture stabilises around 15-18% for a longer storage life.

TECHNOLOGICAL IMPROVEMENTS

Traditional fishermen use the open beach with available tools for the major steps in processing *viz.* evisceration, first boiling descumming, second boiling and sun drying.

Any vessel that is large enough to hold the day's catch is used in boiling. To makeshift fire place provides little for the optimal use of firewood. Hygenic conditions may not prevail in the burial pit area where the sand-fish is to be buried. The material is covered with wet gunny bags for bringing about the partial decomposition of the outer layer by bacterial action. The sand-fish is spread in the sandy beach for drying

resulting in the adherance of sand to the final product.

A circular bowl - shaped boiling pan made of cast iron set in a covered fire place built with mud-clay provides the best alternative to the many types of vessels that are now in use.

Rectangular pits built with brick and cement with a firm cemented base provides a hygenical burial pit, to replace the present method of burying sea-cucumbers in unhygenic areas. The rubbing off the outer-layer facilitates by placing the material from the pits into a cane and trampling over them in knee deep sea water.

Drying *beche-de-mer* on racks made of wire-mesh with wooden frames facilitates better quality of the end product. Alternatively a raised platform in concrete may form the drying yard.

Small Scale Unit for Processing *Beche-de-mer*

The unit needs a land area of 30 m x 30 m in which an open shed with firm base 6 m x 4 m in size is built. Inside the shed, at one end will be fire place or two with the boiling pan; a set of wooden stirrers and a net mesh ended collecter are kept for use during boiling and at the other end will be burial pits. Adjacent shed will be a 10 m x 10 m drying yard on raised platform. In one corner of the land area will be a weather proof store room for storing the product.

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Bull. Cent. Mar. Fish. Res. Inst., 1994, 46 : 81 - 84

4.4

SOME ASPECTS OF PROCESSING AND QUALITY CONTROL OF *BECHE-DE-MER* FOR EXPORT

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ABSTRACT

This paper deals with some aspects of processing of *beche-de-mer* which will improve the quality and specification for export.

INTRODUCTION

There are about ten species of commercially important holothurians in the seas around India, but *Holothuria scabra* is the only species commercially exploited at present. Further the fishery is restricted to small pockets along Palk Bay and the Gulf of Mannar. James (1986) wrote on the factors that improve the quality of *beche-de-mer*. Eys (1986) and Sachithananthan (1986) gave good accounts of *beche-de-mer*.

Sea-cucumber is considered as a delicacy in most southeast Asian countries where ethnic Chinese communities exist. The markets for dried sea-cucumber are concentrated in Asia with Hongkong and Singapore as major import and re-export countries. In general, there appears to be renewed interest during the last decade. The FOB value of export of *beche-de-mer* rose steadily from Rs. 1.1 million during 1982-83 to Rs. 7.8 million during 1987-88. Quantity-wise, the export of *beche-de-mer* increased from 19 to 50 tonnes during the same period. This interest can be attributed to : 1. The need for an increase in foreign exchange income, 2. Entering of more number of small scale fishermen into processing of sea-cucumber, 3. Improved transport facilities, 4. Growing demand from major overseas markets, 5. Improved processing and marketing information flow; and 6. Enforcement of quality control inspection by Govt. of India from 1978.

SPECIFICATION FOR DRIED *BECHE-DE-MER*

Beche-de-mer is prepared from *Holothuria scabra*. The material should be properly dried until they have a moisture content 8 to 10%. The colour of the material shall be dark brown to black on the dorsal side and pale white on the ventral side. The dried *beche-de-mer* shall have characteristic shape and odour of the species and shall be free from any off odour.

The ventral surface of the *beche-de-mer* is pigmented and has chalk like deposits - which should be removed to improve its market value. As such there should not be too much white pigment on the ventral side.

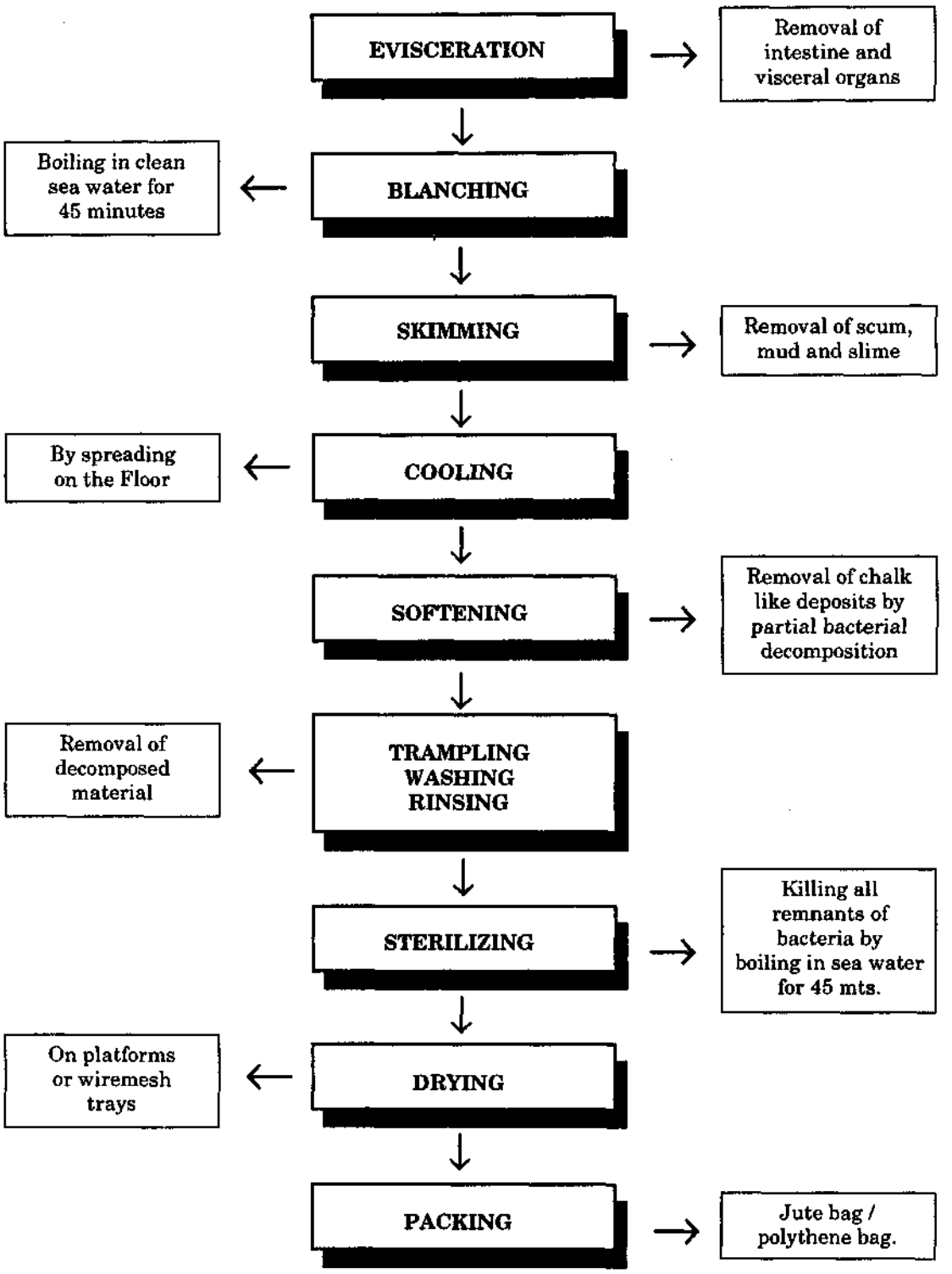
The material should be also free from any visible contamination, fungal, insects and mite infestation.

Only two grades of *beche-de-mer* are allowed for export *i.e.* 3" - 4" annd 4" - 6". In a sample a tolerance of 5% by weight of the next higher or lower size grade along with broken ones shall be permitted. The material shall be packed in Gunny bags with inner polythene lining.

Export of sizes below 3" is banned from 16 August 1982.

The validity of Inspection Certificate for 60 days is calculated from Inspection date. Inspection fees is 0.5% of FOB value (Minimum Rs. 50/- per consignment).

BECHE-DE-MER PROCESS FLOW CHART



RAW MATERIAL HANDLING AND PROCESSING

It is true that once sea-cucumber is processed and dried, little can be done to alter its quality. Thus examination of dried products only permits acceptance of material reaching the desired standard. Hence efficient handling of raw material which fails to reach this standard. Hence efficient handling of raw material and processing are necessary to reduce losses during processing and improve the market value of the products.

Handling the raw material on board

As soon as the sea-cucumber is hauled up on board, a 2 - 3 cm slit is made near the cloaca. The body wall near the oral region is pressed in order to induce the animal to eviscerate, water is also squeezed out from the body by pressing. Immediately the sea-cucumbers are to be transferred to plastic boxes, with smooth inner surface and without drain holes. To prolong holding time in fish boxes sea water is added to the boxes and the water is to be changed every 12 hours.

Boiling the sea-cucumber

Sea-cucumber should be killed instantly by immersion in boiling sea water, to preserve its wholesomeness. For this purpose a cast iron pan is filled with sea water 2/3 of its height and it is allowed to boil. Then eviscerated sea-cucumbers are transferred to the boiling sea water one by one and heated for 45 minutes with stirring until each piece has attained elasticity like a rubber ball. During the process, scum, mud and slime are removed and the pan is refilled with clean sea water and reheated.

Burying the sea-cucumber

In a clean sandy beach a pit of 10 x 75 x 20 cm is made and cooled sea-cucumbers are arranged in a single layer with ventral side downward. Then the material is covered with a jute hessain sack and water is sprinkled over it and then closed with sand. After 15 - 18 hours the material is removed from the pit and transferred to a basket and partially decomposed outer body wall is wahsed away by keeping in baskets in shallow water and trampling with feet. Water is repeatedly poured during the operation. After a final wash, the pieces without white pigment are separated and boiled in sea water for 45 minutes to kill all remnants of bacteria that decomposed the outer layer. The sea-cucumber at this stage is cylindrical in shape, rubber-like wrinkled and ash grey in colour.

Those pieces which may still have patches of white pigment undergo another round of boiling, burying and descumming, etc. The product is then transfrred to drying platforms or wire mesh trays for sun drying. Sea-cucumbers should never be dried on sand. During rainy season drying can be done by smoking. However smoked products are not preferred in the export market.

Packing

On completion of processing, the product is graded on the basis of length, appearance, odour, colour and in some cases - pieces per kg. The material may be packed in polythene bags with outer jute sacks.

CONSERVATION

Processors/fishermen who intend to conserve the only exportable species from over exploitation may take note of the following suggestions.

Since juveniles of sea-cucumbers are found near the shore, fishing should be restricted to 2 - 5 m depth. The remarkable property of regeneration of lost organs during evisceration of holothurians can be better utilized by fishermen in conservation of these animals. Eventhough there is ban on the export of *beche-de-mer* below 3" length there is no restriction on the capture of small forms. As such fishermen should be educated to return the smaller animals to the sea.

CONCLUSION

Exporters seeking to improve their foot hold in the International market for dried sea-cucumber may note the following suggestions.

Production should be in line with demand and requirements of the specific markets. There should not be mixing of species, different quality products and size grades. In view of the long transport time involved, packing is important to guarantee high product quality particularly in respect of dryness and shape. Producers should use solar dryers, instead of smoke dryers.

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Bull. Cent. Mar. Fish. Res. Inst., 1994, **46** : 85 - 90

5.1

5. *BECHE-DE-MER* INDUSTRY AND EXPORT

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

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ABSTRACT

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 carried out from Rameswaram to Sethubhavachatram in Palk Bay and from Pamban to Tuticorin in the Gulf of Mannar. In the Palk Bay, Rameswaram and Thirupalakudi are the most important centres and in the Gulf of Mannar, Kilakarai, Periapatnam 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.

INTRODUCTION

The *beche-de-mer* industry has been introduced in the Gulf of Mannar and Palk Bay by the Chinese nearly 2000 years ago. Industry changed little during its long history towards modernisation. On the other hand due to carelessness and averciousness of the local people the industry further deteriorated. Hornell (1917) made a survey of the industry and studied its revival. He took up the invesigations when the industry was a low ebb. James (1973) surveyed the Gulf of Mannar and Palk Bay and presented a picture of the industry then existing. He also made observations on the status of the industry in other communications (James, 1986, 1987, 1988 a, b). Production of *Holothuria scabra* has been estimated to be about 100 - 150 tonnes per annum from the Palk Bay and the Gulf of Mannar on the Sri Lankan Coast (Anon., 1984). However such estimates are lacking on the Indian side.

In order to make a detailed study of the present status of *beche-de-mer* along the Gulf of Mannar and Palk Bay, a survey was conducted from Adirampatnam down to Cape Comorin covering a distance of roughly 300 kilometres. As far as possible all the proccessing centres have been visited. On the day of visit the catch and effort was noted and enquiries were made about all the details of *beche-de-mer* industry. Total length and weight of the fresh specimens were also noted. At all the centres about 50 numbers of *beche-de-mer* samples were measured at random to find out the average size and the percentage of samples above 75 mm in length. The details of all the information collected during the survey is presented in Table 1 and 2.

There are more processing centres along the Palk Bay than the Gulf of Mannar (Tables 1 and 2). The Palk Bay is shallow and more productive so far as sea-cucumbers are concerned. Beyond Mallipatnam in the north no sea-cucumbers are ccollected and processed. At Adirampatnam there is no industry at all. South of Tuticorin no industry exists. It is of interest to note that 20 years back no industry existed at Tuticorin also.

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TABLE 1. *Details of sea-cucumber fishing in the Palk Bay*

Date	Place	Mode of collection	Depth (m)	No. of units	Total nos. of of sea-cucumber observed	Total wt (kg)	Species	Rate per specimen	No. of persons per unit	Remarks
16.6.87	Rameswaram	Diving	4.5	60	91	27.300	*H. scabra* *H. spinifera*	Rs. 3/- Rs. 0.50/-	12	*Beche-de-mer* above 3" - 67% below 3" - 33%
16.6.87	Mandapam	Trawl	3-6	100	4	1.600	*H. scabra*	Rs. 5/-	-	-
17.6.87	Devipattinam	Diving	2-3	1	-	-	*H. scabra*	Rs. 3/-	-	Above 3" - 67% below 3" - 33%
"	Tirupalakudi	Diving	2-6	50	3280	453.000	*H. scabra*	Rs. 0.50-6.00	8-10	Below 3" - 71% Above 3" - 29% 1" - 12-15/kg 3" - 90-110/kg 4" - 150-170/kg
"	Mullimunai	Diving & Thalluvalai	2-6	20(12) 4	101 18	30.000 9.000	*H. scabra* *H. spinifera*	Rs. 0.50-3.00/- Rs. 0.50/-	-	Below 3" - 65%, Above 3"-35% Av. length - 183 mm Av. weight - 215 g
"	Karangadu	Diving	2-5	20(3)	-	-	*H. scabra*	Rs. 3.00/-	-	-
18-6-87	Thondi	Thalluvalai	-	-	-	-	*H. scabra*	Rs. 1.50-4.00/-	-	Below 3" - Rs. 45/kg Above 3" - Rs. 15-170/kg
"	Pasipattinam	Thalluvalai & Diving	-	1	10-50 nos 1 or 2 nos	-	*H. scabra* *H. spinifera*	Rs. 5.00/-	-	-
"	Pudupattinam	Diving & Thalluvalai	-	3	40-100	-	-	Rs. 4.00/-	5-7 2-4	Above 3" - Rs. 170/-
"	Kottaipattinam	Diving & Trawl	-	100-150 1 or 2	-	-	*H. scabra*	Rs. 4.00/-	-	-
"	Ammapattinam	Thalluvalai	-	10-50	-	-	*H. scabra*	-	-	-
18.6.87	Kattumavadi	Thalluvalai	-	-	50-100 nos	-	*H. scabra*	Rs. 0.50/- to 4.00 Average length in fresh condition is 280 mm.	-	3"- Rs. 100-150/kg 4"- Rs. 200/kg Below 3"-Rs. 40-50/kg Below 3" - 21% Above 3" - 79%
19.6.87	Sethubava-chatram	Diving & Thalluvalai	-	8(2-3)	750	225.000	*H. scabra*	Rs. 5.00/-	18-20 large boat 4-7 small boat	Below 3" - 32% Above 3" - 68% Av. length - 205 mm Av. wt - 134 g.
"	Mallipattinam	Thalluvalai	-	-	1-2 nos	-	*H. scabra*	Rs. 1-2.00/-	4-5	6" - Rs. 140/kg 5" - Rs. 80/kg 3" - Rs. 40/kg

REMARKS

As a result of intensive fishing there are signs of over exploitation at many centres particularly along the Palk Bay. *Beche-de-mer* below 3" (75 mm) accounted more than 70% at some of the centres. The industry is not organised properly and the role of middlemen exploiting the divers was noticed. Often the divers take advance from the processors and are obliged to hand-over the material to the brokers or middlemen who advanced money. The processing is done under most unhygenic conditions. The sea-cucumbers are boiled in rusted oil tins which allows very little stirring during boiling. However, it is gratifying to note that in some of the centres sea-cucumbers are boiled in large aluminium vessels (Pl. I A). This is often resorted to when material is limited. It is best to have saucer shaped cast iron pans for boiling the sea-cucumbers since it allows equal distribution of heat and also facilitates better stirring during boiling. The practice of drying them on sand still continues at some of the centres. One recent innovation in the industry is the introduction of aluminium plates as 'flippers' (Pl. I B) for the divers. Since rubber flippers are costly, divers have taken to the aluminium plates. While these flippers no doubt give the divers greater mobility and manoeuvrability under water it gives them greater chance to pick up more material including smaller forms in a short time. With the advent of mechanised fishing small quantities of sea-cucumbers are caught in trawlers and in some places like Mandapam, material from trawlers alone sustain the fishery. In recent years *'Thaluvalai'* has been introduced mostly for prawns living among algae. Small quantities of sea-cucumbers are also caught in this gear accidentally.

One of the major problems during processing of *Holothuria scabra* is the thorough removal of white chalky deposits over the cured product. Often due to imperfect boiling, decomposition of outer layer and cleaning of the material, the white matter sticks to the product grading poor quality of the material. In order to overcome this problem, Sachithananthan *et al.* (1975) deviced a de-scummer in Sri Lanka for this purpose. The use of the de-scummer remains to be tested in India.

TABLE 2. *Details of sea-cucumber fishing in the Gulf of Mannar*

Date	Place	Mode of collection	Depth (m)	No. of units	Total nos. of sea-cucumbers observed	Total weight (Kg)	Species involved	Rate per specimen	No. of persons per unit	Remarks
4.12.87	Chinnapalam	Thalluvalai	-	50(10)	4	0.800	*H. scabra*	Rs. 1.00	2	Av. length-200 mm Av. wt - 258 g
"	Mandapam	Trawl	-	18	65	16.250	*H. scabra*	Rs. 1.00-6.00	-	Av. length-178 mm Av.wt - 246 g
5.12.87	Seeniappadarga	Thalluvalai	-	-	No holothurian landing on that day			-	-	-
"	Periapattinam	Diving	-	50 (12)	66	22.000	*H. scabra* *H. spinifera*	Rs. 4.00 Rs. 0.50	10-12	Av. length - 210 mm Av. wt. - 320 g
"	Kilakarai	Diving	2-5	25(4)	261	98.000	*H. scabra* 47.5% *H. spinifera* 39.5% *B. marmorata* 13.0%	Rs. 3.00 Rs. 0.50 Rs. 2.50	10-12	Av. length - 223 mm Av.wt. - 372 g (*H. scabra*)
"	Tuticorin	Diving & Thalluvalai	2-5	30	397	120.000	*H. scabra*	Rs. 8.50 Rs. 10.00	5	Above 3" - Rs. 100/kg

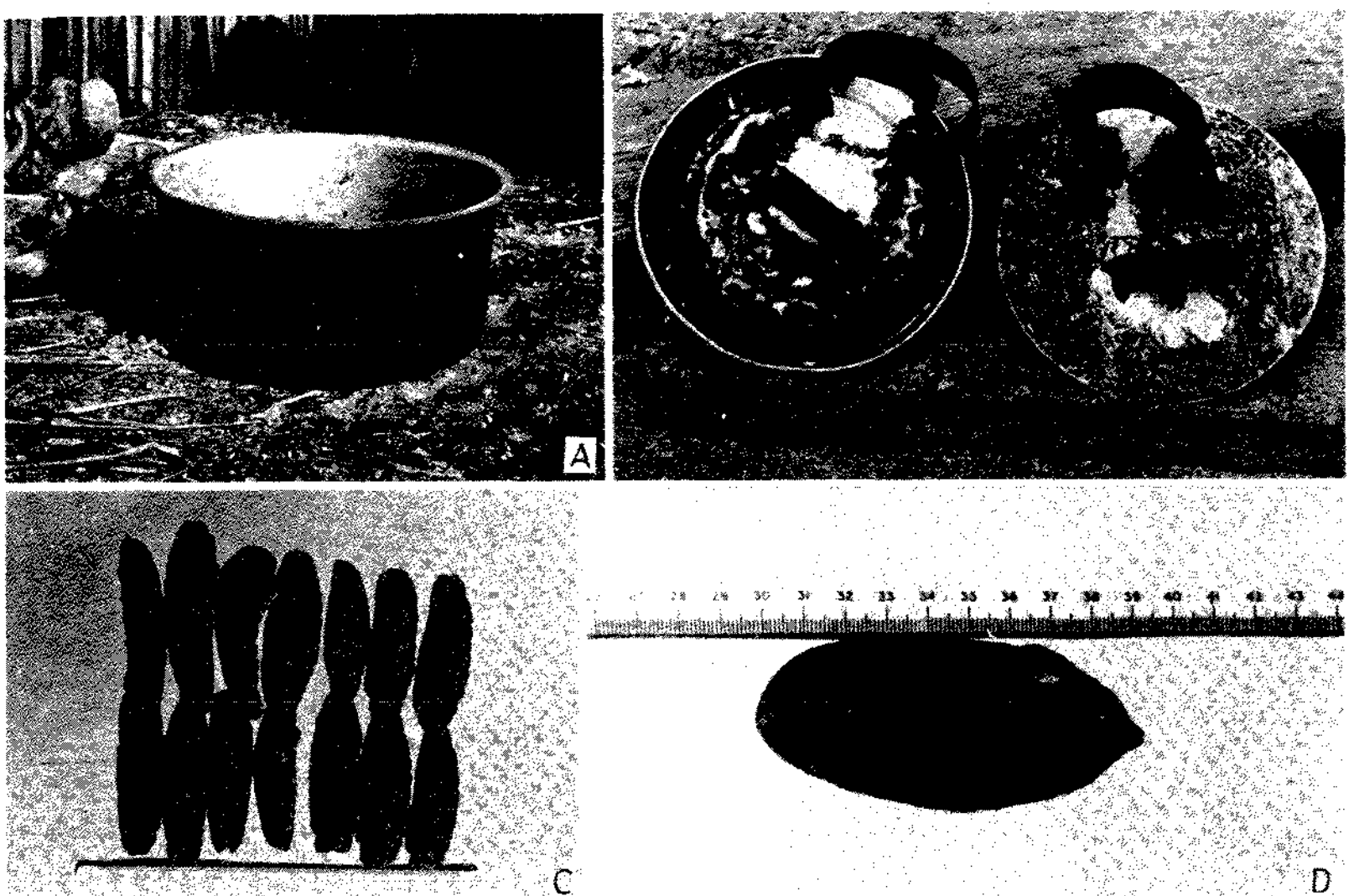

Plate I A. Aluminium vessel used instead of iron drum, B. Aluminium plates used as 'flippers', C. Processed *Actinopyga echinites* and D. Processed *Actinopyga miliaris*.

It is urgently needed to extend the fishery to other centres to avoid over exploitation at particular centres. For example between Kilakarai and Tuticorin extending over 100 km, no collection of sea-cucumbers is made. The resource is available since the same nature of bottom and hydrographical conditions exist between the two points. South of Tuticorin some populations are encountered upto Overi, but again no collection and processing is done. The industry which mainly depended on *Holothuria scabra* and also *Holothuria spinifera* which was once rated very high in value has not much demand today for the latter species. At some of the centres like Kilakarai *Bohadschia marmorata* is processed. Because of the high price offered (large size *beche-de-mer* is sold Rs. 600 per kg), the processors are evincing interest even in *Holothuria atra*. This is a welcome change for the industry since it relieves the fishing pressure on a single species which was processed 20 years ago. *Holothuria atra* is processed in Philippiness and Thailand (Trininad - Roa, 1987; Wainiya, 1988).

New Resources from the Gulf of Mannar and Palk Bay

Although the Indian *beche-de-mer* industry is very old, all these years only *Holothuria scabra* was processed and to a very minor extent *H. spinifera*. At Kilakarai some species of *Bohadschia marmorata* were collected and processed in a small way.

The species of *Actinopyga* though reported from Sri Lanka were never recorded from the Gulf of Mannar on the Indian side. Only in 1989 a few specimens of *Actinopyga echinites* (Pl. I C) locally known as Paar attai due to its habit of attaching to the parrs, were collected. Regular fishery for this species started. It is fished from Vedalai, Kilakarai Periapatnam and Pamban. Annualy about 25 tonnes are fished. Kilakarai is the major centre followed by Periapattinam, Vedalai and Pamban. Only stray specimens could be collected from Tuticorin. This species is collected at a depth of 3 to 7 metres. The sea-cucumbers ranged in length from 110-265 mm and weight in fresh condition ranged from 140-430 g. The price of each specimen varied from Rs. 1.50 to 3.50. The processed product is sold at the rate of Rs. 120 to 150 per kg.

Another species of *Actinopyga* namely *A. miliaris* (Pl. I D) known locally as Pal attai was exploited in large scale from Tuticorin from January 1992. The specimens are collected from a depth of 20-30 metres. During the first three months a total of 90,000 specimens were collected for processing. The length varied from 150-350 mm and the weight varied in fresh condition from 150-1150 g. Fresh species were sold at Rs. 3.00 to 4.50 and the processed material costs Rs. 100.00 to 150.00. In each kilogram 15-20 specimens depending on the size is weighed. During January-March '92, material worth of Rs. 5 lakhs is collected from Tuticorin alone.

Processors started exploiting *Holothuria atra* locally known as Kuchi attai from January, chielfly from Vedalai and also small quantities from Kilakarai. The length varies from 130-310 mm and the weight in fresh condition varies from 50-210 g. This species yield a very low quality *beche-de-mer*. One kg of processed material costs Rs. 50.00 only.

Hornell (1917) when he made the survey of the industry he mentions Tirupalakudi as the most important centre for processing of holothurians. Even today Tirupalakudi remains as the best centre for sea-cucumbers, other important centres on the Palk Bay side are Devipattinam and Rameswaram. In Rameswaram in addition to the material collected by the divers the holothurians coming in the trawlers are also used in processing. Earlier not much information was available on the resources from Mandapam. Now Kilakarai and Periapattinam have emerged as most important centres on the Gulf of Mannar side. In Kilakarai nearly 40% of the material collected belongs to *H. spinifera*. This is due to the fact that collections are made in a little deeper waters where *H. spinifera* is available. At Kilakarai 13% of the specimens collected belong to *Bohadschia marmorata* which is again a deeper water species.

Regarding the price there are a lot of variations for the same species depending on the centre where it is collected. Specimens collected

by Thalluvalai generally fetch lower price since most of them are a little damaged, specimens of *Holothuria scabra* collected by Thalluvalai varied from Rs. 1 to 4, whereas those collected by diving cost Rs. 3.50 to 10. Generally specimens collected at Tuticorin are a little more costly due to the stiff competition at the auction site. A single large specimen may even fetch as much as Rs. 15/- at Tuticorin whereas at smaller places like Kattumavadi the same specimen will not cost more than Rs. 5/-. *Holothuria spinifera* which was once considered as a high quality species now does not command much price. In fact the buyers at the time of purchase first remove *H. spinifera* specimens and only at the end for each specimen Rs. 0.50 is paid. At Kilakarai single specimen of *B. marmorata* costs Rs. 2.50 because of the large size.

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5.2

INTERNATIONAL TRADE IN SEA-CUCUMBERS

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ABSTRACT

The international trade in sea-cucumber is limited to countries in Southeast Asia, Japan and in a few countries where there is substantial ethnic Chinese population. The best price is paid for processed products such as dried gonads, salted fermented intestine (Konowata), dried body meat (trepang or *beche-de-mer*) and excised longitudinal muscles. The major volume of the trade is on dried *beche-de-mer*. Singapore, Hong Kong and Malaysia are the principal trade centres. In Japan, they are consumed fresh and the supplies are mainly from domestic sources. Indonesia, Philippines, Japan, Korea (DPR), Sri Lanka, India, Africa and Oceania are the major suppliers of dried sea-cucumbers. Out of the import of 6453 tonnes into Hong Kong, Singapore and Malaysia during the year 1986, the contribution from India was only 33 tonnes valued at Rs. 38.04 lakhs. Indonesia, Malaysia and Philippines were the major suppliers. This is because of the ban on export of *beche-de-mer* below 3" (7.6 cm) which formed around 70% of our export before the ban. However, our export of dried *beche-de-mer* scaled to new peaks in 1987 worth of Rs. 82.34 lakhs in foreign exchange. Though we have been traditionally exporting this item to Hong Kong, Malaysia, Singapore, Taiwan, U. K. and USA, our export is now confined mainly to Singapore market. Since the trade on sea-cucumber has potential for further expansion, it provides enormous scope for culture / sea-ranching in the oceanic lagoons and Palk Bay area of the Indian seas and increase the production for export. This will pave way to provide employment to the fishermen and earn precious foreign exchange for the country.

INTRODUCTION

Beche-de-mer, another name for sea-cucumbers or holothurians are spiny-skinned animals of phylum Echinodermata. It is an important item of trade among the developing countries in the Indo-Pacific region. They are caught and processed into a Chinese delicacy and are popular in Singapore and Hong Kong. Their reputation as an aphordisiac has undoubtedly enhanced its popularity.

There are over 650 species of holothurians, but only a few of them have commercial value. In the Indo-Pacific region one of the most valuable species is the teat-fish or mammy-fish *Holothuria nobilis* the length of which ranges from 300-400 mm. The live weight is from 2 to 3 kg. Since the thickness of the body wall is important to the final product, teat-fishes are valued for their thick 10-12 mm body wall.

Some of the more commercially exploited species include the following.

White teatfish	*Holothuria fuscogilva*,
Black teatfish	*H. nobilis*,
Sandfish	*H. scabra*,
Blackfish	*Actinopyga* sp.,
Deepwater redfish	*A. echinites*,
Prickly redfish	*Thelenota ananas* and
Surf redfish	*Actinopyga mauritiana*

Several species of holothurians such as *Holothuria scabra, H. spinifera, Bohadschia marmorata, B. argus, Actinopyga mauritiana, A. lacanora, A. miliaris, A. echinites, Thelenota ananas, Holothuria (Microthele) nobilis* and *M. axiologa* occur in Indian waters. But the industry is almost dependent on a single species *viz. H. scabra. H. spinifera* and *B. marmorata* contribute very little to the fishery. Their trade name varies from country to country and some of them are given below:

Burmese	Pan-le-pet-kye, Pin-lehmyaw
Danish	Spolse, Soagurk
German	Trepang, Seegurk
Greek	Holothuria - agouria, Tis thalassis

Hong Kong	Hoy sums
India	Kadal Attai (Tamil), Kadal Vellarikka (Malayalam)
Italian	Olothuria
Israeil	Saebjugu
Indonesian	Tripang, Teripang
Japanese	Namako
Malaysia	Trepang
Norwegian	Sjopolser
Dutch	Seekomkommer
Portugese	Holothuria
Thai	Plin khao
Turkish	Deniz hiyari
Yugoslavian	Morski Krastavac - trp.

The most commong Indo-Pacific holothurian of commercial importance is the sandfish *H. scabra* characterised by white or light yellow bands and fine black dots on a greyish blue dorsal surface. The ventral surface is milky white in colour with fine black dots. It grows to a length of 300 to 400 mm. The body wall is 8 to 10 mm thick while wet weight varies from 500 to 1500 grams. The species is usually found in muddy and silty sand often near the estuaries where turtle-grass grows and where mangrove trees line the near shore. Juveniles are found near the shore while the adults are found in depths of 2 to 5 m. Sea-cucumbers are collected by divers in the inshore water by using a mask. The processing is carried out at the landing centre. The techniques for the handling and processing of sea-cucumbers are relatively simple.

INTERNATIONAL TRADE

The international trade in dried sea-cucumber is almost exclusively limited to countries of the Indo-Pacific region and to some extent to countries with ethnic Chinese Communities outside this region. The major markets for this product continues to be Hong Kong, Singapore and Malaysia. Peoples Republic of China is, however, the major consumer drawing supplies largely from its own domestic production. Imports by major markets consist almost exclusively of dried products. Only Japan is the major consumer of fresh product, but supplies are primarily from domestic sources. The USA also imports dried *beche-de-mer*, for the Chinese population and restaurants. Taiwan Province of China is a growing market for *Stichopus japonicus*, *Actinopyga* sp. and *H. scabra*, but the demand is limited to a few sizes of these products, mainly the smaller ones. Although dried sea-cucumbers can be imported directly, the buyers in many countries prefer to import through Hong Kong, because of high import duties prevailing in other countries. Certain varieties of *beche-de-mer* have consumer preference over others. The white teatfish *H. fuscogilva* is generally preferred and fetch higher price in the international market. It is followed by Sandfish *H. scabra*. Separation into species, therefore, is essential in grading *beche-de-mer*. Size, appearance, odour, colour, moisture content and dirt content are other factors which determine the grade and price. Within a species, the larger the size, the better the grade and higher the price. The commercial sizes are the following :

4" - 6"	Large
3" - 4"	Medium
2.5" - 3"	Small grade I
2" - 2.5"	Small grade II
Below 2"	Very small

The dried *beche-de-mer* is packed in polythene lined gunny bags or coirmat sacks/ jute-hessian sacks of 60 kg and 100 kg accordding to buyers requirements. Packed produce awaiting shipment should be stored in dry place. Since the product is exported in crude form, the importers clean and grade it further and re-export them in value added packs. In this process we loose substantial amount of foreign exchange.

Hong Kong : Hong Kong is the major market for dried sea-cucumber drawing supplies from Indonesia and the Philippines. The export volumes of Pacific Island countries notably Solomon Islands, Papua New Guinea and Fiji to Hong Kong have also increased considerably. The Statistics (Table 1) shows that Hong Kong imported 5896 tonnes of sea-cucumber in 1987 which was 13.5% higher than in 1986. The imports were down in 1984 due to recession. The average domestic consumption which was around

TABLE 1. *Imports of dried sea-cucumber into Hong Kong during 1984-88 (Quantity in Tonnes; Value in HK $)*

	1984		1985		1986		1987		1988 (Jan - Feb)	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Indonesia	1052.0	12951240	243.9	23767117	2472.0	34157909	2173.3	37281617	438.2	9227449
Philippines	1370.0	10690630	2954.0	32003078	1560.4	21036574	1934.0	21060374	247.3	3086716
Japan	17.0	4808634	21.0	6272827	67.7	16745928	55.0	14947251	6.3	1797485
Rep. of Korea	3.0	3470047	26.0	3842726	15.1	2663660	26.0	5312568	0.3	69397
Sri Lanka	-	-	1.4	145351	53.5	4330572	30.0	3082224	3.7	466440
Singapore	77.0	4692788	308.2	10927118	301.3	11937707	399.0	17719205	105.5	5704105
India	-	-	-	-	3.4	100776	12.4	517050	-	-
Africa	16.0	884663	30.8	878022	53.1	914760	44.2	1963000	2.5	165110
Oceania	79.0	3332565	13.1	481160	60.2	2360984	38.0	1658129	6.0	149299
Taiwan PC	3.0	215300	15.1	989698	44.4	1276774	7.0	245560	21.0	374420
PR China	15.0	301556	108.2	1473753	122.0	734165	269.0	4294253	4.0	49825
Macau	0.4	62175	3.3	160062	13.4	515933	2.7	446775	0.2	33700
Vietnam	22.0	402666	1.0	6150	0.7	11384	7.6	136000	-	-
Maldives	-	-	-	-	-	-	0.5	57972	-	-
Solomon Is.	35.0	2743516	24.8	1219011	96.0	4425646	105.5	2877665	15.4	449064
Fiji	22.0	809380	56.7	1353197	155.7	4153030	457.3	11176119	164.5	3018747
P N Guinea	1.0	70000	4.4	165356	17.2	975637	60.0	2384379	72.4	2703582
Others	192.6	5121918	2397.1	6147126	157.9	4606392	184.6	6660364	37.7	1883960
Total	2905.0	50557078	6209.0	89831752	5194.0	110947831	5896.1	131820505	1125.0	29179299

TABLE 2. *Re-exports of dried sea-cucumber from Hong Kong during 1984-88 (Quantity in Tonnes; value in HK $)*

	1984		1985		1986		1987		1988 (Jan-Feb)	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
USA	59.7	6108221	38.2	354606	70.1	5878584	48.5	4655388	10.7	1248819
Canada	5.1	337496	10.0	584961	28.2	1158321	13.2	846496	1.0	54343
France	0.2	18720	0.2	18150	0.3	27990	0.9	25207	-	-
UK	2.0	197947	2.0	229375	3.3	192264	2.0	239680	0.4	60223
Taiwan PC	180.8	6076461	280.0	9815360	296.0	9432468	413.4	10978762	120.1	3451511
Rep. of Korea	387.4	6262123	24.1	431376	13.0	255372	-	-	-	-
Thailand	2.8	322339	2.2	234558	1.6	140156	1.2	101196	-	-
Japan	1.3	138049	3.8	199933	0.2	12875	16.0	1219617	0.6	174485
China	1642.0	16732777	4531.3	51239780	3917.0	32195762	4319.0	28811323	852.0	6081729
Malaysia	1.5	48080	0.6	18500	1.8	150378	1.5	68028	4.5	220421
Singapore	104.0	7632490	92.1	6018967	151.5	8550777	103.3	7364043	25.4	2047947
Australia	4.0	418100	4.4	398913	4.8	403863	3.2	333097	0.3	24397
Others	14.2	386057	19.1	715459	47.6	1423368	52.8	836392	3.4	209404
Total	2405.0	42678860	5008.0	73459938	4535.2	59822178	4975.0	55479229	1018.4	13573279

TABLE 3. *Import of* beche-de-mer *into Singapore 1983-1987 upto (January - July) 1988*

Qty in Tonnes
Value in Singapore $ '000
CIF prices for imports

Name of country	1983		1984		1985		1986		1987		1988	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value (Jan.-July)
Australia	5	79	-	-	-	-	-	-	6	129	-	-
Hong Kong	50	654	27	615	23	475	84	1744	30	542	18	319
India	95	1560	59	933	23	431	64	1331	67	1599	21	527
Japan	15	875	11	676	2	192	4	280	-	-	-	-
Kenya	50	516	65	685	76	811	72	779	90	1315	71	1005
New Caledonia	-	-	67	1030	107	1411	100	1148	34	464	28	350
Malagasy Rep.	2	27	-	-	6	40	7	97	-	-	-	-
Malaysia	4	49	10	64	14	98	138	932	144	1130	66	339
Mozambique	22	322	21	336	-	-	10	142	43	535	-	-
Papua New Guinea	7	61	5	52	12	145	53	555	63	487	31	352
Philippines	98	1075	145	1049	156	937	90	681	62	600	49	429
Sabah	77	184	64	201	59	306	-	-	-	-	-	-
Sri Lanka	52	1407	36	890	32	648	19	375	8	179	-	-
Taiwan	3	24	-	-	-	-	5	-	5	80	-	-
Tanzania	43	190	66	293	119	702	116	583	201	1100	129	849
O C Oceania	2	28	5	110	3	52	-	-	-	-	-	-
Yaman Arab Rep.	-	-	2	30	-	-	-	-	6	57	-	-
O C Other Africa	-	-	3	30	-	-	-	-	-	-	-	-
Pep. Rep. of China	-	-	-	-	1	43	2	75	-	-	5	136
Maldives	-	-	-	-	N.A.	47	3	47	19	295	134	2024
Mauritius	-	-	-	-	-	-	3	35	-	-	-	-
Solomon Islands	-	-	-	-	-	-	32	507	25	434	-	-
Western Samoa	-	-	-	-	-	-	9	133	-	-	-	-
Dijibouti	-	-	-	-	-	-	-	-	9	120	7	102
Fiji	-	-	-	-	-	-	-	-	10	50	3	18
Saudi Arabia	-	-	-	-	-	-	-	-	1	29	-	-
O.C.C & S America	-	-	-	-	-	-	-	-	-	-	3	20
Somali Dem. Rep.	-	-	-	-	-	-	-	-	-	-	7	109
Yemen PDR	-	-	-	-	2	46	5	103	-	-	6	123
Other Countries	7	76	4	59	3	36	5	54	14	105	3	53
Brunei	-	-	-	-	-	-	-	-	-	-	-	-
Korea Rep.	-	-	-	-	-	-	-	-	-	-	-	-
Thailand	-	-	-	-	-	-	-	-	-	-	-	-
Burma	-	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-	-	-	-	-
Total	533	7129	590	7055	637	6374	814	9599	840	9251	580	6755

N. A. = Not available

TABLE 4. *Export of* beche-de-mer *from Singapore 1983-1987 upto (January - July) 1988*

Qty in Tonnes and Value in Singapore $ '000
FOB prices for exports

Name of country	1983		1984		1985		1986		1987		1988	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Australia	-	-	-	-	-	-	-	-	2	46	-	-
Hong Kong	51	317	78	957	253	2433	656	3157	386	4068	303	3272
India	-	-	-	-	-	-	5	39	-	-	-	-
Japan	-	-	-	-	-	-	-	-	-	-	1	21
Malaysia	516	1731	583	1913	683	1927	429	2186	295	1998	212	1363
Saba	3	76	5	95	4	115	-	-	-	-	-	-
Taiwan	110	807	66	666	76	680	116	1095	117	1008	51	742
Other Countries	2	45	2	53	1	29	6	44	-	-	-	-
Brunei	1	30	2	39	2	48	3	63	2	51	2	44
Korea Rep.	14	78	5	29	-	-	-	-	-	-	-	-
Sorawak	18	321	15	231	14	236	-	-	-	-	-	-
Thailand	44	82	22	57	5	63	-	-	-	-	-	-
Burma	-	-	-	-	6	28	-	-	13	149	2	18
France	-	-	-	-	2	67	2	78	2	50	1	39
Total	759	3487	778	4040	1044	5626	1217	6662	817	7370	572	5499

TABLE 5. *Import of* beche-de-mer *into Malaysia 1983-1986*

Quantity in Tonnes and Value in Malaysian $ CIF

Name of country	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	1.05	14494	0.24	3829	0.08	1535	0.07	2096
Hong Kong	0.43	4893	0.07	1302	0.11	3294	1.01	9295
India	11.64	97918	8.08	100783	5.53	71878	20.12	117706
Indonesia	1065.10	1971837	825.16	2209059	318.11	2332978	409.65	2291653
Japan	2.45	27261	2.03	14038	0.29	4236	0.58	7365
Kenya	0.22	5384	-	-	-	-	-	-
Malaysia/Peninsular	0.11	1277	-	-	0.37	384	-	-
Malaysia, Sabah	-	-	0.04	160	0.09	610	0.54	2583
Netherlands	0.12	281	-	-	-	-	-	-
Philippines	92.20	54675	89.13	285808	52.61	132859	48.43	120654
Singapore	3.55	23225	2.42	13022	0.64	3937	3.10	15962
Sri Lanka	0.25	3923	0.11	1102	0.44	4367	-	-
Taiwan	0.31	5740	0.35	5141	1.19	12409	1.08	9104
U S A	0.71	790	0.22	4189	0.49	8446	0.32	3294
Papua New Guinea	-	-	0.99	6251	0.50	5400	0.62	3395
China	-	-	-	-	1.12	12046	-	-
Rep. of Korea	-	-	-	-	0.09	1322	-	-
Malaysia, Sarawak	-	-	-	-	-	-	3.09	14553
Total	1178.14	2211698	928.84	2644684	381.66	2594801	488.61	2597660

500 to 600 t during the period 1982-86 shot up to 900 t in 1987. Quite a substantial portion of the imports are re-exported and the re-export particulars are given in Table 2. The major outlet for re-export is Peoples Reublic of China accounting 87% of total re-exports in 1987. Re-exports to this country consists of cheap products whereas Europe buys the more expensive varieties. The average price for dried sea-cucumber has also increased from HK $ 14.46/ kg in 1985 to HG $ 29.90 in early 1988.

Singapore : In Singapore dried sea-cucumber is considered as delicacy. Dried sea-cucumber does not carry any import duty in the Republic and hence the statistics of imports furnished by the Singaporean Customs Department are seldom reliable. Tables 3 and 4 show import and export of *beche-de-mer* from Singapore. The annual domestic consumption falls in the range of 80 to 100 t. There is no domestic production. The major sources of supply in 1987 was from Tanzania, East Malaysia, Kenya, India, Papua, New Guinea, Philippines and Mozambique. Re-exports in 1987 were made to Hong Kong, Malaysia, Taiwan and Burma.

Malaysia : Imports decreased from 1178 t in 1983 to 489 tonnes in 1986, a drop of more than 50%. Imports are mostly from Indonesia, Philippines, India, Singapore and Hong Kong. Importers in Malaysia prefer to import through their sister concerns in Singapore or Hong Kong rather than placing orders directly to the original suppliers. Import particulars of *beche-de-mer* into Malaysia are given in Table 5.

Consumption Trends

Sea-cucumber is consumed mainly in restaurants and parties. It is an important item in all Chinese parties, Weddings, Chinese New Year and other festival occasions. The consumption pattern in different Asian countries is given in Table 6. The first two months before Chinese New Year *i.e.* January and February holds good demand for this product. July and August also show good demand, because of the Hungry Coast Festival. As the major production season in many producing countries falls from February to September, prices are usually lower during this period.

Indian *Beche-de-mer* Industry and Export Trade

As has been stated earlier the *beche-de-mer* industry in India is almost solely based on a single species *Holothuria scabra*. Moreover, the fihery is restricted to small pockets along the Palk Strait and the Gulf of Mannar. The export trend of *beche-de-mer* during period 1975-87 is given in Table 7. During the last 12 years India exported the highest quantity *i.e.* 91 t in 1975. Converting to wet weight this quantity equals to 1788 t (The mean weight loss in processing Holothurians has been reported as 94.91% *i.e.* the mean yield is about 5.09%).

Table 6. *Consumption pattern of* beche-de-mer *in the various Asian countries*

Month		Market trend
January	:	Very good
February	:	Very Good
March	:	Poor
April	:	Poor
May	:	Average
June	:	Average
July	:	Good
August	:	Good
September	:	Poor
October	:	Average
November	:	Average
December	:	Average

Holothurians are collected by skin diving to a depth of 1.5 to 6.0 m in the shallow seas of Palk Strait and the Gulf of Mannar. During low tide they are either picked up by hand or by small scoop nets. Small quantities occur in trawling operation. Non-mechanised country crafts are used for collection by skin diving. Normally 5 divers go for fishing in one boat and the duration of fishing is from 0600 to 1500 hrs. Normally the size varies between 60-150 mm. In a mixed catch, 100 to 150 mm sizes will constitute about 15 to 20%, 70 to 100 mm about 30% and 50 to 70 mm about 50%. In short the whole catch will fall under the category below 7.6 cm (3") after processing. It has been reported that specimens measuring 150 to 210 mm live size will get reduced to 6.0 - 7.5 cm after processing.

TABLE 7. *Export pattern of* beche-de-mer *from India (1975-1987)*

Qty in kgs and Value in Rs.

Exported to		1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Hongkong	Q:	5020	2500	10681	-	-	-	-	-	280	-	-	-	-
	V:	81553	54028	233419	-	-	-	-	-	28000	-	-	-	-
Malaysia	Q:	-	1050	-	1500	149	563	2635	-	2550	3944	-	-	8099
	V:	-	32570	-	95477	6122	26000	133537	-	272000	420000	-	-	1227681
Singapore	Q:	86248	47278	45872	17037	28090	33450	42646	3714	68714	16771	11933	32864	47767
	V:	1990008	1469440	1515110	786141	1433682	1946314	2448022	1723558	3371307	1377948	1168213	3803858	7006290
Taiwan	Q:	-	5000	5000	6000	3000	-	-	-	309	-	-	-	-
	V:	-	115759	103604	194942	83137	-	-	-	25458	-	-	-	-
U.K.	Q:	-	3750	5000	-	-	-	-	-	-	-	-	-	-
	V:	-	116380	81300	-	-	-	-	-	-	-	-	-	-
U.S.A.	Q:	-	3000	381	-	-	-	2560	-	-	-	-	-	-
	V:	-	108600	13200	-	-	-	47198	-	-	-	-	-	-
Total	Q:	91268	62573	66934	24537	31239	34013	47841	37143	71853	20715	11933	32864	55866
	V:	2071561	1896777	1946633	1076560	1522941	1972314	2628757	1723558	3696765	1797948	1168213	3803858	8233971

Beche-de-mer exported to Singapore and Hong Kong prior to 1980 confined to sizes 4" to 6" and 3" to 4". Since the market demand overshoot the production the buyers started placing orders with our exporters for sizes 2" and below inspite of the fact that such smaller sizes contained a higher percentage of sand content. Since the smaller sizes were exported in large quantity, MPEDA wrote to the Government of India to ban the export of *beche-de-mer* below 3" (7.6 cm) in size and and it is in force from 16.8.1982.

Because of the ban, export of *beche-de-mer* suffered a severe set back in 1982-83 and declined to 28 t from 56 t in 1981-82. Since the major portion of exports of *beche-de-mer* constituted by the size grades 2" to 3" the exporters of *beche-de-mer* were affected considerably and hence they demanded removal of the ban. No other countries have introduced this kind of ban. There is good demand for smaller sizes in the international markets. From the analyses of commercial invoices of exports for the period from 1979-80 to 1983-84 it has been found that the size grades below 3" accounts for 47% to 87% (Table 8).

In 1987 the Government of India constituted a Committee of Experts with Dr. P. S. B. R. James as the Chairman to re-examine the ban on export of *beche-de-mer* below 3". The Committee recommended that the ban already imposed on the export is entirely justifiable from the existing knowledge of the holothurians and as such the ban should be continued. It also recommended that the Tamil Nadu Government should impose a ban on collecting holothurians below 150 mm (natural size). No action has been taken so far by the Government of Tamil Nadu.

In a communication to MPEDA, the CMFRI has pointed out that the holothurian resources are heavily exploited in some areas and under or unexploited in other areas. Therefore, there is a need to survey and explore new areas for export production. The CMFRI has already submitted a project proposal to MPEDA in this respect and it is being examined by the Ministry of Commerce.

TABLE 8. *Size-wise export of* beche-de-mer *(kg) during 1979-1986*

Size	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
4" - 6"	7031 (16.9%)	4756 (14.21%)	2054 (3.06%)	3596 (7.48%)	3051.5 (3.8%)	2851 (18.52%)	2123 (19.5%)
3" - 4"	13987 (33.7%)	9332 (27.89%)	6986 (10.4%)	19192.5 (39.93%)	22643 (28.22%)	12545 (81.48%)	8765 (80.5%)
2" - 3"	18301 (44%)	15867 (47.42%)	45675 (66.50%)	22370.5 (46.54%)	39021 (48.64%)	- -	- -
Below 2"	2182 (5.25%)	3502 (10.46%)	13373 (19.95%)	2906 (0.04%)	15495 (19.31%)	- -	- -
Total	41501	33457	67088	48065.0	80210.5	15396	10888

CONCLUSION

There appears to be a renewed interest in the dried sea-cucumber industry in many of the tropical countries. This interest can be attributed to the need for an increase in foreign exchange income, improved processing and marketing information flow and growing demand from major markets. Although the number of consumers remain fairly constant, the enthusiastic group of consumer *i.e.* the Chinese are always willing to pay a good price for it.

India is fortunate to have holothurian resources and we should find a way for judicious exploitation for export. The trade has to undergo a revolutionary change to export this product in value added form. Since the demand is picking up in the international markets we should explore the future of increasing the production through aquaculture and sea-ranching.

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5.3

THE ROLE OF FISHERWOMEN IN THE *BECHE-DE-MER* INDUSTRY

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ABSTRACT

Beche-de-mer industry is essentially a cottage industry. The men are engaged in going out into sea and diving for the material. At some places women and children are engaged in collecting holothurians during low tide from muddy flats. After men return from sea the work can be taken over by women in degutting and boiling holothurians. This will relieve additional burden on men who go out into sea and also gainfully engage the women. Formation of fisherwomen Societies and imparting training to them will definitely improve the *beche-de-mer* industry in Tamil Nadu. The active participation of fisherwomen in this foreign exchange earning industry will certainly improve both the industry and the financial conditions of the fisherwomen.

INTRODUCTION

Beche-de-mer indstry is essentially a cottage industry based on artisanal fishery and located in rural areas. In this industry men, women and even children play a significant role. This paper mainly deals on the involvement of fisherwomen in the industry and their role in different stages of processing is given.

The author expresses his deep sense of gratitude to the Director of Fisheries, Tamil Nadu for his kind permission to present this paper in the National Workshop on *beche-de-mer* industry.

ROLE OF FISHERWOMEN

Collection of sea-cucumbers

Though the collection of sea-cucumbers remains the domain of men, women also take part in shallow waters. The divers are all men collecting the material from 2 - 5 m depth. In some places like Kungadalgut during low tide the women wade in water and collect the specimens from the muddy flats.

Degutting

When men return home tired after a days diving women can take over the processing from them to relieve the burden. In some places like Tirupalakudi and Devipattanam women are actively involved and engaged in degutting operations. This is a relatively simple process involving in making a small slit near the posterior end of the animal on the dorsal side. The women are well equipped to do the job.

Boiling

Boiling the holothurians during processing can also be taken up by women with advantage since it is only cooking the animal to the required stage. The usual practises is to put them in drums and boil when the numbers are large. In some places like Mullimonai and Kattumavadi where the collections are small, they are boiled in large aluminium vessels. This type of boiling an Aluminium vessels is largely taken up by the women.

Burying

The material after it is boiled, is buried near the shore to allow bacterial decomposition of the outer layer of the skin. This work also is now taken up by the women in some places.

Cleaning

The material which is buried is kept moist to allow bacterial decomposition. After 15-18

hours, the holothurians are removed from the pit and put into plamfiblre oven baskets. While one woman pours water men trample and clean the material thoroughly. In some places women clean individual specimens by brushes. After second boiling the material is put out for drying on palmyrah mats.

Grading

Grading is an important aspect in processing of sea-cucumbers. Women are excellantly suited to do the job in separating the samples according to the species, size and also shape. The value of the material depends much on the shape, size, colour and odour of the material. So grading has to be done carefully otherwise the labour involved goes as a waste.

Packing

Packing of the mateial is the last operation in the processing of *beche-de-mer*. Packing materials include coir mats, jute hessian sacks and polythene bags. Packing in attractive cartons lined by polythene helps in extending the storage life and commands better price in the market. Packing operations can also be taken up by women since grading and packing are relatively simple jobs.

Formation of Fisherwomen Societies

Fisherwomen societies are to be formed in every fishing village where holothurians are processed. The entire catches of the holothurians are given to the societies by the fishermen. Not a single specimen should reach the hands of private agents who are at present making huge profits in the industry as middle man. The members of each society in each village may be divided into minimum required groups so as to look after the works of the cottage industry without any hindrance. Each group should attend specific works like procurement of materials from landing centres to the processing centres, processing of the material and packing of the processed goods and also marketing. Thus the doors of the industry can be closed to the middlemen. The entire profits gained by the society is shard by the women of the society. So each member is responsible for the success of this cottage industry.

Short-term Training Courses for Women

The Department of Fisheries in collaboration with other Central Institutes should take responsibilities to impart the practical training of the processing methods to the women of the society by conducting short-term courses. The curriculum should cover in giving the basic knowledge of the functioning of the society, technical knowledge of the processing methods, the consciousness in quality control, marketing and management aspects, etc.

Other Infrastructure Facilities

The Marine Products Export Development Authority should come forward to provide other facilities to the women societies. Each society should be provided with a cleaning shed, processing hall, smoke house and store room, etc. MPEDA should provide financial assistance for this.

Audio-visual Training to Fisherwomen

Generally the fisherwomen are illiterates. Audio-visual education programme in all the fishing villages are to be conducted so as to inculcate the need for the conservation of sea-cucumber resource and also the need for the hygienic way of handling the highly valuable yet easily perishable and exportable products.

The role of fisherwomen in the industry right from procurement to packing gives employment opportunities to the women folk. The social status and economical standards of the fisherwomen will be improved by involving women in *beche-de-mer* industry.

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5.4

SOME REMARKS ON THE PRESENT STATUS OF *BECHE-DE-MER* INDUSTRY OF MALDIVES AND ITS LESSON FOR THE LAKSHADWEEP

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ABSTRACT

The *beche-de-mer* industry in Maldives is of recent origin. The exports started in a modest way in 1986 and during the current year Singapore imported maximum quantities from the Maldives. At present nine species are processed in the Maldives along with the best grade holohurian *Holothuria* (*Microthele*) *nobilis* which is in abundance. The Lakshadweep and Maldives being contiguous areas in the Arabian Sea the faunal composition is similar. Processing can first be taken up by Minicoy people who are ethnically connected with the Maldive people. Because of their relations and contacts they can see and learn the processing and initiate it in Minicoy. Later processing can be extended to other islands since the holothurian fauna is similar and abundant in other islands.

INTRODUCTION

The Maldive Archipelago consists of over 1200 coral islands, all low-lying accumulations of coral sand and rubble and orginating out of 26 atolls. If the unvegetated sand banks are included, the total number of islands is around two thousand. They extend from latitudes 7° 6' 39" N and 0° 4' 48" S and between longitudes 72° 32' 30" E and 73° 45' 54" E in the Western Indian Ocean. The atolls stretch in an approximate north-south direction, forming a long narrow chain extending 860 km from north to south. The single chain of atolls widens in the centre, to form a double chain nearly 120 km across at the widest point.

The Maldives are well known for its richness of the sea-cucumbers. Pearson (1913, 1914) reported on the holothurians of the Maldives in a cursory manner. In recent years Clark and Davies (1966) have listed some sea-cucumbers from the Maldives. It was possible for one of us (MA) to visit the Maldives in recent years and collect some information on the *beche-de-mer* fishery.

The senior author thanks Dr. P. S. B. R. James, Director, C. M. F. R. Institute, Cochin for his kind interest and encouragement and also for his permission to prepare this paper.

HISTORY OF THE *BECHE-DE-MER* INDUSTRY

The fishery for *beche-de-mer* in the Maldives is of very recent origin and seems to have commenced in 1985. A trail shipment of 31 kg of Prickly Redfish (*Thelenota ananas*) was made to Singapore in late 1985. A second species, white Teatfish (*Microthele nobilis*) has been collected and exported from late 1986. Since 1988, nine species are being processed and exported. Joseph and Shakeel (1991) and Joseph (1992) wrote about the *beche-de-mer* industry of the Maldives. The second paper is a review of the *beche-de-mer* fishery in the Maldives.

HOLOTHURIAN RESOURCES

In the Maldives perhaps the best grade holothurians are available for *beche-de-mer*

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processing. *Holothuria* (*Microthele*) *nobilis* and *Thelenota ananas* are the species which yield high quality *beche-de-mer*. They are abundant in many of the islands. At present about ten species are used in the processing.

Thelenota ananas (Pl. I A) is one of the most valuble species for processing. It grows to 700 mm in length and weighs 2-6 kg in living condition. It is characterised by the presence of numerous large pointed teats in groups of two or three all over its body. It is found at a depth of 2-30 m on clean sandy bottoms of the reef and in enclosed lagoons. It was the target species at the beginning of the *beche-de-mer* fishery in the Maldives resulting in depletion of the resource from shallow water areas within a few years. It is now vary rare in most of the islands and only a few are reported to be available and these are in deeper waterss of 20-25 m outside the reef. Processed material ranges in length from 125-225 mm.

Although *Holothuria* (*Microthele*) *nobilis* (Pl. I B) is reported to be the most valuble species in Maldives this product fetches lower price than *T. ananas*. The presence of six contractile teat-like projections seen in the living condition is the most distinguishing feature of the animal. It grows to 400 mm in length and 2-3 kg in live weight. It is found in two colours. The white teatfish is more valuble than the black one and occurs in waters 3-30 m depth in coral sand in reef passages and in sea grass beds. The black form is found on clean sandy bottoms in shallow water of 3 m depth. This species was also harvested selectively in the beginning of the *beche-de-mer* fishery in the Maldives. It is now very rare and at present taken from deeper waters and from outer surf areas. Processed material is 100-200 mm in length.

Stichopus chloronotus (Pl. I C) is very dark green looking almost black in colour. It grows upto 400 mm. The body is quadrangular in cross section with numerous prominent teats at each corner of the qudranglė. It is found freely on the shallow waters of the lagoons and on the reef flats with broken coral rubble, in depths upto 2 m. Large specimens are taken from depths of 9-10 m. It is quite abundant in most of the islands. This species is often listed as of little or no commercial value, because it degenerates slowly when taken out of water and tends to break up when boiled. Maldivian fishermen keep green fish in sea water right upto the time of processing. It fetches third highest price next to *T. ananas* and *Holothuria* (*Microthele*) *nobilis* of all varieties exported from the Maldives. Processed material ranged in length from 60-125 mm.

Actinopyga mauritiana (Pl. II A) has a cylindrical body and a flattened underside. It is brick red in colour on the dorsal side and white on the ventral side. It grows to a length of 300 mm and weighs in the living condition from 0.5-1.0 kg. It is commonly found near the low water mark where the surf breaks on the outerside of the reef, firmly attached to the rocks. Processed material ranges in length from 100 to 150 mm.

Actinopyga miliaris (Pl. I D) is black or dark brown in colour and cylindrical, growing upto 300 mm and 0.5-2.0 kg live weight. It is found in shallow waters of more than 2 m in clear water on reef flats and on algal beds.

Actinopyga lecanora (Pl. II B) is dark brown in colour and grows to a length of 400 mm and is found at depths 2 - 10 m, often on the under side of stones and on coral sand with sea weeds.

Actinopyga echinites (Pl. II C) grows upto a length of 300 mm on sandy bottoms and among live corals. Some of the nocturnal species are collected at night using torches.

Bohadschia marmorata (Pl. II D) is short and thick, with uniformly distributed dark brown spots on its light yellow to light brown body. It grows upto 400 mm in length and extends sticky cuvierian threads when disturbed. It is commonly found on coarse coral sand, grassy bottom and sometimes underneath coral rock. This species remains buried in sand during the day and are active during the night. Fishermen from many islands collect them at night with the help of torches along with species of *Actinopyga*.

Holothuria atra is most abundant on the Maldives. It is black in colour, cylindrical, with a smooth body surface. It grows to 600 mm. The red fluid 'holothurian' given off, when the body surface is rubbed is toxic. Smaller specimens

occur in large numbers in ankle deep water in sany reef flats. Inside the reef it reaches 300 mm length and is found upto a depth of 6 m. Larger specimens of 600 mm in length usually occur in deeper waters outside the reef. *Holothuria atra* fetches very low prices. Nearly 90% of the catch comprises of less than 100 mm when processed. *Holothuria atra* was exploited only from 1991 as other species became scare.

Microthele axiologa is a large species, growing upto 600 mm in length and 2-4 kg in live weight. It is almost cylindrical in shape and has prominent wrinkles on the upper surface and a slightly flattened underside. The colour is dark orange or brown above, with pale grey sides and underside. It is found in deeper waters (10-40 m) on sandy bottoms.

Thelenota anax grows to a length of 800 mm, is square in cross section and has many tubercles on its body. It is found in fine sandy bottoms at depths greater than 10 m. It is taken only in a few islands.

The names of different species of sea-cucumber commercially harvested and exported from the Maldives are given in Table 1.

SCUBA divers. The sea-cucumber fishery is during non-tuna season in most of the islands. The peak tuna fishery season is either during the Southwest monsoon (May to October) or the Northeast monsoon period (November to April) depending on the geographic location of the island. Even during the tuna fishery season some fishermen go for sea-cucumber if the tuna fishing is poor. When the fishery started sea-cucumbers were picked by hand during low tide from the intertidal region and from shallow water lagoons of less than one metre depth. As the resource became less abundant in these areas, snorkeling and use other aids helped to exploit the resources in deeper waters, upto 15-25 m. SCUBA diving for sea-cucumbers, which is now spreading rapidly, developed in response to the depletion of the high valued species *T. ananas* and *M. nobilis*, in shallow waters. SCUBA diving has started in 1989. The bulk of the catch is collected from a depth range of 5-30 m. It is estimated that there are about 50 SCUBA divers.

PROCESSING

Processing of sea-cucumbers is done in the fishermen's own island or on other islands. The fishermen process frequently on uninhabited

TABLE 1. *Names of commercially harvested holothurians from the Maldives*

Scientific name	English (Trade) name	*Maldivian (Dhivehi) name*
Microthele nobilis	White Teatfish	Batu
Microthele axiologa	Elephant's Trunkfish	Elephant
Actinopyga sp.	Blackfish/Killofish	Kalhu Kiru
Actinopyga mauritiana	Surf Redfish/Sandfish	Mushi
Thelenota ananas	Prickly Redfish	Molhu
Thelenota anax	Turtleshell	Turtle (Kachala)
Halodeima atra	Lollyfish	Fulhi (Holhi)
Stichopus chloronotus	Greenfish	Feeru (Kudi Kashi)
Bohadschia marmorata	Amberfish	Hudu Kiru

Source : Joseph (1992)

FISHING METHODS, AREAS AND SEASONS

Where there is an organised sea-cucumber fishery, the sea-cucumbers are collected by

islands. Cleaning of sea-cucumbers is commenced on the fishing boat itself, while it is returning to the base after a fishing trip. A horizontal cut is made on the upper or lower side

of the animal to remove the internal organs and they are thrown into the sea. The rest of the cleaning is done on the shore. The cleaned sea-cucumbers are cooked in a oil drum which is cut lengthwise. Aluminium vessels used in the preparation of tuna, are also used in some islands. In most of the islands the sea-cucumbers are introduced into warm waters.

For large and thick walled species like *Thelenota ananas* and *Holothuria (Microthele) nobilis* cooking is generally done for 45 minutes. Other species are cooked for 15 to 30 minutes. The sea-cucumbers are generally sorted species-wise for processing. In another method the viscera is removed as far as possible without cutting the specimen. The product is boiled for 30 minutes, wahsed and buried for 12-18 hours. After retrival a ventral cut is made mid-ventrally and then the sea-cucumbers are cooked again for 30 minutes. This method is reported to yield a better product than the more popular cooking method.

In some islands Prickly Redfish is cooked twice, 30 minutes at a time with a change of water in between. After cooking the product is smoke dried to reduce the moisture content. Short splinters are usually placed across the cut ends to keep the sides wide apart. This facilitates proper drying of the inner side. Smoking is done inside kitchens or on platforms generally constructed with coconut leaf stems. When the fishermen undertake long trips they resort to smoking in their boats. The smoke dried material is then sun dried.

Marketing and Export

Beche-de-mer produced in the islands is either taken to Male or sold in the islands. Some of the major exporters have agents in the islands purchasing on their behalf. The exporters usually get the *beche-de-mer* into their warehouses within a month of processing. They are sorted into different varieties and packed in polypropylene bags just two or three days before shipping. Earlier the material was kept for nearly two months, but since 1990 no exporter keeps *beche-de-mer* in his warehouse for more than 20 days. Then it is shipped out, usually in container. In maldives six persons are exporting *beche-de-mer* chiefly to Singapore and Hong Kong and to a much less extent to Taiwan. Exporters have to obtain an export licence for a fixed sum. No export duties are leived on the export of fishery products from the Maldives. Only very small quantities of *beche-de-mer* is cconsumed in some Male hotels and some resorts and rest is exported. Table 2 gives the Export of *beche-de-mer* during 1985-1990.

Table 2. *Export of* beche-de-mer *from Maldives during 1985-1990*

Year	Quantity in tonnes	U. S. Dollars
1985	0.31	28
1986	2.557	25,540
1987	33.886	337,921
1988	553,114	4,496,327
1989	410,286	2,240,892
1990	745,925	3,307,230

Source : Ministry of Fisheries and Agriculture.

Problems Facing the Fishery

Decreasing catches

The *beche-de-mer* fishery in the Maldives developed at a very rapid rate from 2 tonnes to 745 tonnes within a very short period of 1986-1990. The yearly catches continued to rise rapidly, but the income generated showed a decreasing trend in recent years. This is due to the decreasing catches of the high valued species and the increased catches of the low value species. The average value of *beche-de-mer* per kg dropped from US $ 9.99 to US $ 4.43 in five years time. If the spawning populations which are generally found in greater depths are removed by SCUBA diving, recovery may take a very long time.

The nocturnal species : Some of the species like *Bohadschia marmorata* and *Actinopyga* sp. are fished in the nights using torches. The increased catches of *B. marmorata* are due to selective harvesting and not due to real increase in abundance. The possibility of depletion through intensified night fishing cannot be ruled out, particularly when other high value species are in short supply.

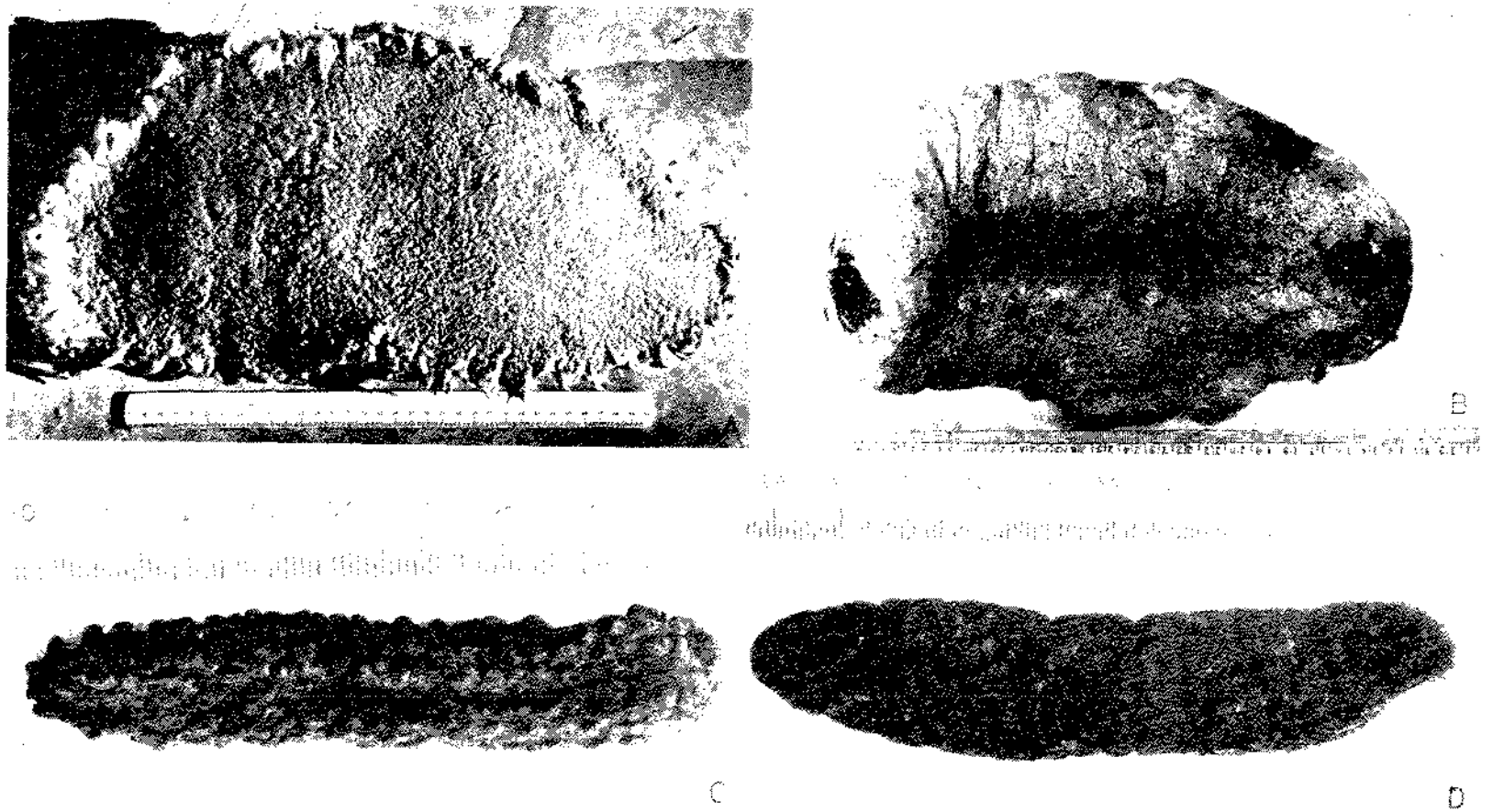

Plate I A. *Thelenota ananas* (Ventral view), B. *Holothuria (Microthele) nobilis*, C. *Stichopus chloronotus* (Processed) and D. *Actinopyga miliaris*.

Plate II A. *Actinopyga navvitiana* (Processed). B. *Actinopyga lecanora*. C. *Actinopyga echinites* and D. *Bohadschia marmorata*.

Harvesting juveniles : Very low value species like *Holothuria atra* forms the main stay today due to its abundance. Due to overfishing very small forms also are harvested. Large proportion of juveniles are seen in the processed material.

Poor processing : Correct methods of processing are not taught to the Maldivian fishermen. Some of the pioneer exporters who received instructions at the commencement of the fishery passed on the fishermen. No books are available in local language explaining the correct methods of processing. Foreign buyers have complained about the poor quality of *beche-de-mer* from the Maldives. If the quality is improved the value of the exported material will go up by thirty percent.

Migration of fishermen : There is considerable amount of migration of fishermen to other atolls in search of *beche-de-mer*. There have been instances where migrant fishermen have been turned back by Atoll chiefs. The migrations will increase with more and more fishermen desiring the benefit from this resource. Fishermen are of the view that for a sedentary resource like this it is better to be left for the people of an island/atoll.

LESSONS TO LAKSHADWEEP

The Lakshadweep and the Maldive being continuous chain of Islands in the Arabian Sea, the faunal composition is remarkebly same. All the species mentioned above are also distributed in the Lakshadweep.

1. In Lakshadweep also processing can be taken up for all the nine species listed above.
2. Exploitation should be judicious and should not be directed at particular species.
3. Use of SCUBA for fishing sea-cucumbers should not be introduced.
4. Collection of night fishing with the help of torches should not be take up.
5. A data collection and monitoring mechanism should be established.
6. Regulations should be introduced giving exclusive right to the fishermen of Lakshadweep only.
7. Fisherfolk should be instructed in the correct and hygenic methods of processing to achieve maximum economic returns from the processed product. Different species are processed in different ways. In the beginning itself correct methods of processing should be taught by demonstrations, leaf lets, radio and television talks.
8. The establishment of sea-ranching programme for sea-cucumber, with the active participation of fishermen should be considered. By sea-ranching programme the natural populations can be enriched.

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5.5

BECHE-DE-MER TRADE : GLOBAL PERSPECTIVES

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ABSTRACT

The interaction between the producers and consumers of *beche-de-mer* through the traders all over the world is discussed on species composition of the trade; price levels in the major markets; consumer preferences; supply situations; quality variations; management measures towards better processing and quality control. Place of this fishery in the general fish trade and contraints in marketing in selected countries are also discussed.

INTRODUCTION

Estimated global production of *beche-de-mer* at present does not exceed thirty thousand tonnes of which 90% is processed by drying, a small percentage is canned and the rest is consumed fresh. Major production areas are the shallow seas of the Indian and Pacific Oceans. In the Atlantic Ocean, *beche-de-mer* is reported to be harvested in the Carrebean Sea. Nearly thirty countries in the world are engaged in the production, consumption, import and/or export of *beche-de-mer*.

Chinese are the traditional consumers. Japanese, Koreans, Melanesians, Micronesians and Polynesians consume *beche-de-mer* in significant quantities. Fishermen in Yemen and Oman consume *beche-de-mer* only as a curative for muscular aches and related disorders in the limbs and spine.

Beche-de-mer trade has been prerogative of the Chinese traders for a long time. Chinese mariners have been going to almost all countries in the Indian and Pacific Ocean area from time immemorial. Wherever they went they located *beche-de-mer* as a commodity to be taken back home for their cusine. The quantum of the trade was then limited by the frequency of sailings. Frequency of sailings increased with the introduction of western trading ships in the traditional Chinese sea lanes after the 15th century A. D. *Beche-de-mer* trade received the attention of the trading ships from the west. *Beche-de-mer* became an inter-trading commodity.

From East Africa to Polynesia, ships calling at the traditional trading and at the newly established trading posts scouted for inter-trading cargo and *beche-de-mer* became one of the cargoes destined to China. Aden, Colombo, Singapore, Penang, Hong Kong, Shanghai, Tokyo and Manila became important trading centres for *beche-de-mer* in the Indo-Pacific region.

Port of Aden became the collecting centre for *beche-de-mer* from East Africa. Ships taking westward cargo from Mauritius, Reunion Is., Madagascar, Mazambique, Zanzibar, Dar-es-salaam, Mombasa and Mogadishu also carried *beche-de-mer* upto the Port of Aden. Also *beche-de-mer* from Hurghada, Port Sudan, Arab, Djibouti, Hodeidah and Mukalla reached the Port of Aden through traditional boats. Chinese merchants based in Aden bought these goods in large quantities and shipped them to China and to other Far Eastern ports.

Colombo became the collecting centre for *beche-de-mer* from North Sri Lanka and South India. Also *beche-de-mer* from Maldives, Seychelles, Mauritius and other Wester Indian Ocean Islands reached Colombo either directly or through ports in South India. Makassar, Penang and Singapore became collecting centres for *beche-de-mer* produced in Sumatra, Java,

Celebes Is., Timor Is. and Borneo. Those *beche-de-mer* collected at Makassar derived the name Makassar-type at the Chinese market, because of the peculiar teste. Suva in Fiji and Manila in Philippines became trading centres for the *beche-de-mer* produced in the Pacific Islands. Ships carrying cargo in between the numerous Islands in the Pacific collected *beche-de-mer* wherever they went and brought them either to Suva or to Manila. Hong Kong and Shanghai were the entry points to the mainland China for the *beche-de-mer* collected all over the region at that time.

Beche-de-mer was not the only marine product that was meant exclusively for the Chinese home market. Sharkfins and dried cuttlefish also fetched attractive prices at the Chinese ports, Hong Kong and Shanghai. The two world wars and the political consequences thereafter brought a lull in the *beche-de-mer* trade. Subsequent to the second world war, western colonial rulers started withdrawing from their domains in the Indo-Pacific region. Second world war also saw the penetration of the Japanese might into the Pacific Islands. The revolution and the aftermath in China, the departure of the British from India, the dismantling of the Dutch rule in Indonesia and the gradual emergence of nationhood in Arabia and Africa had brought about a radical change in the trading pattern of *beche-de-mer* and many other locally produced commodities.

The closure of the Suez and the subsequent loss of trade traffic through Red Sea made the port of Aden loose its significance as a trading-transit port in the region. East African suppliers and fishermen were slow to move their cargo to Singapore or Hong Kong as the sailings between East Africa and Far East were scanty. The fishery and the trade suffered. Makassar became less relevant and the focus of the import-export trade during the fifties and sixties shifted to Jakarta. Like many post-independent regimes of that time Indonesia was experimenting with new policies. Suva, Haniara, Port Villa and other ports in the South Pacific which received regular cargo liners touching ports like Manila, Hong Kong and Shanghai during the pre-war period remained remotely connected during the post-war period were from the American continent. *Beche-de-mer* fishery and the trade gradually slowed down due to the inconsistancy of shipping connections. Penang in Malaysia did not continue to be an attractive port for *beche-de-mer*. Shanghai in China lost its importance to foreign trade during the post-revolution period. Peoples Republic of China banned the imports of *beche-de-mer* along with many other commodities. Declining supplies as well as the closure of the main market resulted in a lull which continued till the early seventies. However, whatever supplies that were available were consumed by Chinese settlers in the Malay archipelago, Indo-China and the American Continent.

The disturbance of the *beche-de-mer* trade during the late forties and early fifties, resulted in the emergence of Singapore and Hong Kong as the major trading centres for *beche-de-mer*. Indonesia, Sri Lanka and India emerged as the regular suppliers of *beche-de-mer* to these markets apart from sporadic supplies from the Pacific and Middle East and East Africa. In Hong Kong most of the *beche-de-mer* trade is handled by traders who deal with dried products including marine products like dried abalone, sharkfins, dried fish, etc. The low quantum of the trade both in the retail as well as in the whole sale trade. Like the Indians and Hong Kong, Chinese also had their trading outports in Singapore for trading in *beche-de-mer*.

In 1970 about 500 tonnes of *beche-de-mer* were imported into Hong Kong. This rose to about 1000 t in 1980 and in 1985 total imports amounted to 6200 t. Indonesia has been a steady supplier to the Hong Kong market, supplying nearly a third of the total imports. During seventies South Asian and East African *beche-de-mer* reached Hong Kong either directly or through Singapore. However the pattern has now changed with Philippines becoming the largest source for *beche-de-mer*, amounting to one half of the total imports into Hong Kong during 1981-1985 period. Taiwan has been the major importer of *beche-de-mer* from Hong Kong importing approximately 200 t per annum. Korea also imports about 150 t per annum. Peoples Republic of China had gradually improved its level of imports in the recent past. Hong Kong re-exported about 60 t in 1981, which rose to 4531 t in 1985 to China.

In Singapore the trade is handled by wholesale traders dealing with other marine products like sharkfins, cuttlefish, dried fish, etc. During the late sixties and early seventies, India and Sri Lanka were the major suppliers to the Singapore market. Gradually Sabah (North Borneo) province of (East) Malaysia overtook the South Asian suppliers. Early eighties saw the steep decline of *beche-de-mer* supplies from South Asia and a sharp increase in the supplies from Philippines. Total imports of *beche-de-mer* into Singapore have remained at about 500 t per annum during the past 30 years, only the suppliers have changed. Re-exports from Singapore has been mainly to West Malaysia and Hong Kong.

The usual demand-supply-price relationship does not seem to apply to *beche-de-mer*. Prices in late sixties were about US $ 0.50 per kg on the average at the two major markets. Supplies were low then. Supplies improved thereafter. Prices have not come down, because of the increased supplies. On the contrary the prices have increased remarkably in 1985; the average price was about US $ 2.50 per kg in both trading centres. Not only that the price level was going up gradually, but also the conversion rates in the supplying countries like India, Sri Lanka, Indonesia, Philippines, Mazabique, Kenya have been favourable to exporters, that the value of these products in the producing countries have been very attractive.

At present two species of holothurians *Holothuria scabra* and *Holothuria nobilis* dominate the market. *Holothuria scabra*, the sand fish is available in large quanties and in almost all the producing countries. It is priced moderately and is affordable to most middle class Chinese. *Holothuria nobilis* the teatfish is not available in large quantities. It is harvested mostly in the seas around the Pacific Islands. Japanese prefer to eat the teatfish in its fresh form. It is also processed for drying. It is the most expensive species of *beche-de-mer* in the world. Many species of holothurians are also harvested for processing.

Mombasa in East Africa, Djibouti in the Red Sea, Suva in Fiji and Manila in Philippines appears to be developing at the regional trading centres for *beche-de-mer*, in the future. *Beche-de-mer* from Somalia, Tanzania and Mozabique find their way into Mombasa not through proper trade channels. Regularisation of this trade will enhance production in this area and the fishermen will engage themselves in the fishery with confidence. With frequent shipping links to Hodeldah, Aden, Mukalla, Asab, Port Sudan and Barbera, Djibouti appears to be a good collection point for *beche-de-mer* produced in the Red Sea and Gulf in Aden. At present, most of the resources in the sea remain unexploited. South Pacific Islands require a regional trading centre. Suva in Fiji, Honiara in Solomon Is. and Port Morseby in Papua New Guinea may be one of the ports suitable for a regional trading centre. This largely depends on the accessability to the regional trading centre by traders in the Pacific region.

People's Republic of China should reopen Shanghai port for import of *beche-de-mer* from the littoral states in the Indian and Pacific Ocean. Ports in the region receive ships from China, mostly from Shanghai and the reopening of the port for *beche-de-mer* may usher an era for the re-establishment of the prerogative Chinese enjoyed in the trade not so long ago. The market for *beche-de-mer* in the American Continent is relatively important taking the high proportion of Chinese and Japanese settlers in almost all parts of the continent. North American Chinese and Japanese are becoming conscious of quality and to match this requirement, canneries in Australia are engaged in occasionaly canning of teatfish for the North American market.

The demand for *beche-de-mer* is always on the increase. The consumers are in such large numbers. The resource is not as large as one would expect. However a planned exploitation of the available resources will sufficiently meet the immediate demand. Research laboratories have started artificial culturing of holothurians. Successful breeding under controlled conditions and their growth under natural conditions will enhance the production of *beche-de-mer* significantly. The cost of such production may be initially high affecting the price; however as the technique becomes broadbased and extended to the small-scale fishery the price of the product would be within the reach of the present market.

Producer countries should encourage direct trade with China for *beche-de-mer*. China has long been known for its barter trade. *Beche-de-mer* could be a commodity for the barter trade with China. Diversification of marketing by producing countries will take away the burden of dependency on the two major trading centres. Afterall most of what Singapore imports, is re-exported as also in the case of Hong Kong. Why not establish direct links between producer countries and consumer countries?

The market for fresh sea-cucumbers in Japan, Korea and the North American Continent should receive the attention of producer countries with facilities for to air freight their holothurian harvest. Canneries in the producer countries should be encouraged on trial basis to produce canned *beche-de-mer*. The technology is not out of reach and the market for canned *beche-de-mer* is not saturated. Improved processing method for drying and improved packing method for shipping especially for the sand-fish will improve the price level further in the market.

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5.6

PROBLEMS FACING THE FISHERMEN OF THE *BECHE-DE-MER* INDUSTRY

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ABSTRACT

The main problem facing the fishermen of the *beche-de-mer* industry is the shortage of raw material for processing. The Government of India banned in 1982 to export material less than 3" has caused furtherr hardship to fishermen since 67% of the material processed is below 3" size. To overcome the crisis the industry should diversify and extend to other areas and also take to processing of other more valuble species. Suitable extension programmes on proper handling and processing will be very helpful to the fishermen to increase their income, besides this will help to fetch more foreign exchange for the country.

INTRODUCTION

The *beche-de-mer* industry is an ancient one introduced by the Chinese to Indian more than one thousand years ago. It is essentially a cottage industry based in rural areas needing very little investiment. Though the industry was introduced long back it is not an organised one. The industry consists of the fishermen who are divers, the processors who act as middlemen and the exporters. Unfortunately the divers who strain most get the least returns and it is the exporters who get the lion's share in this industry.

In this paper some of the problems facing the fishermen are given and also some suggestions are given for the welfare of the fishermen. James (1989) published a good account on *beche-de-mer* resources, fishery and industry from India.

PROBLEMS AND SOLUTIONS

The main problem facing fishermen is finance since they belong to the financially weaker section of the society. Due to lack of finance unscrupulous middle-men take advantage of their financial conditions. They often advance some money to the divers and they are obliged to hand over the sea-cucumbers to them only often at a much cheaper rate. In order to redeem the fishermen from the clutches of the middlemen a Fishermen Co-operative Marketing Society must be formed and all the fishermen who are involved in this industry should be enrolled as members. Finance should be arranged through the society and the society should repay the money borrowed from the middlemen and the fishermen should be relieved.

An organised purchasing cell must be formed through the marketing societies to get their legitimate prices for the sea-cucumbers collected by them. At present due to the financial indebtedess the material is often sold at a lower rate. This can be avoided by organising a purchasing cell.

The fishermen should be given proper training with scientific diving equipments to stay underwater for a longer time and collect more catches. Joseph (1992) has mentioned that mostly SCUBA divers only collect the sea-cucumbers at Maldives. A training programme can be conducted for the divers to use SCUBA diving equipment.

At present the processors are using oil drums for processsing. This is not a good practice since it will not allow proper boiling of the material. A saucer-shaped cast iron pan is the best one for this purpose. This has been

figured and described by James (1989). Such types of vessels can be supplied to the processors at a few selected centres to improve the quality of the product.

It is desirable to provide transport facilities from remote centres so that the material can be pooled at a big centre so that the processing can be done in a better manner.

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5.7

PROSPECTS FOR ESTABLISHING A *BECHE-DE-MER* INDUSTRY IN LAKSHADWEEP

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ABSTRACT

The paper embodies the successful results obtained from experimental trial fishing and processing of sea-cucumber resource, conducted by a private party at Androth Island during the two fair fishing seasons 1975-76 and 1976-77. The processing method used in the present experimental trial is described and discussed. The prospects, major contraints and problems faced in establishing and developing the *beche-de-mer* industry in the islands are dealt with.

INTRODUCTION

Beche-de-mer industry is not established in the Lakshadweep although valuable species of sea-cucumbers are available for processing. Hornell (1917) observed some materials processed in Kiltan Island. Ayyangar (1922) also made a reference to this processing. James (1973, 1989) pointed out the good resources of *beche-de-mer* in Lakshadweep.

The availability of commercially important species of sea-cucumbers in Lakshadweep is well established. Despite lack of facilities, it is possible to establish the industry in Lakshadweep, since it is a cottage industry depending on artisanal fishery. The present paper records the results obtained from a recent survey conducted in the islands. It also probes into the problem and prospects of developing a *beche-de-mer* industry in this remote oceanic territory.

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EXPERIMENTAL PROCESSING

Experimental processing conducted by the Lakshadweep Fisheries Department in 1968 proved that suitable sea-cucumbers are available for *beche-de-mer*. With the help of the Fisheries Department, M/s. Marine Products Exporters, Madras, started exploitation of sea-cucumbers at Androth from 10.3.'76 to the end of the fair season. The party engaged ten labourers on daily wages at the rate of Rs. 8/- per head per day for the processing work. In addition, the labourers were paid five paise on individual specimens of sea-cucumber collected and brought by local men and children. Local people other than the labourers were also paid five paise per sea-cucumber collected, towards the cost. An additional incentive of Rs. 5/- per 100 sea-cucumbers was paid. Ten more additional labourers at the rate of Rs. 8/- were employed from the second day. Till 8.4.1976, there was no departmental control over the collection.

The Department kept a watch on the collecctions made from 8.4.1976. From 19.3.76 to 15.4.76, a total of 75,316 sea-cucumbers were collected and processed to get 3633 kg of *beche-*

de-mer. The Department got a royalty of Rs. 3633/- at the rate of Rs. 1/- per kg of *beche-de-mer* processed. The product was taken to mainland for export. This trade gave employment to about 40 labourers per day. During the 1975-76 season the sea-cucumber was found in abundant quantities very near the shore about 150 specimens distributed in an area of 100 sq. m. During the 1976-77 season (November 1976 to January 1977), however, a reduction in stock of the sea-cucumber was noticed and the work was suspended for want of sea-cucumbers. A total of only 2115 kg of *beche-de-mer* was obtained during this season, giving the Fisheries Department a royalty of Rs. 2115/-. The method of processing however was not correct since the processing method used for sand-fish is applied to the species available in Lakshadweep.

REMARKS

In view of the good resources available in Lakshadweep there are excellent prospects for *beche-de-mer* industry. Proper methods of processing have to be followed to get maximum price in the export market. Care should be taken to see that over exploitation does not take place and the industry is spread to all the islands.

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