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MARINE LIVING RESOURCES OF THE UNION TERRITORY OF LAKSHADWEEP —

An Indicative Survey With Suggestions For Development

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

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PREFACE

The Union Territory of Lakshadweep located in the southern Arabian sea is endowed with many natural resources. Since isolated from the mainland of India, however, the inhabitants of these islands had to live for ages in utter backwardness, ill-health and poverty. After the islands became a Union Territory of India in 1956, there has been rapid progress in the field of agriculture, fisheries, education, health etc. Next in importance to agriculture, the fisheries sector plays an important role in the economy of the islands.

Realising that the marine fisheries has to play a key role in maintaining and upgrading the standard of living in the Lakshadweep islands, the Central Marine Fisheries Research Institute established a Research Centre at Minicoy in 1956 with limited facilities. This centre has carried out extensive research on tunas, live bait fishes, coral reefs and fishery oceanography of the area more particularly around Minicoy. The results of studies so far conducted on the marine fisheries and related aspects in Lakshadweep have been recently reviewed in a special issue of the *Marine Fisheries Information Service : Technical and Extension Series* (No. 66) published by this institute.

Of late, the Government of India have assigned top priority for planned development of its island territories and in 1985 the Hon'ble Prime Minister Shri. Rajeev Gandhi himself visited the Islands to personally appraise himself of the problems faced by the islanders and to usher a speedy development programme. He observed that fisheries being a major natural resource of the Union Territory there was urgent need for systematic planning and implementation of fisheries development schemes. Keeping this in view and to widen our knowledge of the marine living resources of the islands and related environmental parameters which would help in accelerated development of the fisheries sector, the Central Marine Fisheries Research Institute has carried out a comprehensive survey of the fishery potential of the Islands from January to March 1987 involving 24 expert scientists under my leadership. The survey has been very successful in that the scientists were able to collect considerable amount of data and scientific material from all the inhabited and most of the uninhabited islands.

The present Bulletin embodies the scientific results of this survey assessing the various types of fishery resources and their potential; impact of environmental damages of the endangered ecosystems such as coral

reefs; evaluating the ancillary marine resources such as sea cucumbers, sponges and ornamental fishes; identifying areas and species suitable for mariculture in the islands and suggesting measures that would help the administration and development agencies in perspective planning and development of fisheries in Lakshadweep.

I deeply appreciate the hard work, sense of devotion and unfailing enthusiasm evinced by my colleagues in fulfilling this mission-oriented and time bound survey programme bringing to light considerable amount of fresh information on the fishery potential of Lakshadweep as reflected in the various contributions included in this Bulletin.

My sincere thanks are due to Dr. C. Suseelan for editing the papers and bringing out this bulletin.

P. S. B. R. James
Director
Central Marine Fisheries
Research Institute

INTRODUCTION

P. S. B. R. James

The Union Territory of Lakshadweep, consisting of several inhabited and uninhabited islands, lie between 08°00'N and 12°30'N latitudes and 71°00'E and 74°00'E longitudes. The remoteness of the island territory from the mainland has forced the inhabitants to live in isolation amidst injustice, poverty, ignorance and ill health. Coconut and tuna formed the mainstay of the economy of the islanders. The lagoons and the surrounding waters are replete with a wide variety of flora and fauna. The tunas and the food fishes were being exploited ever since human settlement. The islands became a Union Territory of India in 1956. Since then there has been rapid progress especially in the fields of agriculture, fisheries, education, health etc. Next in importance to agriculture, the fisheries sector plays an important role in the economy of the islands.

Geomorphology

The tiniest of Union Territory of India, Lakshadweep is located on the Laccadive-Chagos ridge which is supposed to be the continuation of the Aravali mountains. The islands are believed to be the remnants of the submerged mountain cliffs and formed as a result of coral formation. The submarine bank that supports the atolls rises from depth ranging from 1500 metres to 4000 metres. The Laccadive, Maldive and Chagos Archipelagoes form a contiguous submarine bank covering a distance of over 2000 km. The atolls of the island rest on an underwater platform of about 100 fathom deep. The islands have formed as a result of many thousand years of reef building activity and the geological changes took place especially during Pleistocene period. The subsidence of a volcanic island resulted in the formation of a fringing reef and the continued subsidence allowed this grow upwards. With the submerging of the island the atoll is formed encircling the lagoon. The rim of the atolls can grow only to a height which would prevent its exposure during low tides. A reef may be about 300 m across with channels in its perimeter which allow the inflow of tidal waters in the lagoon. The islands are formed by the accumulation of coral sand in the form of sand bars with the action of wind, waves and currents. Later it got compressed into sand stone. In course of time vegetation got established and the consequent ecological succession took place. The height of the land above sea level in the islands is generally 1-2 metres. Coral boulders are heaped up on one side of some of the islands due to natural calamities like cyclones and heavy storms.

The archipelago consists of 12 atolls, three reefs and five submerged banks. There are 36 islands covering an area of 32 Sq. km. Of these only 10 islands, namely, Androth, Amini, Agatti, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti, Kiltan and Minicoy are inhabited. Among the unhabited islands, Bangaram is a tourist resort and Suheli is a coconut growing and fishing centre. Pitti or the bird island is small reef with sand bank covering an area of 1.2 hectare lying north west of Kavaratti where terns in thousands visit for nesting. The details of inhabited islands are given in table 1.

Information in detail about Lakshadweep relating to georaphical features, land flora and fauna, history etc are given by Ellis (1924) and Mannadiar (1977). Except Androth all the islands have a lagoon, some of which are fast getting filled up by calcareous sand. Bitra has perhaps the most magnificient lagoon. Minicoy has a large and deep lagoon with a boat channel on the northern side giving safe access and anchorage to vessels of about 3 m draught. The outer edges of atolls drop precipitously to the ocean floor. Mostly on the eastern side the atolls overhang the precipitous shelf. The eastern side is generally more sheltered from

Table 1. The names and details of the inhabited island in the UT of Lakshadweep.

Name	Georgraphic location	Distance from Cochin (N. M)	Area in Sq. km.	Area in hectares	Population 1971	Population 1981	Language
Agatti	Lat. 10°51'N Long. 72°11'E	248	2.7	271	3155	4111	Malayalam
Amini	Lat.11°07'N Long. 72°44'E	220	2.6	259	4542	5367	,,
Androth	Lat. 10°49'N Long. 73°41'E	158	4.8	484	5424	6812	,,
Bitra	Lat. 11°36'N Long. 72°43'E	261	0.1	10	112	181	,,
Chetlat	Lat. 11°41'N Long. 72°10'E	233	1.0	104	1200	1484	,
Kadmat	Lat. 11°13'N Long. 72°47'E	220	3.1	213	2416	3114	,,
Kalpeni	Lat. 10°05'N Long. 73°39'E	155	2.3	228	3152	3543	,,
Kavaratti	Lat. 10°33'N Long. 72°38'E	213	3.6	363	4420	6604	,,
Kiltan	Lat. 11°29'N Long: 73°E	218	1.6	163	2046	2375	,,
Minicoy	Lat. 08°17'N Long. 73°04'E	215	4.4	437	5342	6658	Mahl (Divehi)

wind and current. The islands, ranging in area from 1 ha. to nearly 440 ha., are little specks in the Indian Ocean. They are beautiful, idyllic and strategically located from the point of view of economic and defence considerations of India. Being oceanic islands, the continental shelf around them is limited to about 4336 sq. km. But considering the lagoon area of about 4200 sq.km., 20,000 sq. km. of territorial waters and about 400,000 sq. km. of oceanic zone, Lakshadweep is one of the largest territories of our nation.

Climate

The climate, more or less comparable to that of the coastal areas of Kerala, is warm and humid but bearable. The average rainfall is about 1640 mm for Minicoy and 1504 mm for Amini. The rainiest months are June to September with June receiving the maximum. Maximum temperature may range from 35°C to 38°C and minimum from 17°C to 18°C. Occasionally cyclonic storms occur, the oldest and the most serious recorded being the one that struck Kalpeni and Androth on April 15, 1847 (Mannadiar, 1977). The subsequent ones were in 1891, 1922, 1948, 1963 and 1965 but never of the magnitude of the first one (Jones 1986)

Mineral resources

The mineral resources of the island consist of low grade phosphate derived out of bird droppings before the islands were colonised by man and calcium carbonate sands. Exploitation of these are linked with the very existence of the islands and any attempt made in this direction should not turn out suicidal.

Natural resources

The most important items coming under the flora and fauna of the islands are the coconut trees and fishes which form the mainstay of the economy of the islands. Though there are several kinds of plants in the islands none of them has as much importance as the coconut

tree. It forms the real tree of life of islanders and every part of it is of use to them. No cereal of any significant importance is grown in the islands. The flora of the islands consists mainly Banana (Vazha) (*Musa paradisiaca*), Chembu (*Colocasia antiquorum*), drumstick 'Moringakki' (*Moringa oleifera*) bread fruit - 'Chakka' (*Artocarpus incisa*) and Wild almond (*Terminalia catappa*) Some of the shrub plants are Kanni (*Scaevola koenigii*), Punna (*Calophyllum inophyllum*), Chavok (*Casuarina equisetifolia*) and Cherrani (*Thespesia populnea*) which are unevenly grown throughout the islands. Tapioca, yam, gourds, legumes etc are also cultivated. A variety of wild herbs and shrubs grow and new plants occasionally introduced from the mainland. The area available is so limited, the population is on the increase and there is shortage of fresh water leaving very little scope for large-scale cultivation.

Until the territory came under the Central Administration, large-scale fishing has been in vogue in Minicoy. Remarkable strides have been made in fishery development during the last thirty years. The CMFRI made a comprehensive study of the fish fauna of the entire archipelago. There is no land fauna of any special importance except perhaps the tree rat, which is of a very distructive nature.

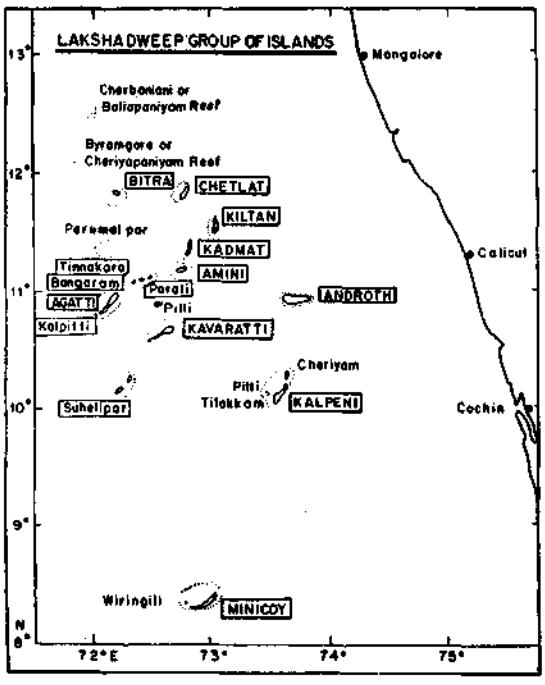

Fig. 1. The Lekshadweep group of islands. The islands marked inside boxes indicate those surveyed during the present investigation.

Social and cultural background

The people in the islands are all muslims who are very devoted to their religion. They are peace loving, and criminal records are few, though litigation cases arising out of property disputes are rather high.

The early migrants were mostly from the mainland India, especially from Malabar. A certain type of caste system was in existance

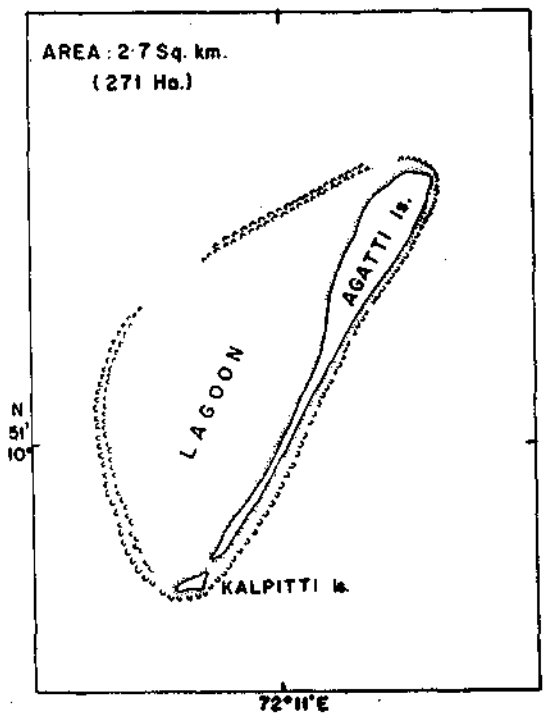

Fig. 2. Agatti and Kalpitti Islands

before Islamisation. The social structure in Minicoy bears close affinities with that of Maldives. The *Attiri* or village system is of special kind there and women play a dominant role in the society, unlike anywhere else among the Muslims. The social conditions in the Lakshadweep bears close resemblance to those in Maldives. The people of the southern most island, Minicoy, are ethinically related to Maldivians and speak the Mahl Chalet or Divehi language while the rest of the islanders speak Malayalam with a characteristic local slang. Culturally they are closely related to Kerala.

Realising the importance of oceanic tuna fisheries, the Central Marine Fisheries Research Institute established a Research Centre at Minicoy in 1958, and the Department of Fisheries

Lakshadweep was established in 1959. During the past 30 years research activities carried out by the scientists of CMFRI as well as scientists of other research organisations mainly going from the mainland have furthered our knowledge on the fishery reaources, their potential, fishing methods, fishery biology of commercially important tunas and bait fishes, and environmental

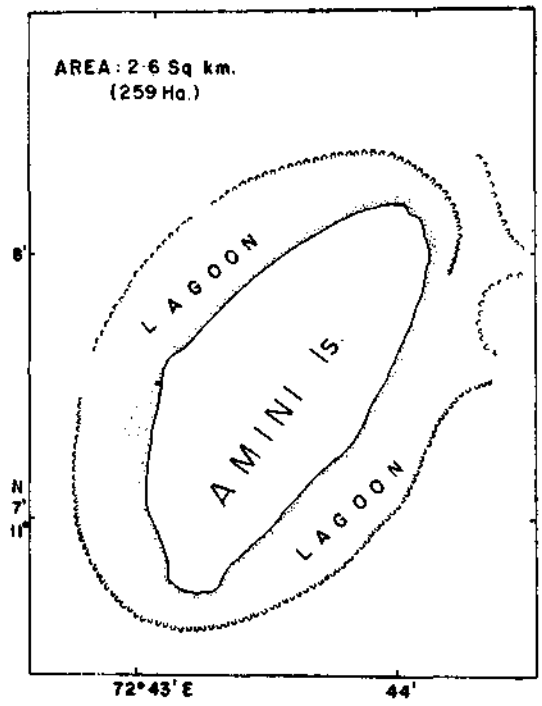

Fig. 3. Amini Island

characteristics. Research on corals and coral reefs has been strengthened. But, except for the useful information available from Minicoy in the south, little is known trom the northern islands, mainly because the Institute could not undertake survey/research programmes for want or manpower and infrastructural facilities.

The recent interest in the development of Lakshadweep through modern scientific and technological inputs has brought into a sharper focus on the marine wealth. The efforts aim at assessing these resources for exploitation for the economic benefits of the people of the islands as well as for improving the national economy without jeopardising the ecosystem and the resources which are unique to these islands.

The Futurology workshop held in July 1986 organised by the Department of Science and Technology, Government of India, and the Lakshadweep Administration has identified definite areas for evaluation under each subject, such as agriculture, fisheries etc. Based on the S&T inputs suggested at this workshop and also the main objective of the Institute during the VII Plan, *viz.*, to assess the underexploited and unexploited resources of the EEZ, the CMFRI undertook a comprehensive and indicative survey of the fishery potential of the various islands under the leadership of Dr. P. S. B. R. James, Director, CMFRI. An action plan for the survey was drawn up by the end of 1986. Regarding the modalities for uniform collection of data and facilities and equipments needed for the survey the team leaders and members had detailed briefing at Headquarters, Cochin. The survey was accomplished by 24 scientists of CMFRI from identified fields, divided into three teams and each team surveying a group of islands for a period of one month, from January to March 1987.

The comprehensive survey mainly aimed at an overall assessment of the various fishery resources, especially tunas and baitfishes, their potential, evaluation of ancillary marine resources such as ornamental fishes, sea cucumbers and sponges, impact of environmental damages caused to the ecosystems such as coral reefs, identifying areas and species suitable for mariculture in the islands and for suggesting measures that would form the basis for evolving suitable strategies of exploitation.

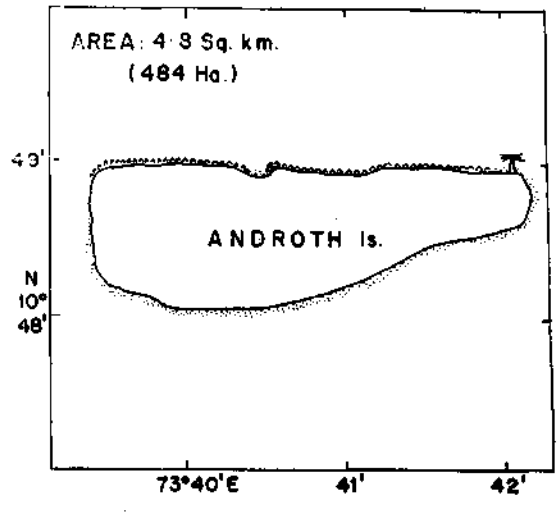

Fig. 4. Androth Island

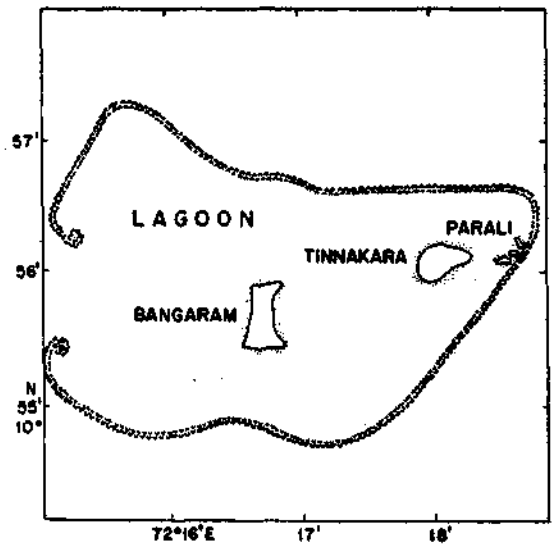

Fig. 5. Bangaram, Tinnakara and Pareli Islands

The objectives as defined covered the following :

1) Collection of basic information on the present status of exploitation of the marine fishery resources including data on infrastructure facilities and manpower.

2) Identification and estimation of non-conventional, underexploited and unexploited resources.

3) Faunistic survey with estimates of abundance of ancillary resources, such as ornamental fishes, echinoderms, sponges, molluscs, crustaceans and seaweeds.

4) Aimed survey of the bait fish resources in the lagoon, reef flat and adjacent sea, looking into possibilities for development of these resources.

5) Investigation of ecology of lagoon, reef and adjacent sea to understand the environmental parameters and productivity.

6) Survey of the mariculture potential of the islands in terms of species, seed availability and suitablity of sites.

7) Estimation of ecological damage caused by man-made changes on the entire marine ecosystem, particularly coral reef and possibilities of protection/rebuilding of the ecosystem.

8) Consideration of setting up of National Marine Parks in the islands.

Since survey of this nature would not be possible during the southwest monsoon, January to March 87 was chosen for carrying out the programme. The first team was in the islands from 3 January to 8 February and surveyed Amini, Kadmat, Kiltan and Chetlat. The second team surveyed the islands Agatti, Kalipatti, Bangaram, Tinnakara, Parli and Bitra from 5 February to 4 March. The third team conducted survey of Kavaratti, Suheli Par, Minicoy and Kalpeni from 5 March to 3 April. The Project Leader Dr. P. S. B. R. James, Director, CMFRI, along with two other Scientists Dr. P. P. Pillai and Shri A. A. Jayaprakash visited Minicoy, Kavaratti, Agatti and Bangaram to make an on-the-spot study of the pole-and-line fishery for skipjack, live-bait fishes, coral reef ecosystem, the associated flora and fauna and other ancillary marine resources. The discussions he held with the Administrator and Director of Fisheries Lakhshadweep could identify the major constraints and programmes to be implemented for future development.

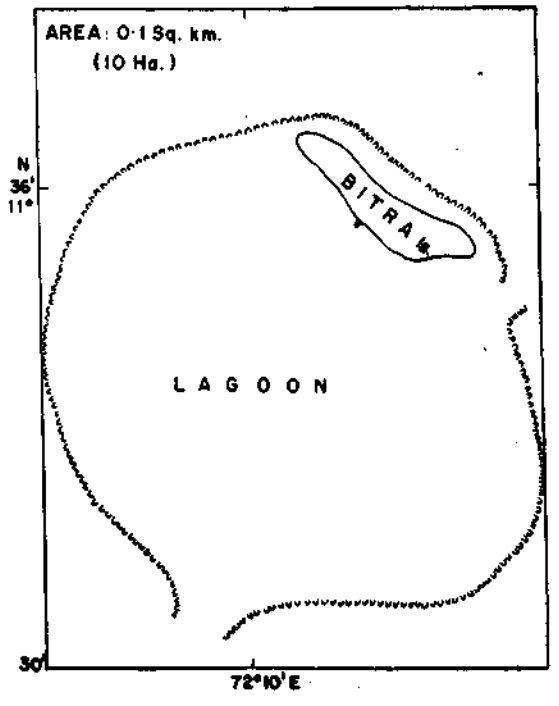

Fig. 6. Bitra Island

The composition of the various teams were as follows :

Project Leader : Dr. P. S. B. R. James, Director, CMFRI, Cochin

Team 1 : Dr. C. S. Gopinadha Pillai (Associate Leader), Dr. V. S. R. Moorthy, Dr.

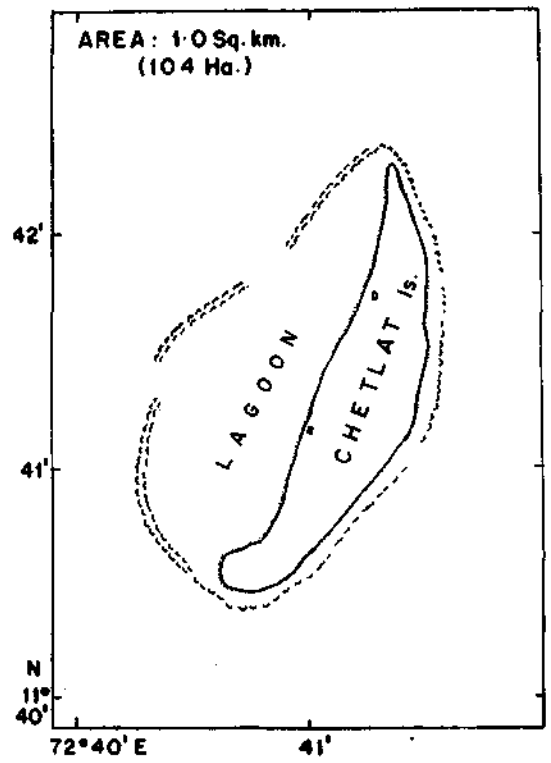

Fig. 7. Chetlat Island

G. Sudhakara Rao, Dr. D. B. James, S/Shri K. Ramdoss, K. Kaladharan, I. David Raj (Scientists) and K. K. Kunhikoya (Tech. Asst.)

Team 2 : Shri M. Kumaran (Assoctate Leader), Dr. C. Suseelan, S/Shri K. K. Appukuttan, S. V. Alavandi, A. Chellam, K. P. Said Koya (Scientists), S. Kalimuthu (Tech. Asst.) and P. Kojan Koya (Fieldman).

Team 3 : Dr. R. S. Lal Mohan, Dr. P. A. Thomas, Dr. N. Kaliaperumal, S/Shri M. Kathirvel, K. G. Girijavallabhan, A. C. C. Victor, M. M. Meiyappan (Scientists) and Mohamed Koya (Lab. Attendant).

The three teams successfully completed the survey of the different islands (Fig. 1-12) as per schedule. A large volume of data and scientific materials on various resources of fin fishes, crustaceans, molluscs, sea cucumbers, sponges, corals, coral reefs and seaweeds have been collected. The environmental damages caused by natural factors and due to human interference in each island have been assessed and measures suggested including the need for establishing marine parks and reserves in this area. Studies on hydrology and ecology of the lagoon, reef and adjacent sea have been made. Special emphasis was laid to survey the mariculture potential of the islands. The materials collected during the survey were analysed independently and collectively by the scientists who prepared reports according to their specialisations, using all the materials and data collected by the three teams.

Earlier studies as well as the present survey have indicated the need for further exploitation of the untapped resources of tuna. Introduction of large pole-and-line units, purse seiners and longliners can augment production. The reported potential is 90,000 tonnes (Jones & Banerji 1973). Finfishes other than tuna could be exploited by gillnetting and hooks and lines. Since FADs can augment production, experiments to fabricate these having a long life will be worth trying. Attention should be focussed to conduct experiments on artificial breeding and culture of live-baits. Experiments to reduce

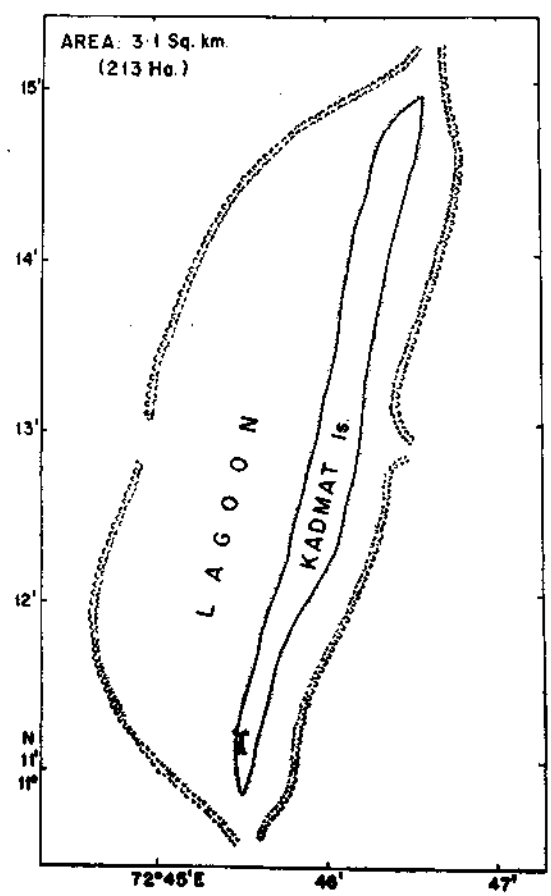

Fig. 8. Kadmat Island

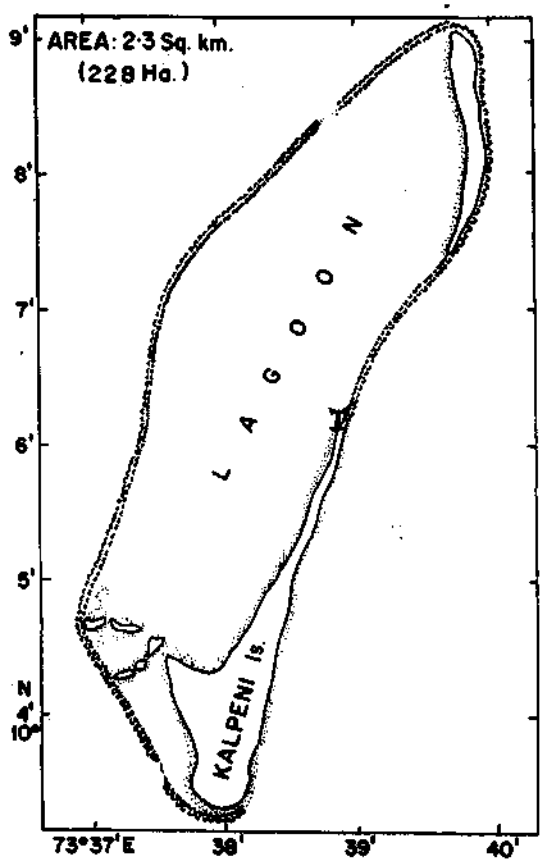

Fig. 9. Kalpeni Island

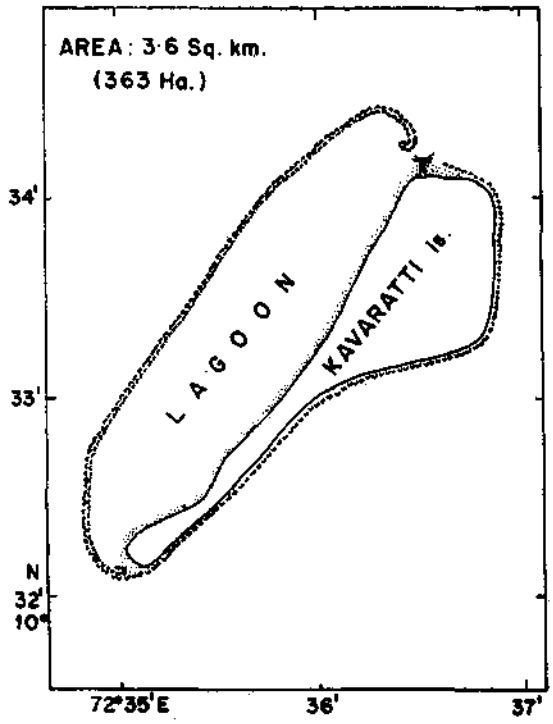

Fig. 10. Kavaratti Island

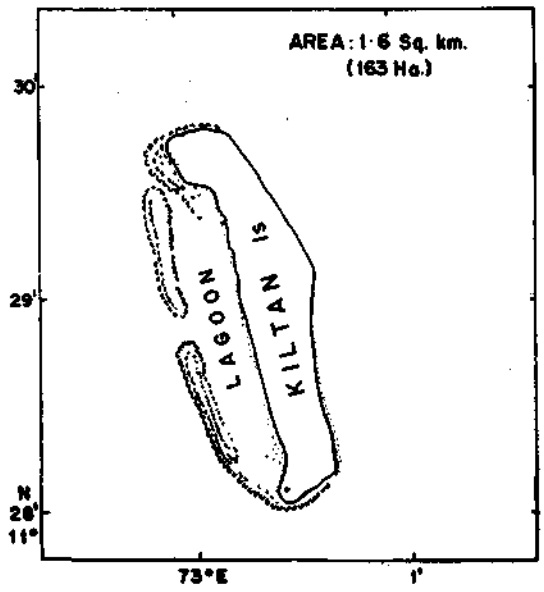

Fig. 11. Kiltan Island

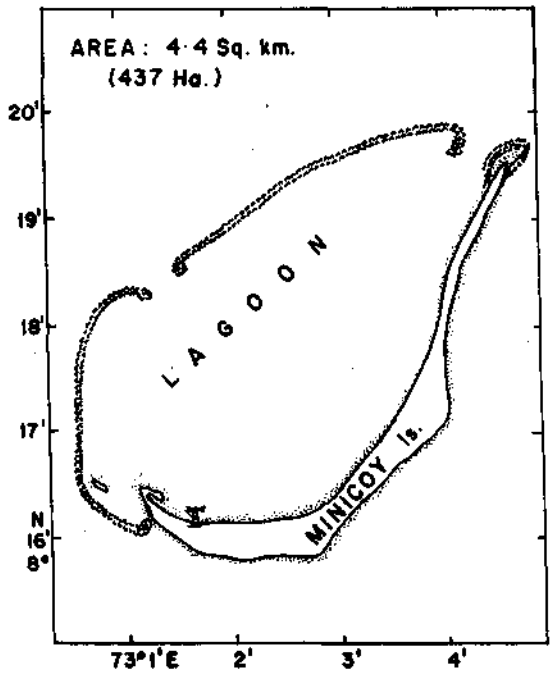

Fig. 12. Minicoy Island

mortality of live-baits durlng handling, transportation and storing in live-bait tanks is of utmost importance. Immediate attention should be given to carry out demonstration programmes so as to convince fishermen in the use of live baits other than the traditionally exploited sprats. Trials with artificial baits also have to be made. Manpower development through training as well as by appropriate socio-economic programmes need consideration. The interisland movement of fishermen/boat would result in further

expansion of the existing pole-and-line fishery. Some of the uninhabited islands where fishermen stay should have facilities for camping, repair and maintenance of the vessel, supply of fresh water and fuel. An organised marketing system will be beneficial to the fishermen. Product diversification to suit consumer preference will be ideal. Ways and means of utilisation of the tuna waste need consideration.

There are prospects for exploitation of a number of ornamental fishes and some of the ancillary resources in a limited way. But culture of some of these organisms in an organised manner in the lagoons of some of the islands will be worth trying. In view of the environmental damages caused by man, effective steps are underway to prevent further deterioration by legal measures and as well by creating greater awareness among the islanders. Steps to transplant and rejuvenate corals in areas of mass mortality of corals and construction of artificial reefs to attract a variety of reef fishes also have to be undertaken. A continuous monitoring of the resources and a close vigil on the resources response to the management measures is a sine-qua-non. Moreover, the overall approach and plans to ensure a fast and balanced growth of the economy of islands should visualise to bring to light the complexities of the various problems in the correct perspectives, so as to build up proper linkages between different components of the entire system.

The Lakshadweep Administration and the Directorate of fisheries of the Union Territory whole heartedly cooperated in the Survey without which it would not have been possible to complete the work. Our grateful thanks are due to Shri Jagdish Sagar IAS, then Administrator of the Union Territory of Lakshadweep. Our special thanks are due to Shri George Varghese, Director, Shri P. A. Raghavan, Asst. Director, Shri C. G. Koya, Fisheries Officer and their colleagues, Department of Fisheries, Lakshadweep for their kind cooperation, making available their departmental boats and other services for executing the survey programme as per the schedule.

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2. HISTORY OF MARINE RESEARCH IN LAKSHADWEEP

P. S. B. R. James

INTRODUCTION

The Lakshadweep consisting of a number of islands, islets and submerged reefs lie scattered in the vast Arabian sea on the west coast of India. This geographic isolation has been a major impediment to maintain *status quo* with the progress and developmental activities on the mainland. Of recent, the stress has been to achieve a conduce growth of the economy of the islanders so as to improve their standard of living. Besides agriculture the traditional source of livelihood of the islanders is fishing which plays an important role in the economy. Since the land area is limited, the scope for large scale development of land based industries and agriculture is meagre, the future programmes have to be centred on the exploitation of marine living resources. Ever since human settlement in these islands a variety of marine living resources available in the lagoons and in the surrounding oceanic waters have been in different state of exploitation, mostly in a primitive way. Significant strides have been made in the field of fisheries thanks to the various developmental activities carried out by the Department of Fisheries, Lakshadweep. The Central Marine Fisheries Research Institute also has played a key role in research, development and management of the fisheries. Now, the various activities in research, development and management are anxious to break out of the introversion displayed so far.

There is general consensus that the living resources in and around the islands hold great potential for exploitation to a high magnitude. But from a resource point of view the Lakshadweep archipelago was not surveyed or investigated upon seriously till recently. Most of the studies made, so far, mainly centered around Minicoy. Information that is available on the living resources is confined to faunistic records, taxonomic studies, observations on the fishing craft and gear, accounts on the biology of tunas and live-baits, natural history and some environmental parameters. With the realisation of the importance and scope for further development, attention is now being paid to take stock of the marine living resources by proper survey to assess and monitor these resources to postulate management measures.

The present review is to document all available information on marine research in Lakshadweep. The paper highlights essential aspects concerning the marine biological, fisheries and oceanographic research carried out in Lakshadweep.

A historical resume of marine fisheries research in Lakshadweep has been given by James *et al.* (1986a). The marine biological and fisheries research in this area dates back to the latter half of the 19th century when attempts were made by some British naturalists to study the flora and fauna of the Lakshadweep and Maldive Archipelagoes. The surgeon naturalist A. Alcock set sail on 17th October 1891 by R. M. S. *Investigator* and for two months cruised the Lakshadweep sea. Apart from a graphic description of the islands Alcock (1894) gave an account of the deep sea fishes collected from the Lakshadweep sea. The Cambridge University Expedition under the leadership of Prof. J. Stanley Gardiner was a significant event in the marine biological and oceanographic research and the results were reported in two volumes of *'Fauna and Geography of the Maldive and Laccadive Archipelagoes* (J. S. Gardiner (Ed.) 1903-1906). The atoll of Minicoy has been described by Gardiner (1900). Later, Hornell (1910) and Ayyangar (1922) described briefly the tuna fishing methods in Lakshadweep. The importance of the marine living resources and the need for judiciously exploiting them has been realised which resulted in the establishment of a Research Centre of Central Marine Fisheries Research Institute (CMFRI) and the Department of Fisheries, Lakshadweep in 1958 and 1959 respectively. During the last three decades scientists of CMFRI, NIO and Fisheries Department of Lakshadweep have furthered our

knowledge on the environmental characteristics, fishery resources, fishing methods and fishery biology of important tunas and live-bait fishes, corals, coral reefs and ancillary resources.

STUDIES ON ICHTHYOFAUNA

Some of the early accounts on the ichthyofauna are that of Alcock (1894, 1092) and Alcock (1890, 1892, 1898, 1899, 1900). A noteworthy contribution towards the knowledge of the ichthyofauna was made by Balan (1958). He made a visit to the islands Agatti, Kavaratti, Amini and Kadmat in March 1954 and documented 80 species of fishes belonging to 65 genera. Later, Jones and Kumaran (1959) while describing the fishing industry of Minicoy listed 154 species of fishes from the lagoon and reef, many of which being new records. Jones (1960a, 1960b, 1969), Jones and Kumaran (1967a, 1967b, 1967c, 1971), Jones *et al.* (1969, 1970) elaborated the list of ichthyofauna. The publication of the *'Fishes of the Laccadive Archipelago'* by Jones and Kumaran (1980) remains to be the most comprehensive account on the fish fauna of the Lakshadweep. They have documented 603 species of reef fishes and bathypelagic forms. Due consideration has been given to the systematics of commercially important tunas and related fishes as well as the common live-bait fishes.

EXPLORATORY SURVEY

As early as 1928 experimental trawling in the seas around Lakshadweep was carried out by the erstwhile Madras Fisheries Department, using Steam Trawler *Lady Goschen* (Sundara Raj, 1930). The material collected from *Basses de Pedro* Bank included quality perches such as *Lethrinus* spp., *Epinephelus* spp. and *Lutjanus* spp. A variety of invertebrates also have been collected.

A detailed account of the co-operative oceanographic cruises by R. V. *Kalava* is given by Jones (1959c). Valuable information on the oceanographic conditions and the fishery resources of the seas around Lakshadweep was collected during the cruises of this vessel. Larval fishes such as *Xiphias gladius, Istiophorus gladius, Katsuwonus pelamis, Euthynnus affinis* and *Auxis* sp. were collected (Jones, 1958a, 1958c, 1959a, 1959b, 1959d, 1960c, 1963). The results of the exploratory surveys of R. V. *Varuna* in the sea around the islands have been well documented by Silas (1968, 1969, 1972).

ASSESSMENT OF FISHERY POTENTIAL

Studies on the assessment of stock of tunas in the Lakshadweep and nearby seas were given priority in the research programmes of CMFRI in view of the fact that the steady increase in the landings and decrease in mean length of yellowfin tunas exploited by the Japanese tuna fishing fleet. Recent development of the purse seine fishery in the western Indian Ocean with reference to the repercussions on the stocks of migratory skipjack tuna have been pointed out by Jones (1986). The present estimate (1986) of the total marine fish production in Lakshadweep is 5535 tonnes of which tunas formed 4807 tonnes. This figure is quite low compared to the reported potential of 90,000 tonnes (Jones and Banerji, 1973) around the Lakshadweep The skipjack tuna resource of this area has been estimated to be 50,000 tonnes (George *et al.*, 1977).

STUDIES ON TUNAS AND RELATED FISHES

There is a well-established traditional system for the capture of tunas in Minicoy and some of the other islands by the pole and line fishing using live-baits. Scientific observations on the craft and gear and fishing methods were initially carried out by the erstwhile Madras Fisheries Department. Valuable observations on the fishing tackles and tuna fishing industry in the islands are that of Hornell (1910), Ayyangar (1922), Ellis (1924), Mathew and Ramachandran (1956), Jones (1958, 1960a, 1960b, 1964a, 1964b), Jones and Kumaran (1959), Varghese (1971), Puthran and Pillai (1972), Ben-Yami (1980), Silas and Pillai (1982, 1986), Ali (1983), Koya (1984), Madan Mohan *et al.* (1986), Nair (1986), Silas *et al.* (1986a) and Livingston (1987c, 1987d, 1987e).

Eversince the establishment of a Research Centre in Minicoy, the CMFRI has undertaken studies on tunas and live-bait fishes. Aspects such as the fishery, length frequency distribution, age and growth, length-weight relationship, maturity, spawning, food and feeding habits and other biological characteristics of the yellowfin and skipjack tunas have been studied by

Raju (1961, 1963, 1964a, 1964b, 1964c), Thomas (1964a. 1967), Thomas and Kumaran (1963), Appukuttan *et al.* (1977), Madan Mohan (1986a), Madan Mohan and Kunhikoya (1986a, (1986b), Madan Mohan *et al.* (1986a) and Varghese and Shanmugham (1987). Different types of tuna shoals have been described by Sials and Pillai (1982) and Livingston (1987a, 1987b). Madan Mohan (1986) gave a brief account of tuna shoals associated with flotsam. Studies on the population dynamics of tunas have been made by Silas *et al.* (1986b) and James *et al.* (1986c). The status and the various programmes of tuna fishery development and management in Lakshadweep have been discussed by Varghese (1986, 1987), Silas and Pillai (1986), James (1987), James and Pillai (1987) and James *et al.* (1987b).

RESEARCH ON LIVE-BAIT RESOURCES

The success of the pole and line fishery purely depended on the easy and timely availability of the live-baits in required quantity. Pioneering works on the faunal composition and exploitation of tuna live-baits of Lakshadweep, especially of Minicoy are those of Jones (1958, 1960a 1960b, 1961a, 1961b, 1964a), Jones and Kumaran (1980) and Thomas (1964b). During the cruises of R. V. *Kalava* the occurrence of *Spratelloides delicatulus* around many islands have been observed, and Jones (1960a) rightly pointed out its tmportance as a potential live-bait. Subsequently Jones (1961a, 1961b) recorded *S. japonicus*. Later, Jones (1964a) described 45 species of live-bait fishes belonging to 30 genera and 19 families based on the results of the primary survey. Detailed account on the fishing methods, storage and utilisation of the live-baits are also available (Jones, 1958). Another noteworthy work on the live-baits is that of Thomas (1964b). During 1960-61 he made observations on the fluctuations of live-bait fishes in Minicoy and pointed out that 11 species were being regularly exploited. The study included the length frequency distribution of *Lepidozygus tapeinosoma*, *Archamia fucata*, *Caesio caeruleus*, *C. tele*, *C. crysozoma*, *Dipterygonotus leucogrammicus*, *Chromis caeruleus*, and *Spratelloides* sp. Other studies on the ecology and biology of reef fishes at Minicoy with special reference to live-baits are also available which included *Spratelloides delicatulus* and *S. japonicus* (Madan Mohan and Koya, 1986c), *Chromis caeruleus* (Madan Mohan *et al.*, 1986b), *Dascyllus aruanus*, *Acanthurus triostegus* and *Abudefduf glaucus* (Pillai *et al.*, MS., Pillai, 1983). Unusual and massive recruitment of the reef fish *Ctenochaetus strigosus* to the Minicoy atoll has been shown by Pillai *et al.* (1984b). The microhabitat and coral association of the live-bait fishes of the lagoon of Minicoy has been elucidated by Pillai (1983a). He, further, pointed out the impact of mass mortality of corals on reef associated fishes. Functional mechanism of co-existance of some of the species of live-baits have been shown by Pillai *et al.* (1986). The correlation between the lunar cycle and the occurrence of pelagic baitfishes was demonstrated by Madan Mohan (unpub.). The present exploitation potential and plan for development of the live-bait fishes of Lakshadweep have been described by Nair (1986), Pillai *et al.* (1986) and James *et al.* (1987a). The ecological stress in Minicoy lagoon and its impact on tuna live-baits has been pointed out by Pillai and Madan Mohan (1986). Population characteristics of tuna live-baits in the Lakshadweep have been studied by Gopakumar and Pillai (1988).

The increase in the number of pole and line units consequent on mechanisation of boats has resulted in higher catches of tunas and hence the demand for live-baits also increased. This will have adverse effect on the stock of some of the common live-baits. Jones (1964b) thought of *Tilapia mossambica* as an alternate for live-baits and introduced it to Minicoy. Now the species has established itself in all the freshwater ponds, wells and some of tne marine tidal pools. Studies have revealed the unsuitability of this species as an alternate for live-baits.

STUDIES ON OTHER FIN FISH RESOURCES

The highly productive waters around the islands, the submerged banks and the crevices of coral boulders and reefs are ideal habitats for a large number of economically important fishes (Jones and Kumaran, 1980) which offers scope for extensive fishing by simple crafts and gears. Nearly one fourth of the landings in Lakshadweep at present is accounted for by fishes belonging to important groups such as elasmobranchs, perches, carangids, half beaks belonids, red mullets and seer fishes. An account

of the fishery resources of Laccadive Archipelago has been given by Jones (1968). Silas (1968) described the oceanic and demersal fishery resources of the Laccadive Sea. Problems, prospects and developmental programmes in fisheries sector, the need for diversification of the fishing effort for exploiting various resources have been pointed out by Varghese (1974), Haneefa Koya (1982), Kumaran and Gopakumar (1986), Varghese (1986, 1987a, 1987b). James (1987) and James *et al.* (1986b, 1987b). Silas and George (1970) have described the larval and post larval development and distribution of the mesopelagic fish *Vinciguerria nimbaria*.

Many of the reef fishes are colourful and attractive and have good demand for home aquaria in different parts of the world. Cheap to very expensive ornamental fishes offer scope for export on a limited scale and can be attempted with suitable arrangements for storage, transportation and marketing (Anon, 1985; Tomey, 1985, 1986; George *et al.*, 1986; James, 1987 and James *et al.*, 1986b, 1987b).

FISHERY ENVIRONMENTAL STUDIES

The Central Marine Fisheries Research Institute was first to initiate detailed oceanographic investigations on the environmental features of this region. During the cruises of R. V. *Kalava* and R. V. *Varuna* a lot of information on the physical, chemical and biological parameters of the marine environment and also some oceanographic features such as currents, water masses, upwelling etc. have been collected. The importance of the waters in this region with their special ecological conditions have been shown by Jones (1959c). The investigations of Ramasastry (1959) and Jayaraman *et al.* (1959) have revealed the existance of four distinct water masses in the Arabian Sea. The influence of the nutrient rich Antarctic bottom water in the Lakshadweep sea area was indicated by Prasad (1951) and Jayaraman *et al.* (1960). Other noteworthy contributions to the knowledge on oceanographic features of this area are those of Patil and Ramamirtham (1963). Rao and Jayaraman (1966), Rao and Jayaraman (1970), Sankaranarayanan (1973), Rao *et al.* (1976), Sen Gupta *et al.* (1979) and Ramamirtham (1979). A brief account of the environmental features of the sea around Lakshadweep has been given by Nair *et al.* (1986).

The early studies on the primary production of tuna grounds of the Lakshadweep are by Prasad and Nair (1964). The productivity of the reefs has been estimated by Nair and Pillai (1972). Qasim *et al.* (1972) made a comprehensive study on the primary production of the ambient waters and reefs of Kavaratti atoll. The primary production of the seagrass beds of Kavaratti atoll has been determined by Qasim and Bhattathiri (1971). Other major investigations on primary production of Lakshadweep waters are those of Bhattathiri and Devassy (1979) and Qasim *et al.* (1979). Nair *et al.* (1986) briefly described the productivity of the seas around Lakshadweep.

The earliest work on zooplankton is that of Wolfenden (1906) on copepods. Studies on zooplankton assemblages around some of the northern islands have been studied by Jones (1959). Silas (1972) estimated the zooplankton biomass closer to the reefs of the islands during the cruises of R. V. *Kalava*. Based on the studies on the Deep Scatterihg Layer (DSL) closer to the islands Silas (1972) suggested that the DSL constituted an important source of forage to the pelagic fishes. Tranter and Jacob (1972) made quantitative study of the zooplankton of Kavaratti and Kalpeni atolls. In spite of the importance of the zooplankton in the reef ecology, these organisms have received vary little attention. What little information available are due to the works of Gardiner (Ed.) (1906), Wolfenden (1906), Prasad and Tampi (1959), Goswamy (1973, 1979, 1983), Silas (1972), Tranter and Jacob (1972), Madhu Pratap *et al.* (1977), Nair and Rao (1973), Mathew (1982), Rengarajan (1983) and Silas and Mathew (1987). Qasim (1970) described some characteristics of a *Trichodesmium* bloom in the Laccadives.

The importance of satellite imageries from Landsat and Indian Remote Sensing Satellites and ocean colour sensing from Coastal Zone Colour Scanner (CZCS) of NIMBUS-7, which can provide general level of productivity, details of water masses in the area and aggregation of of fish schools, has been shown by Silas *et al.* (1985).

MARINE INVERTEBRATE FAUNA

The marine fauna and flora of Lakshadweep islands are unique and diverse. The early information on the marine fauna are mostly

based on the various articles published in the two volumes of *'Funa and Geography of Maldives and Laccadive Archipelagoes'* (J. S. Gardiner (Ed.) 1903-1906). Results of the detailed ecological survey of the marine fauna of the Minicoy atoll have been given by Nagabhushanam and Rao (1972). The studies carried out on the marine fauna are mainly from Minicoy which included foraminifera (Chapman, 1895): Corals (Gardiner, 1903b, 1906a, 1906b, 1906c; Cooper, 1906b; Pillai, 1971a, 1971 b, 1972, 1983a, 1983b, 1985, 1986,1987), Sponges (Thomas, 1973, 1979, 1980a, 1980b); turbellaria (Faidlaw, 1903), Coelenterates (Borradaile, 1906d; Browne, 1906a, 1906b; Mamman, 1963; Rengarajan, 1987), nemertines (Punnet, 1903a), cephalochordata (Cooper, 1903; Punnet, 1903b), enteropneusta (Punnet, 1906), echiuroids (Shipley, 1903a), Sipunculoids (Shipley, 1903b), Stomatopods (Fanchester, 1903) crabs (Alcock, 1895, 1896, 1898, 1899, 1900; Borradaile, 1903a, 1903b, 1903c, 1903d, 1906a, 1906b, 1906c; Sankarankutty, 1961), lobsters (Meiyappan and Kathirvel, 1978; Pillai *et al.* 1984a), cirripedia (Borradaile, 1903c), amphi-, poda (Walker, 1906), alphids (Coutiere, 1903, 1905, 1906), molluscs (Eliot, 1906; Hoyle, 1906; Smith, 1906; Hornell, 1910; Buston, 1940; Appukuttan, 1973; Rao *et al.*, 1974; Namboodiri and Sivadas, 1979; Nair and Dharmaraja, 1983; Panicker, 1978) and echinoderms (Bell, 1902; Gardiner, 1803a; Buston, 1940; Sivadas, 1977; Murty *et al.*, 1970; Mukhopadhyay and Samana, 1983, James, 1966; Nagabhushanam and Rao, 1972; Daniel and Haldar. 1974 and Rao and Misra, 1983).

ANCILLARY LIVING MARINE RESOURCES

There are a number of ancillary living marine resources which include seaweeds, crustaceans, molluscs, sponges, echinoderms, reptiles such as turtles, birds etc. Informations on these resources are based on the faunistic observations on one time or intermittant collections by different workers. An account of the ancillary resources have been given by George *et al.* (1986).

Algae: The marine algal distribution is generally sperce and heterogenous. From a resource assessment angle the marine algae have been surveyed (Anon, 1979) by Central Salt and Marine Chemicals Research Institute. Ansari (1980) observed the benthic micro and macrofauna of seagrass (*Thalassia hempricheii*) bed. Jagtap and Untwale (1984) gave an account of the chemical composition of marine macrophytes, their surrounding water and sediment from Minicoy. Untwale and Jagtap (1984) described the marine microphytes of Minicoy.

Crustacea: The prawns and crabs are not fished in Lakshadweep, The brachyuran crabs and lobsters of Lakshadweep have baen studied by Alcock (1895, 1896, 1898 1899, 1900) and Borradaile (1903, 1906). Alcock reported 41 species of crabs and Borradaile 52 species of crabs and two species of lobsters. Sankarankutty (1961) recorded 36 species out of which 27 were from Minicoy and the rest from some of the other islands. Meiyappan and Kathirvel (1978) published some new records of crabs and lobsters from Minicoy. Pillai *et al.* (1985) recorded *Panulirus versicolor* from Minicoy and opined that this species is most common with a seasonal distribution pattern. According to Meiyappan and Kathirvel (1978) *P. Penicillatus* was the most common lobster in Minicoy in the late seventies.

Mollusca: Early records on the molluscan fauna are that of Smith (1906) and Burton (1940). Appukuttan (1973) observed nine species of coral boring bivalves causing destruction to the fringing reef of the islands, Appukuttan and Pillai (MS) have listed 48 gastropods and 12 bivalves. Among the gastropods Top shells (Trochidae), Spider conch (Strombidae), Cone shells (Conidae), Cowries (Cypraedae) and Helmet shells (Cassidae) are commercially important and are exploited by the local fishermen.

Sponges: Thomas (1973, 1979, 1980a, 1980b) made observations on the sponge fauna and reported 41 species including some shell boring forms from Minicoy. The common Indian bath sponge, *Spongia officianalis* has been observed in Minicoy. Many of the sponges are rich in bromine and iodine.

Echinodermata: A number of holothurians suitable for *Beche-de-mer* are available in the lagoons of the islands. Early observations by Gardiner (1903) recorded both surface living as well as large numbers of white variety living in the sand. Later, Burton (1940) observed several

species of holothurians in every pool in Chetlat. *Holothuria atro, H. scabra, Actinopyga mauritiana* and *A. echinites* are most abundant species in Minicoy. James (MS) recorded ten species from Kiltan. Quantitative assessment of the resources has not been made and the available information points out lesser chances for large scale exploitation of this resource for the *Beche-de-mer* industry.

Turtles and Birds: Bhaskar (1984) has reported four species of turtles which occur and nest in Lakshadweep. They are the hawksbill (*Erethmochelys imbricata*), the olive-ridley (*Lebidechelys olivacea*), the green turtle (*Chelonia mydas*) and the leather-back (*Dermochelys coriacea*).

The whole sand bank of Pitti island was found literally covered with young of two species of terns (Alcock, 1902). The only specific studies on birds are that of Betts (1938) who reported 44 species including several shore and water birds such as plovers, terns, sand pipers, shear waters, teals and herons.

CONSERVATION OF THE ECOSYSTEM

Conservation of the ecosystem and the marine resources assumes paramount importance in any future plans for the development and as well to the very existance of these islands. The coral colonies which harbour a variety of flora and fauna are prone to natural senescence. A plethora of events both natural and man-made have been creating havoc to the ecosystem. Indescriminate dredging and blasting of the corals and sea erosion and the consequent siltation have resulted in the death of corals leading to imbalances in the reef ecosystem. The details about the oil spill in the Kiltan from oil tanker 'Transhuron' have been described by Qasim *et al* (1974). The lagoon environment of Minicoy has undergone visible change in the last decade due to natural causes and human interference (Pillai, 1983a, 1985, 1986). Possible threats to marine environment and ecology of Lakshadweep (Laccadive Islands) have been described by Sivadas (1987). The need for preserving these delicate ecosystems has been pointed out by James (1987) and James *et. al.* (1986b, 1987 b). The islands and the lagoons with the corals and a wide variety of flora and fauna are beautiful' idyllic and exhillarating and is a coral paradise (Anon, 1984). Declaration of a few undisturbed and undamaged areas in the region as marine parks and reserves are necessary (James, 1987; James *et al*, 1987b). This would have the advantage of not only preserving the nature but also providing excellent tourist attraction.

POTENTIAL FOR MARICULTURE

Limited experiments conducted in Bangaram lagoon for pearl oyster culture showed encouraging results. Further research will be required to study the technical feasibility and economic viability before large-scale programmes can be introduced (Varghese, 1987a; James, 1987; James *et al*. 1986b). It may also be worthwhile to undertake investigations on the feasibility of introducing aquaculture programmes suitable to the island conditions (James *et al.*, 1986b). James (1987) has pointed out the need for undertaking culture of live-bait fishes. Experiments are underway in the Research Centre of CMFRI at Minicoy. There exist amble scope for culture of finfishes in cages, seaweed culture, creation of artificial reefs and sea-ranching of commercially important fishes as well as holothurians.

DEVELOPMENT AND MANAGEMENT

The problems of Lakshaweep are varied and peculiar by virtue of its geographic location, density and variations of the marine living resources. developing suitable crafts. and gears as means of exploitation, meeting the requirements of manpower including trained personnel, making available the credit needed and providing infrastructure facilities for fish processing, transportation and marketing are some of the important aspects concerned with the development of marine fisheries (Jones, 1986; Sagar 1986; James, 1987; James and Pillai, 1987; James *et. al.*, 1986b; James *et. al.* 1987b; Silas and Pillai, 1986).

A wealth of information on the marine flora and fauna are now availabie. Except for continuous monitoring of some of the important resources such as tunas, live baits. corals and seaweeds most of these studies on the flora and fauna are based on intermittant observations at Minicoy and a few other islands by various authors from time to time. A realistic estimate

of the various resources both quantitative and qualitative is essential for any future plans for development and the CMFRI has conducted a short and time bound survey. This will remain as a bench mark for future surveys and developmental programmes. The various teams have collected information on various resources and their potential, could identify problems and prospects of fisheries development and areas and species for mariculture. Proper implementation of the suggestions and recommendations, it is hoped, would definitely give an uplift to the fisheries sector and finally the economy of the islanders.

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3. SOME OBSERVATIONS ON THE FISHERIES OF LAKSHADWEEP

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INTRODUCTION

Lakshadweep group of islands is constituted by 36 small islands, islets and submerged banks (reefs) lying scattered in the Arabian Sea between Lat. 8° and 12° 30'N. and Long. 71° and 74° E. This Union Territory has an area of 32 sq.km. and possesses 400,000 sq. km. of Exclusive Economic Zone. Of these, only ten islands are inhabited. Each island except Androth has a lagoon on the western side, and the lagoon and the reef provide ideal coral habitat for a variety of animals and plants. Water areas around these islands and submerged reefs which possess rich fishery resources are Agatti, Bangaram, Tinnakara, Parali, Perumul Par, Pitti, Suheli, Bitra Cheriyapaniam, Baliyapaniam, Kadmat, Kavaratte, Androth, Kiltan, Kalpeni, Elikalpeni and Minicoy. Of these, Minicoy, Agatti, Suheli and Bitra are important with regard to tuna pole and line fishery.

In recent years, Lakshadweep has assumed importance in view of the special consideration shown by the Government of India towards its alround development and welfare of the people. Marine fisheries has to play a major role in maintaining and upgrading the standard of the life of the islanders. In this context, contributions by CMFRI to the management of marine fishery resources are worth mentioning. Further steps are being taken by the Institute to expand research activities in particular fields in this Union Territory.

A series of recent publications have dealt with the status and Fishery of major and ancillary resources and ecological problems being faced by the islands, and management of the fishery (Alagaraja, 1987; George *et. al.* 1986; James, 1987; James and Pillai, 1987; James *et. al.* 1986 a, 1986b; 1987a, 1987 b; Jones, 1986; Kumaran and Gopakumar, 1986; Livingston, 1987a, 1987

b, 1987 c, 1987d, 1987e; Madan Mohan *et. al.* 1986; Piliai, 1983, 1985, 1986; Pillai and Madan Mohan 1986; Pillai *et al.* 1986; Pillai and Gopakumar, 1987; Silas and Pillai, 1982, 1986; Silas *et al.* 1986a, 1986b; Varghese, 1987a, 1987 b; Varghese and Shanmugham 1987).

FISH AND FISHERIES

Jones and Kumaran (1980) recorded 603 fish species from the Laccadive Archipelago. Planned programme for the development of fisheries in Lakshadweep commenced with the establishment of a Fisheries Section in 1959, with the objective of enhancing fish production by motivating local people by taking up modern methods of fishing, extension, education, training and providing subsidies. Prior to this, the fishing methods were primitive although a regular pole and line fishery was in existance in Minicoy using *Mas-odis*. Introduction of mechanisation and training of fishermen in modern methods of fishing, handling of mechanised boats and transfer of technology in fishing. processing, issue of mechanised boats to the islanders, establishment of boat building yards, workshop and processing units and providing infrastructural facilities such as jetties were the major achievements of the Fisheries Department in this field. Details of implementation of the schemes and impact of fisheries departmental activities on the socio-ecomic life of the islanders were dealt with earlier (Varghese, 1987b). However, according to Alagaraja (1987) there are about 3750 fishermen engaged in the actual fishing among whom 2100 persons are engaged in full time fishing, 200 in part time fishing and the rest 1450 in occasional fishing.

CRAFT AND GEAR

Details of mechanised and non-mechanised vessels engaged in different types of fishery in the Lakshadweep from early period were described by Jones (1958), Ben-Yami (1980) and Silas and Pillai (1982). Comparative merits of mechanised boats over non-mechanised boats in the skipjack tuna fishery was evaluated by Varghese (1971). Detailed description of mechanised crafts engaged in the pole and line fishery at Minicoy and Agatti islands has been provided recently by Madan Mohan *et al.*, (1986) and Varghese and Shanmugham (1987) respectively. Island-wise boats engaged in the pole and line, troll line and longline fishery as stated by the Department of Fisheries, Lakshadweep are as follows:-

Islands	*Pole and line Boats*	*Troll line Boats*	*long line Boats*
Agatti	51	6	—
Amini	2	2	19
Androth	—	—	34
Bitra	10	—	—
Chetlat	—	4	12
Kadmat	—	3	5
Kalpeni	—	—	5
Kavaratti	16	—	15
Kiltan	—	—	16
Minicoy	35	—	—

There are about 235 mechanised and 488 non mechanised plank built boats engaged in the fishery in the Lakshadweep group of islands (Alagaraja, 1987). Mechanised boats used for pole and line fishery number 114 (49%), followed by those for troll lines fishery (45% and longline fishery 15 (6%).

A variety of gears and implements such as pole and line, troll line, cast nets, shore seines, gillnets, harpoons, hand lines and long-lines are employed in the fishery from the lagoon and outside. Recently, Alagaraja (1987) summarised the fishing units in the fishery in the Lakshadweep, and according to him there are 115 units of pole and lines, about 600 gill nets, 210 boat seines (drag nets), 305 shore seines and 1360 cast nets. He also provided the gear-wise contribution during the five-year period 1980-84 (Table-1) and opined that the major contribution came from pole and line fishing, which accounted for about 56% of the total landing by all Bears. Troll and line contributed to about 22% followed by shore seines (11%), gillnets (3%), harpooning (2%), cast nets (1%) and the rest by hand lines. However, no clear-cut trend in the landings of these gears is evident as in the case of pole and line.

PRODUCTION

Year-wise production of the marine fishes in the Lakhshadweep during the 10 year period 1977-1986 is presented in Fig. 1 Ch. 4. The

average annual marine fish landings during the decade was estimated as 3903 tonnes. Though there were fluctuations in the annual landings during 1977-80 with the minimum of 2215 tonnes in 1977 and maximum of 3846 tonnes in 1979, a steady increase with minor oscillations from 2909 tonnes in 1980 to 5537 tonnes in 1986 has been noted during the rest of the period.

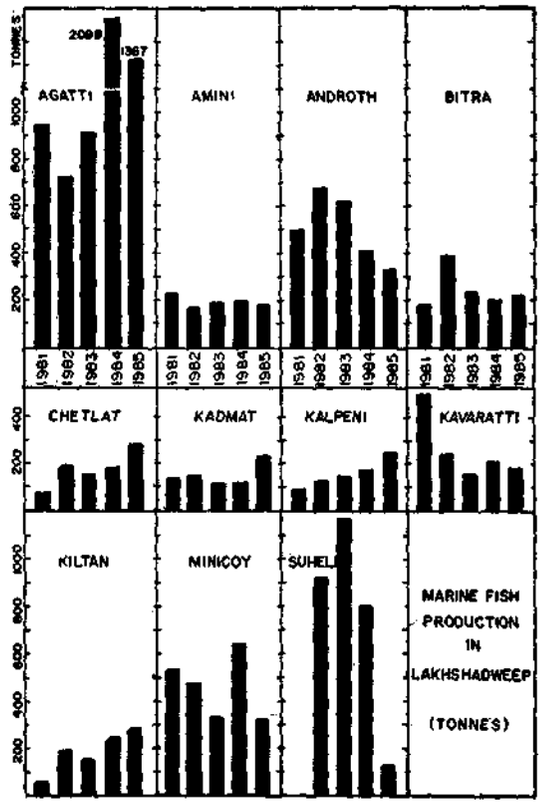

Fig. 1. Marine fish production in the different islands during 1981-85

The island-wise total marine fish production during 1981-85 is presented in Fig 1. The average annual production is indicated in Fig. 2. The major contribution to the total marine fish production came from Agatti, Suheli Par, Minicoy and Androth. There is year to year fluctuations. Compared to these islands, the landings in islands such as Amini, Bitra, Chetlat, Kadmat, Kalpeni, Kavaratti and Kiltan are low.

Average annual production of different marine groups for the period 1977-86 are presented below in their order of abundance:

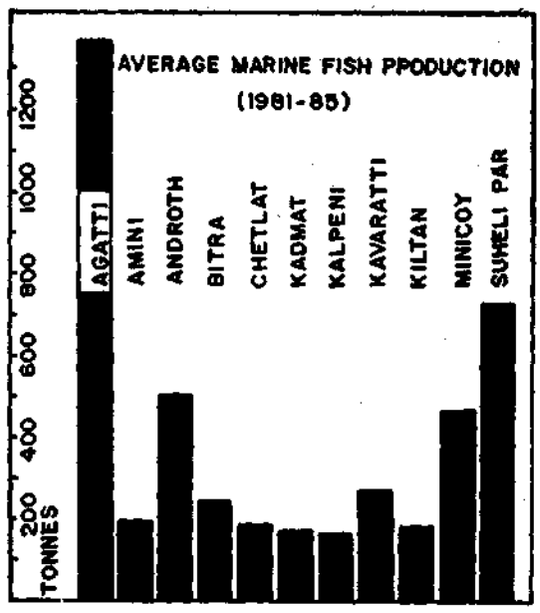

Fig. 2. Average (1981-85) marine fish production in the different islands of Lakshadweep.

(1977-1986)

Group	Average annual production (tonnes)	Percentage
Tunas	2873	73.9
Pelagic sharks	186	4.8
Perches	162	4.2
Garfishes	85	2.2
Rainbow runner	76	2.0
Rays	70	1.8
Carangids	66	1.7
Seerfishes	50	1.3
Sailfishes	33	0.8
Goatfishes	29	0,7
Coral fishes	26	0.7
Flying fishes	21	0.5
Octopi	16	0.4
Barracudas	13	0.3
Triggerfishes	8	0.2
Miscellaneous items not classified	174	4.5

Major share of total marine landings has been accounted for by tunas which formed about 74% in the average, and the trend of production of tunas follow the trend of total marine fish production. Further, the contribution of tunas increased from 71% in 1982 to 87% in 1986. These indicate the dependence of marine fisheries in the Lakshadweep on this group of scombroids. Other groups which contributed

to in a major scale were pelagic sharks, perches, gar fishes, rainbow runner, rays, carangids and seer fishes.

Total production of tunas in the Lakshadweep during the period 1977-86 is presented in Fig. 1(Ch. 4). The minimum landing of 1165 tonnes was in 1977 and maximum of 4807 tonnes was recorded in 1986. Skipjack tuna and young ones of yellowfin tuna contributed to 90% of the surface catch in the Lakshadweep. However, on an average,annually about 2873 tunas were landed in Lakshadweep during this period.

The status of total tuna landings in India and contribution of Lakshadweep in recent years are as follows:

	Total all India tuna landings (tonnes)*	*Tuna landings in Lakshadweep* (Tonnes)**
1983	17871	3037
1984	21618	4313
1985	32363	3774
1986	35607	4807

*Estimate by CMFRI

**Estimate by the Fisheries Department, Lakshadweep

From the above data it is evident that, the average contribution by Lakshadweep to the total tuna production in the country was about 18%.

Average annual island-wise landing of tunas during the period 1977-86 is presented below:

Island	*Tuna landing* (tonnes)	*Percentage*
Agatti	1114	51.1
Amini	78	3.6
Androth	218	10.0
Bitra	185	8.5
Chetlat	99	4.5
Kadmat	55	2.5
Kalpeni	62	2.8
Kavaratti	184	8.4
Kiltan	73	3.4
Suheli	626	28.8
Minicoy	483	22.2

The significant increase in the landing by pole and line (live-bait) fishery at Agatti, Suheli, Minicoy and Bitra contributed much to the total production of tunas in the Lakshadweep.

Varghese and Shanmugham (1987) indicated that based on average for the years 1976-85, the tuna catch at Agatti, Minicoy and Bitra accounted for about 63%, 27% and 9% respectively of the total tuna catch. At Agatti, a bimonthly peak in abundance in tuna catch was recorded by him viz., during March-April and November-December periods in most of the years under consideration. Similar trend in the peak periods of tunas were observed at Minicoy by Pillai and Gopakumar (1987) during 1984-87.

A comparative account on the annual average catch composition (%) of different groups of fishes in the fishery at Agatti (1976-85) and Minicoy (1984-87) islands is presented below:-

Groups	*Agatti Is*	*Minicoy Is*
Tunas	87.30	84.10
Billfishes	0.75	0.40
Carangids	0.76	1.60
Garfishes	1.05	No data
Perches	0.67	2.00
Pelagic sharks	4.30	3.20
Rainbow runner	0.20	3.33
Octopi	0.17	No data
Coryphaena	No data	0.50
Barracudas	No data	0.60
Seerfishes	No data	4.30
Miscellaneous	4.80	—

The differential composition in the catch may be due to the employment of different gears during monsoon and non-monsoon months in these islands.

DISCUSSION

The Central Marine Fisheries Research Institute has already developed a data base on various marine resources of the Lakshadweep islands and related conservation problems. Of recent, the concentration of efforts by the Institute was on coral reefs, tunas, tuna live-baits, ornamental fishes and other ancillary resources. The Institute has recently conducted an aimed survey on tuna live-baits around and

inside tha lagoons of all inhabited islands (Nov. 86-March, 87) and an overall survey of the fishery potential of the Lakshadweep (Jan-March, 87). The former aimed at indepth investigations on the habitat patterns and quantitative distribution and availability of the tuna live-bait resources, and the latter concentrated on an overall assessment of various types of fishery resources, their potential, impact of environmental damage to the coral reef ecosystems, evaluation of ancillary marine resources such as sponges, echinoderms and ornamental fishes and for identifying areas for mariculture, and measures that would help in perspective planning and development of fisheries and other marine living resources.

Skipjack tuna, *Katsuwonus pelamis* and young ones of yellowfin tuna, *Thunnus albacares* constitute the major tuna resources of these Islands taken by the pole and line fishery. At Minicoy, the pole and line fishery using live-baits has been in vogue for over a centuary. Introduction of mechanisation in the early 60's and the spread of pole and line fishing practice to some of the northern islands such as Agatti, Suheli, Bitra, Perumul Par etc are the two developments in this sector. The trend of tuna fishery in the Lakshadweep has been reviewed by Silas *et. al.* (1986 b) based on the information gathered at Minicoy. The present trends, constraints and strategies for future development of small scale pole and line fishery at Lakshadweep has been critically reviewed by James *et al.* (1987b). Strengthening and expansion of the pole and line fishery by the introduction of larger pole and line boats with adequate chilling and storing facilities needs attention. Introduction of medium sized purse seiners, especially in the northern islands, provided processing, marketing and handling are taken care of, is another proposal for better returns. Other operations like gillnetting, surface trolling and longlining suitable for local conditions could be tried and popularised for tuna fishing which would assist in reducing live-bait requirement. Further, for commercial exploitation, it is proposed to operate large purse seiners and pole and line vessels on collaborative terms with other countries, and to operate a mother vessel to enhance the range of operation of smaller vessels (Varghese, 1987a).

The impact of Fish Aggregating Devices (FAD) as observed by Silas and Pillai (1982) and James *et al.* (1986 b) will be on the small scale fishery sector such as pole and line tuna fishery. Tuna fishing around these structures will result in increased catches, reduction in scouting and voyage time, conservation of fuel energy and also it will be a safety factor. This method with modifications can be employed in the whole island realm for increasing tuna catch in the small scale sector.

Live-baits form an important component in the tuna fishery. In recent years the demand for live-baits has increased considerably, and shortage for the same has been faced. As described elsewhere by Pillai *et. al.* (1986), James *et al* (1987a) and Kumaran *et al.* (in this volume), the non-availability of live-baits in required quantities can be attributed to (1) tampering of the lagoon ecosystem, (2) seasonality in the recruitment pattern of migrant species, and (3) exploitation pressure. In Minicoy, the CMFRI is making attempts for rearing and culture of important live-baits such as *Chromis caeruleus* and *Spratelloides delicatulus*. In the northern islands, rational exploitation of *S. delicatulus* which is the only species utilised for tuna pole and line fishing, should be advised and management measures for the maintenance of the stocks implemented. Fishermen should be encouraged to exploit alternate species belonging to Pomacentridae, Apogonidae and Caesionidae which are associated with coral colonies in the deeper regions of the lagoon. The Department of fisheries may also provide necessary infrastructure and facilities to collect from open sea areas and outside the lagoons, transport and impound live-baits in the lagoon areas for future use.

Even without much organised effort, nearly 20% of the landings in Lakshadweep is accounted for by other fishes such as pelagic sharks, perches, carangids, seerfishes, rainbow runner etc. Diversified fishing efforts such as longlining for sharks, drift gillnetting for other groups coupled with improvements in crafts to fish in distant waters would help in a long way in tapping these resources.

Several coral reef fishes are considered as excellent ornamental fishes for aquarium in

many parts of the world. Cheap to very expensive ornamental fishes offer scope for export on a limited scale (Anon, 1985; Tomey, 1985, 1986; George *et al.* 1986; James *et al.* 1987b). More than 100 species of ornamental fishes belonging to 28 families could be exploited and marketed. Recent survey of the fishery potential of Lakshadweep carried out by the CMFRI has also proved the existance of exploitable quantities of ornamental fishes. Collection methods without tampering the reefs, packaging and transportation facilities needs to be developed so as to tap these resources for export trade. Resource surveys for the holothurians (*Beche-de-mer* industry) and sea weeds (*Agar Agar* Industry) were conducted by the Department of Fisheries, Lakshadweep and CMFRI. But the occurrence, abundance and replenishment of these resources for taking up commercial ventures are yet to be ascertained.

Tuna fishing is the mainstay of the Lakshadweep islands. The strategies for future development of the tuna fishery at Lakshadweep as suggested by Silas and Pillai (1986), James and Pillai (1987) and James *et al.* (1987), coupled with the future programme of development of fishing industry suggested by Varghese (1987a, 1987b) will go a long may in making the industry more lucrative, economical and beneficial for the people.

TABLE 1. *Annual gearwise catches (in tonnes) in Lakshadweep during 1980-84.*

Gear	1980	1981	1982	1983	1984
Pole and line	1160	1636	2366	2573	3713
Troll line	854	878	966	921	828
Castnet	56	25	27	35	24
Shoreseine	410	401	462	508	382
Gillnet	128	128	112	137	77
Harpooning	72	36	41	89	102
Handline	4	7	7	11	7
Longline	225	189	220	268	198
Total	2909	3300	4201	4542	5331

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4. TUNA RESOURCES AND PLAN FOR DEVELOPMENT

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INTRODUCTION

In recent years attention has been focused towards the development of Fisheries in the Lakshadweep by the Government to improve the life style and economy of the islanders. Introduction of mechanisation in the early sixties has resulted in the increase of tuna production at Minicoy, where a traditional fishery employing 'Masodis' was in existance. Coupled with this, the spread of pole and line fishing practise towards the northern islands such as Agatti, Bangaram, Perumul Par, Suheli and Bitra has resulted in the production of tuna from a few hundred tonnes in the 60's to about 4807 tonnes in 1986.

Oceanic tunas such as skipjack (*Katsu wonus pelames*) and young ones of yellowfin tuna (*Thunnus albacares*) constitute the major resources of this area taken by the pole and line live-bait fishery during September to May period every year. Surface trolling also land yellowfin, skipjack and billfishes in the order of their abundance, especially during the monsoon period.

CRAFTS AND GEARS

The crafts and gears engaged in the tuna fishery has been dealt with recently by Silas and Pillai (1982), Madan Mohan *et al* (1986), George Varghese (1987) and Livingston (1987 a, 1987 b, 1987 c). The statistics of crafts and gears presently engaged in the tuna fishery are summarised by James *et al* (1988: in the same volume).

PRODUCTION

The total tuna catch in the Lakshadweep Island during the period 1977-86 is presented in Fig. 1. It is evident that the total catch increased from about 1165 tonnes in 1977 to 2794 tonnes in 1979, after which the catch declined to 1759 tonnes in 1980. In 1981 about 2236 tonnes of tunas were taken. Subsequently, the tuna catch increased steadily with minor fluctuations and reached an all time peak of 4807 tonnes in 1986.

Based on the data from Minicoy (1976-1987) and Agatti (1976-1987) and Agatti (1977-1985), if the average annual catch of tunas which amounts to about 2900 tonnes

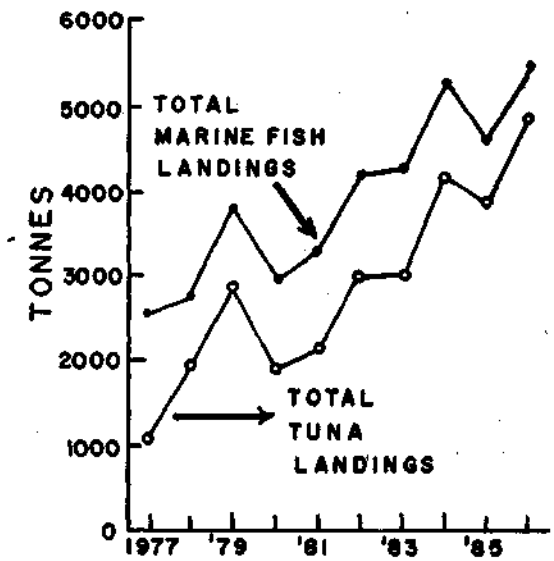

Fig. 1. Total marine fish and tuna landings in Lakhshadweep during 1977 1986

(1977-86) at Lakshadweep is aportioned group-wise, the skipjack tuna may constitute on an average 2156 tonnes, yellowfin tuna 560 tonnes and other tunas and billfishes 84 tonnes during this period.

Island-wise production of tunas during the period 1977-86 is indicated in Figs 2-12. It is evident from the data that Agatti Island ranks first with an annual average catch of 1114 tonnes, followed by Suheli (626 tonnes), Minicoy (483 tonnes) and Bitra (185 tonnes). According to Varghese (1987), the annual average CPUE at Agatti, Minicoy and Bitra are 419 tonnes, 180 tonnes and 252 tonnes respectively during the period 1977-86.

At present the information available on the catch, effort, CPUE and biology of tunas are

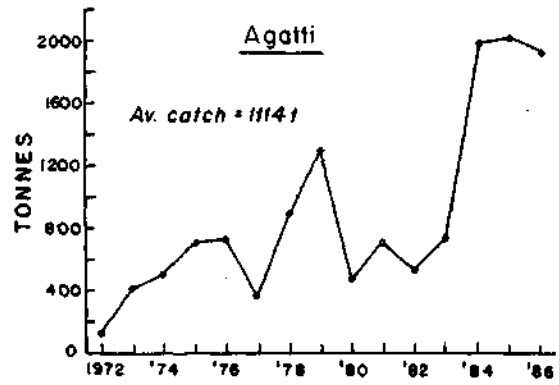

Fig. 2. Year-wise tuna landings in Agatti

from Agatti (1971-85) and from Minicoy (1979-87). The trend of these factors at Minicoy has been described by Madan Mohan *et al* (1986) and at Agatti by Varghese and Shanmugham (1987). In both the islands, relatively high catch rates were observed during March - April and November - December periods.

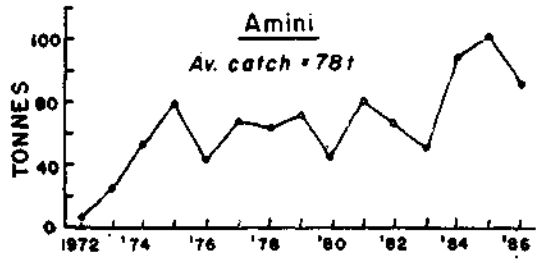

Fig. 3. Year-wise tuna landings in Amini

Biological information on the growth parameters of skipjack tuna and spawning biology of skipjack tuna are also available (Silas *et al.*, 1986; Madan Mohan and Kunhikoya, 1986). Information on sex ratio, spawning season and food and feeding habits of skipjack tuna at Agatti has been presented by Varghese and Shanmughom (1987) for the period 1977-79.

Basic data on the stock structure and growth parameters of these two species have been described by Silas *et al.* (1986), and the results obtained were as follows:-

	Silas et al (1986)	*James et al* (1986)
	K. pelamis	
$L\alpha$	90.0 cm	90.0 cm
K (annual)	0.4898	0.4898
t_o	-0.0600	-0.0600
Z	2.56	1.89
E_p	0.71	—
	T. albacares	
$L\alpha$	145 cm	
K (annual)	0.3200	
t_o	-0.3400	
Z	3.488	
E_p	0.85	

In both the studies, it was indicated that the present level of exploitation of the skipjack tuna does not affect the species stock and the capture of this species has not reached the MSY level. Studies conducted on the yellowfin tuna (young ones) by Silas *et al.* (1986) revealed that expansion of the fishing operations to areas beyond the present zone of exploitation would widen the scope for realising higher yields.

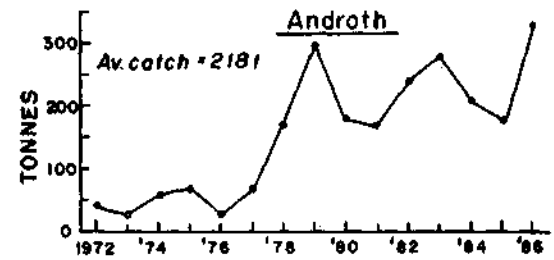

Fig. 4. Year-wise tuna landings in Androth

Expansion of pole and line fishery is limited by the availability of suitable live-bait resources in quantity, their maintenance and transportation, availability of tuna shoals in the fishing ground, response to chumming, expertise of fishermen etc (James and Pillai, 1987). Recent aimed resource survey on baitfishes conducted by CMFRI in the Lakshadweep have proved beyond doubt the vast resources of potential tuna live-bait species belonging to the families

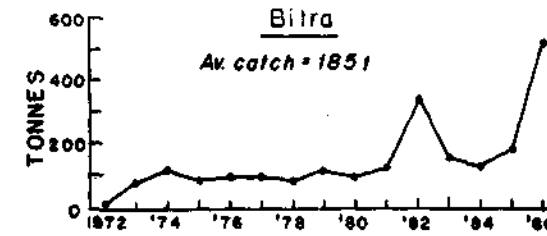

Fig. 5. Year-wise tuna landings in Bitra

Dussumieridae, Apogonidae, Caesionidae, Pomacentridae and Atherinidae (other than the traditionally used sprat *Spratelloides delicatulus*) around Agatti, Bangaram, Perumul Par, Suheli Par, Kadmat, Kalpeni and Bitra. *S. delicatulus* with positive chumming quality and easily fished

by surrounding nets is the only species currently exploited for the tuna pole and line fishery in all the northern islands other than Minicoy. Major constraints in the utilisation of this species are the large scale mortality at the time of capture, storing and transportion. Since the fishery is chiefly dependent on the availability of this species, its scarcity often results in abrupt suspension of tuna fishery in these islands. Exploitation of the alternate bait fishes belonging to Apogonidae, Caesionidae and Pomacentridae

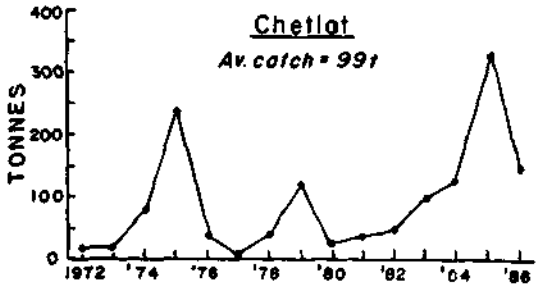

Fig. 6. Year-wise tuna landings in Chetlat

should be encouraged in all the islands which would lead to the augmentation of live-bait production and dispel the threat of overfishing and consequent depletion of the exploitable stocks of *S. delicatulus*.

In this context, it is worthwhile to mention that experiments/attempts have already been commenced at Minicoy by the CMFRI for rearing and culture of selected species of tuna live-baits

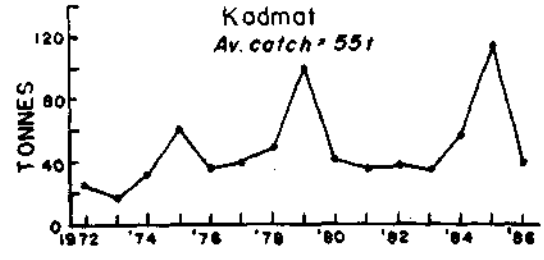

Fig. 7 Year-wise tuna landings in Kadmat

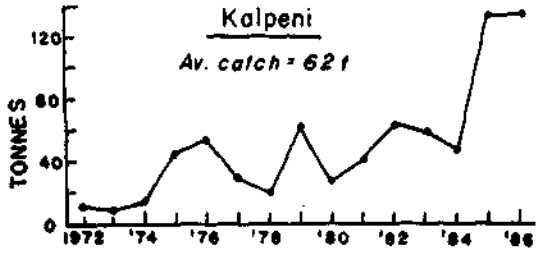

Fig. 8. Year-wise tuna landings in Kalpeni

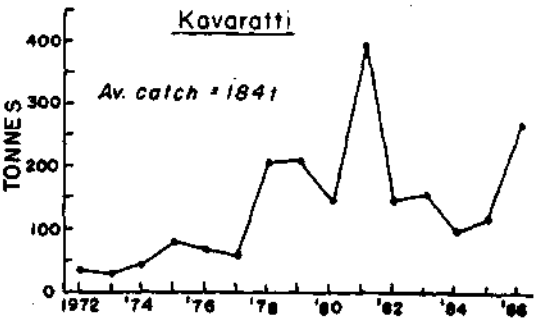

Fig. 9. Year wise tuna landings in Kavaratti

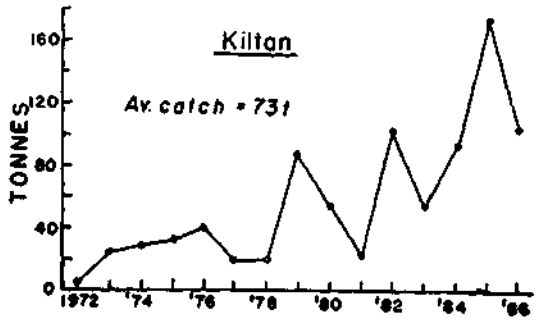

Fig. 10. Year-wise tuna landings in Kiltan

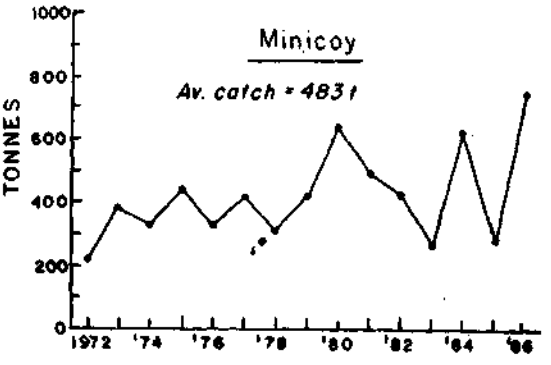

Fig. 11. Year-wise tuna landings in Minicoy

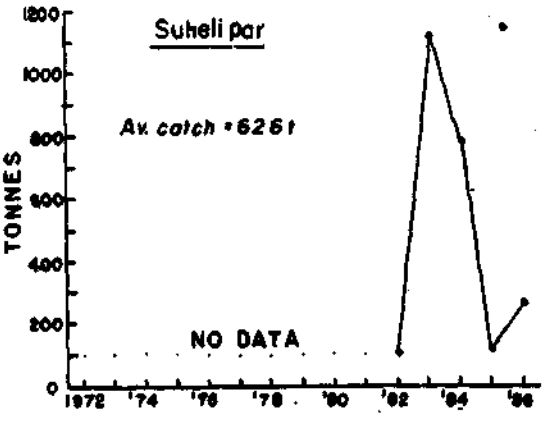

Fig. 12. Year-wise tuna landings in Suheil Par

such as *Chromis caeruleus* in the field and lagoon to evaluate their sturdyness, behaviour and production under captivity.

As opined by Silas and Pillai (1986) and James and Pillai (1987), at the modest estimation of production 60-100 tonnes of tunas per season per boat of OAL 15-20 m OAL and estimating average as 120 kg/production of tunas/per kg of baitfish, the requirement of each boat per season will be about 0.6-08 tonnes. Introduction of about 100 boats of the above size would enhance the production of skipjack and yellowfin tuna (young ones) to about 10,000 tonnes by 2000 AD.

FUTURE DEVELOPMENT AND MANAGEMENT OF TUNA FISHERY IN THE LAKSHADWEEP

Development of the infrastructure, technology and human resources in addition to harvesting, processing, marketing, servicing and material supply to enable the country to harnes the fishery resources are important in the fishery development plans. In the development of small-scale pole and line tuna fishery in the Lakshadweep, the following strategies appear to be pertinent:

1. *Information Base*

Statistics on all aspects of fisheries are needed for planning, implementation and subsequent monitoring of fishery management and development, Departmental capability to collect data and information at sub-regional level in the Lakshadweep need strengthening.

2. *Man power*

According to Varghese (1986), the major problem faced by the fishery sector is the shortage of manpower, and blocking of manpower in the nonproductive sector. A feasible proposal for providing employment and income generation for the local population would seem to be to make fishing in the small-scale sector more lucrative by introduction of enhanced per capita income plans by IRDP/NREP agencies.

3. *Conservation of coral ecosystem*

Development and management plans should take into account the need to protect marine habitat around the island ecosystem from any form of degradation. The coral colonies which harbour the live-bait fishes are prone to natural senescence. Indiscriminate dredging and blasting of the lagoon habitat may cause altered current patterns, which may result in the siltation in the areas of coral growth, thereby causing the death of coral colonies and the resident live-bait species. Environmental damage should be kept minimum while implementing development programmes for navigation. Installation of artificial reefs and habitat studies should be given priority to attract coral associated bait fishes to these habitats. Further, rejuvenation and trials to regrow corals by transplanting live corals into regions where they thrived earlier need consideration,

4. *Bait fishes*

Aimed exploratory tuna bait resources surveys conducted in the Lakshadweep by scientists attached to the CMFRI establisments at Minicoy and Agatti (Nov. 86 to March, 87) have proved that vast resources of potential bait fish species, both migrants and resident forms are available around Agatti, Bangaram Perumul par, Suheli Par, Kadmat and Bitra. Results of these surveys, coupled with the encouragement to use economically viable confinement and transportation methods for hardy live-baits would contribute much in planning the utilisation of bait species of these areas, without exhausting their resources.

The sprats being shallow water species can easily be fished in desired numbers using encircling type of nets. The major constraint in the utilisation of this species is the large scale mortality at the time of capture, storing in live-bait tanks and transportation, due mainly to osmoregulatory stress, Since the fishery is dependent on the availability of this single species, scarcity of the same often causes abrupt suspension of fishing activities even during peak fishing months, and also the threat of over exploitation of stock can be anticipated. Steps should, therefore, be taken and fishermen encouraged for exploiting the baitfishes belonging to pomacentridae, apogonidae and caesionidae which are associated with coral colonies in the deeper parts of the lagoon by means of lift nets. Species belonging to the above groups also exhibit good chumming qualities. In view of the vast resources of bait fishes in the lagoons and outside around most islands it is suggested

that they could be harvested by small purse seines and other suitable gear and transported to adjacent areas where they could be impounded in the lagoons for further use on demand. Necessary infrastructure for such operations should be provided by the Department of Fisheries.

Future programmes of CMFRI include large scale rearing, attempts on culture and estimation of the natural stocks of live baits in Lakshadweep. Night fishing through lights will also be experimented upon. Research on transportation of live-bait, holding them in large impoundments, compatibility and density of species in such impoundments etc. would also be undertaken.

5. *Tuna fishery*

An average of about 2900 t o tunas were annually exploited by the small scale pole and line fishery during 1977-86, and in recent years the approximate contribution by Agatti, Minicoy, Suheli Par and Bitra are 51%, 22%, 29% and 9% respectively. Of these, at Minicoy its isolated geographical location and the consequent immobility of small pole and line boats for expanding the area of fishing without navigational aids, and the live-bait scarcity often experienced by the fishermen are the main constraints for the further expansion of the fishery. On the contrary, Agatti, Suheli Par and Bitra, due to their proximity to other islands and reefs and also due to the added advantage of getting enough live-baits. offer further scope for the present small-scale pole and line fishery.

The introduction of a new generation of larger pole and line vessels (15.20m OAL) with adequate navigational, chilling and storing facilities for 4-5 days of fishing as recommended by Silas and Pillai (1982) is particularly significant to Minicoy Island due to its isolated geographical location. In this connection, it is worth mentioning that a radio beacon station and a radar transponder beacon (RACON), (9300 to 9500 MHZ) can be made use of by the fishermen with the help of a simple direction finder/ radar equipment. For commercial exploitation of tuna it was proposed to operate large purse seiners in collaboration with other countries, and to operate a mother vessel to enhance the operational range of smaller boats (Varghese, 1987).

The high catch rate of fishing from schools associated with flotsam at Minicoy, indicate that installation of fish Aggregating Devices (FADs) may be successful in augmenting tuna production. The major impact of FADs, as observed by Silas and Pillai (1982) and James *et al.* 1987) will be in the small-scale sector such as pole and line fishery as tuna fishery around these structures result in increased catches, reduction in scouting and voyage time and as well save fuel. The method with modifications if needed can be extended to the whole region for increasing tuna catches.

6. *Product development marketing and post-harvest technology*

At Lakshadweep the main catch disposal method is by converting it to *masmin.* At Agatti, Suheli Par and Bitra, the catch after removing a fraction for domestic consumption is converted to *masmin.* Approximately about 500 tonnes of *masmin* is produced annually from Lakshadweep in recent years. The price of *masmin* varied from Rs. 30 to Rs. 40 per kg. The development of an organised marketing system will be beneficial to the tuna fishermen since it can solve to some extent the present problems of getting proper market and sudden price fall of the product. At Minicoy, a portion of the catch (average 70 tonnes annually) is canned by the Govt. Canning Factory, and a scheme for establishing canning factory at Agatti has recently been proposed. However, in view of the economical returns, steady markets for *masmin* inside the country and export should be explored and developed.

Utilisation of waste

Disposal of waste is another aspect deserving immediate attention. At present, the head, bones, fins etc of the fish are discarded on the beach of the islands, which get decayed and act as breeding sites of house flies, causing health hazards during the fishing season. A small-scale waste utilisation method by converting them to fish meal may be advisable since the product can be used as an excellent manure for coconut plantations in the islands or the possibility of converting the waste from tunas as ensilage should be explored.

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5. LIVE-BAIT RESOURCES AND DEVELOPMENT

M. Kumaran, P. P. Pillai, R. S. Lal Mohan, V. Sriramachandra Murty and G. Gopakumar

INTRODUCTION

The success of the pole and line fishery of Lakshadweep depends, among other factors, directly on the availability in sufficient quantities of suitable live-bait fishes around the islands. Information on the live-bait resources of Lakshadweep is limited to a few reports from Minicoy. Jones (1958, 1964) described the fishing method, storage and utilisation of bait fish and listed the various species of live-bait fishes of Lakshadweep. Jones (1961 a, 1961 b) has predicted the potentialities of *Spratelloides delicatulus* and *S. japonicus* as live-bait for pole and line fishery for skipjack much earlier than mechanised fishing was introduced in the northern islands of Lakshadweep. Thomas (1964) made some observations on the fluctuations in the live-bait fishes at Minicoy. Fluctuations in the seasonal availability of live-baits at Minicoy during the years 1981-85 has been presented by Pillai *et al.* (1986). However, details of exploited bait fish resources and seasonal abundance of different bait species around the various islands is still lacking.

Exploratory surveys for live-baits covering all the lagoons and adjacent shallow reef areas of the islands have not been attempted till now. The important findings of the survey of tuna live-bait resources to assess the availability and abundance forming part of the survey of the fisheries potential of Lakshadweep carried out from January to March 1987 is presented in this paper. The results of exploratory tuna live-bait resources survey by the staff of the Research Centre at Minicoy around some of the islands and reef areas from October 1986 to March 1987 have also been incorporated in this report to make the same more comprehensive.

METHOD OF SURVEY

Observations and collections were made in the intertidal regions, lagoons, reef flats and windward and leeward slopes of the islands. The data on the occurrence and relative abundance of potentially important species were collected by operating bait fishing nets used in pole and line fishing by professional fishermen, supplemented by visual observations and by operating drag nets and velon screen.

CRAFTS AND GEARS

Mechanised boats of 7.62 and 9,14 m OAL were used for tuna live-bait survey in different islands. Bait tank measuring 1.6 x 0.8x 0.8m fitted in front of the engine room is divided into two compartments by a movable partition in the middle of the tank. Sea water circulation in the bait tank is maintained by specially devised water circulation system, the intake position of which is near the hull along the bottom. The quarter deck which is about 1m broad is constructed on the top of the quadrant which serves as the pole and line fishing platform. The space between the engine room and the fishing platform is used as the fish hold.

Two types of bait fish nets operated traditionally for bait fishing in the islands and drag nets measuring 12 m x 1.5 m were employed for the survey. In Minicoy, "Engala dhau", a rectangular net measuring 5.8 x 5.3m made of nylon webbing having mesh size of 6 mm is used for collection of bait fishes like sprats, apogonids, caesiodids, pomacentrids etc. from the deeper parts of the lagoon and from the nearshore waters on the leeward side. After locating bait fish concentrations, the net is lowered and spread near the bottom with the help of four poles tied to its corners. Bait fishes are lured by fish meat paste and the net is quickly hauled up when sufficient quantity of bait fishes are gathered over the net, and the baits transferred to the bait tank of the boat. This traditional method of bait fish capture is not practised in any of the other islands.

For collection of bait fishes, "Hondeli dhau" made of nylon webbing 30 x 1.5 m having mesh size of 6 mm with wooden floats and lead sinkers is used in all the islands where pole and line fishing is carried out. This net is used as an encircling net (Fig. 1 A) to collect baits

especially sprats atherinids and apogonids from shallow areas of the lagoon. The shoal is encircled by a scare line with coconut leaves by about 6 persons who drive the bait fishes to the nylon net operated by two persons. A small netting made of organdie or mosquito curtain cloth is used for collection and transfer to the bait tank.

SPECIES COMPOSITION OF LIVE-BAITS

The data collected during the surveys indicate that the species belonging to the families Dussumieriidae, Apogonidae, Caesiodidae, Pomacentridae, Emmelichthyidae and Atherinidae are present in varying proportions in the collections made by encircling nets, lift bait fishing

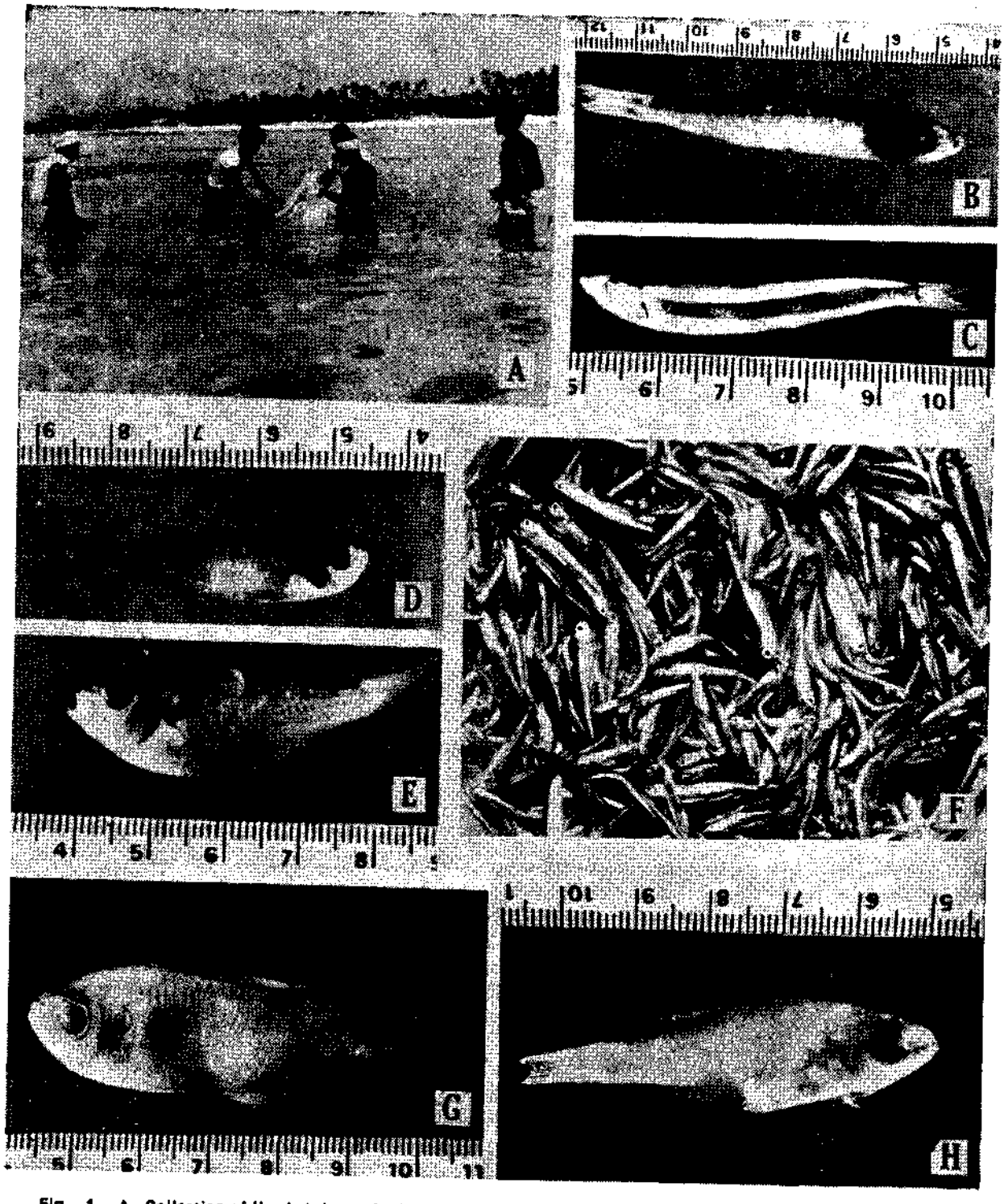

Fig. 1. A. Collection of live bait by encircling net at Chetlat. B. *Gymnocaesio argenteus* C. *Spratelloides japonicus*. D. *Lepidozygus tapeinosoma*. E. *Chromis caeruleus*. F. Mixed catch of *Spratelloides delicatulus* and *Allanetta barnesi* at Kadmat Island. G. *Archamia fucata*. H. *Ostorhynchus apogonides*.

nets and drag nets from different islands and reef areas. The species which are abundant and commonly occurring are listed in Table 1. It could be seen that *Spratelloides delicatulus, S. japonicus. Archamia fucata, Apogon leptacanthus, A. sangiensis, Dipterygonotus leucogrammicus, Gymnocaesio argenteus, Caesio chrysozona, Lepidozygus tapeinosoma* and *Chromis caeruleus* are the most important bait species abundantly occurring in the Islands. *Spratelloides delicatulus* which is the most widely used and sought after species of bait fish is available at all the islands except Amini and was abundant at Perumal Par, Bitra, Suheli, Minicoy and Kalpeni. The length range observed in the collections during the survey is 20-55mm. *Spratelloides japonicus* (Fig. 1 C) is abundant at Perumal Par, Bangaram and Minicoy. The length ranged from 22-65 mm in the collections. Apogonids are abundant at Kavaratti, Minicoy, Kadmat and Agatti and the catches are low at Amini, Androth, Chetlat and Kiltan. Atherinids are abundant at Amini, Bitra and Kadmat. The length range of *Allanetta barnesi* is 18-65 mm. *Chromis caeruleus* is either abundant or common at most of the islands except Androth, the length range being 22-63 mm.

The percentage composition of major groups of live-baits collected during the resources survey from October 1986 to March 1987 given in Table 2 indicates that pomacentrids and sprats are most abundant around most of the islands. When the live-bait collections from each island are considered separately, the percentage composition of pomacentrids collected from different islands varied from 9.40% to 76.35%, sprats from 11.93% to 51.0% and apogonids from 1.02% to 63.22%. Sprats are more abundant at Chetlat (51.0%), Perumal Par (45.0%), Bitra (37.50%), Suheli (34.60%), Minicoy (33.43%) and Kalpeni (30.65%). The percentage composition of sprats around the islands Kadmat and Kavaratti is low. Pomacentrids are abundant at Bangaram (76.35%), Suheli (45.47%), Perumal Par (41.0%), Chetlat (40.23%), Kalpeni (35.

TABLE 1. *Distribution and abundance of live-baits collected during October 1986 to March 1987*

Species	Agatti	Amini	Androth	Perumal Par	Bangaram, Tinnakara Parli	Bitra	Chetlat	Kadmat	Kalpeni Cheriyam, Thilakkam	Kavaratti	Kiltan	Minicoy	Suheli Par
1. *Spratelloides delicatulus*	XXX		XXX	XXX	XXX	XXX	XXX	XX	XXX	XX	XX	XXX	XXX
2. *Spratelloides japonicus*	XX		XX	XX	XXX	XX						XXX	XX
3. *Stenatherina temmincki*		XX				XXX	XX						
4. *Allanetta barnesi*		XXX				XX		XXX			XX		
5. *Pranesus pinguis*		XX	XX				XXX	XX		XX		XX	
6. *Rhabdamia cypselurus*	XXX			XX		XX			XX				
7. *Rhabdamia gracilis*	XX			XX				XXX	XX	XX			XX
8. *Archamia fucata*	XX			XXX	XX			XXX		XXX		XXX	
9 *Apogon leptacanthus*	XXX	XX			XX	XXX		XXX	XX			XX	XX
10. *Apogon sangiensis*	XX		XX		XX	XXX	XX		XXX	XX		XXX	XX
11. *Ostorhynchus novemfasciatus*		XX	XX			XXX	XX		XX	XX		XX	XX
12. *Ostcrhynchus apogonides*	XX		XX	XX	XX			XX	XX				XX
13 *Dipterygonotus leucogrammicus*			XX			XX		XX				XXX	
14. *Gymnocaesio argenteus*	XX		XX	XX					XX			XXX	
15 *Caesio chrysozona*	XXX	XX		XXX	XX	XX			XX	XX		XX	XX
16 *Caesio pisang*				XX		XX		XX	XX				XX
17. *Caesio coerulaureus*	XX			XX	XX			XX			XX	XXX	
18. *Lepidozygus tapeinosoma*			XX					XX				XXX	
19. *Chromis caeuleus*	XXX	XX		XXX	XXX	XXX	XXX	XX	XXX	XX	XXX	XX	xXX
20. *Chromis nigrurus*	XX			XXX	XX		XX	XXX	XX	XX			XX
21. *Pomacentrus pavo*	XX			XX	XX		XX	XX				XX	

xxx Abundant
xx Common

TABLE 2. *Percentage composition of live-bait collected during the live-bait resources survey (October 1986 to March 1987)*

Island	Sprats	Apogonids	Caesiodids	Pomacentrids	Atherinids
Agatti	12.24	38.33	15.38	34.05	—
Bangaram, Tinnakara,. Parli	22.63	1.02	—	76.35	—
Bitra	37.50	16.35	0.96	32.69	12.50
Chetlat	51.0	—	—	40.23	8.77
Kadmat	11.93	38.53	10.09	29.05	10.4
Kalpeni, Cheriyam, Thilakkam	30.65	22.21	9.89	35.21	2.04
Kavaratti	12.36	63.22	1.44	22.98	—
Minicoy	33.43	40.19	14.98	9.40	2.00
Perumal Par	45.00	6.50	7.50	41.00	—
Suheli Par	34.60	9.81	3.63	45.47	6.50

21%), Agatti (34.05%) and Bitra (32.69%) and scarce at Minicoy. Apogonids are abundant at Kavaratti (63.22%), Minicoy (40.19%), Kadmat (38.53%) and Agatti (38.33%) whereas the percentage was low at Suheli Par, Perumal Par and Bangaram and absent at Chetlat. Caesiodids are common at Agatti (15.38%), Minicoy (14. 98%), and Kadmat (10.09) and scarce or absent at other islands. Atherinids are common at Bitra (12.5%) and Kadmat (10.4%) and the percentage was very low in other islands during the period of survey.

ISLANDWISE PRODUCTION OF LIVE-BAITS

Reliable data are not available on the exploitation and seasonal abundance of bait fishes from different islands in the Lakshadweep except at Minicoy. The seasonal pattern of exploitation of live-baits from October 1986 to March 1987 at Minicoy is given in Table 3. The total live-baits caught at Minicoy during the above period is estimated as 3994 kg. The trend of production of live-baits at Minicoy indicates that the total catch was relatively less during November-December and the highest in March (1254 Kg). Catch per unit effort of bait fishes at Minicoy varied during the above period from 1.47 to 3.10 kg with low values during November-December and the highest C/E was in March, being 3.10 Kg. The cumulative values of C/E for the period of survey was 2.23 kg. In other islands, the C/E varied considerably and the observed values in order of abundance are given in Table 4. It could be inferred from the catch per unit effort of fishing conducted during the survey that fairly good concentrations of bait fishes were available at Minicoy, Kadmat, Bitra, Agatti and Suheli Par whereas the availability of bait fishes was low at Kavaratti and Chetlat.

TABLE 3. *Tuna live-bait production at Minicoy during October 1936 to March 1987*

Month	Total live-bait (kg)
October	629.5
November	387.5
December	561.0
January	691.5
February	410.5
March	1254.0

TABLE 4. *Catch/unit effort of bait fishes in different islands.*

Island	C/E (kg)
Kadmat	1.30
Bitra	0.87
Agatti	0.82
Suheli Par	0.79
Bangaram	0.69
Kalpeni	0.61
Perumal Par	0.40
Kavaratti	0.35
Chetlat	0.28

The highly fluctuating nature of bait fish catch at Minicoy has already been dealt with by Pillai *et al.* (1986). The abundance of different species vary highly in different years and seasons. According to the above authors, during 1981-82 season, *Spratelloides delicatulus* formed 64.16% followed by *Archamia fucata*, 22.23% whereas during 1983-84 season, these constituted 32.68% and 30.56% respectively and in 1984-85 season, *S. delicatulus* consisted of 36.1%, the second position being taken by *Caesio coerulaureus*, 18.5%. During the present survey at Minicoy, apogonids, sprats and caesiodids constituted 40.19%, 33.43% and 14.98% respectively. When the total catches from all the islands and reefs surveyed is considered as a whole, *Spratelloides delicatulus* constituted 27.0%, apogonids 26.0%, pomacentrids, chiefly *Chromis caeruleus* 32.4%, caesiodids 8.0% and atherinids 6.6%. *Lepidozygus tapeinosoma*, *Gymnocaesio argenteus* and *Dipterygonotus leucogrammicus* which used to be important constituents of bait fish catches at Minicoy in the past has either declined considerably or absent in the catches in recent years. Pillai *et al.* (1986) stated that during 1981-82 fishing season there was a gradual decline in the live-bait catches at Minicoy from November to March 1982, whereas during 1982-83 season live-bait catches increased from November to January and declined in February and March. However, during 1984-85 season, the highest catch was recorded during March and this agrees with the langings in 1987. In general, the premonsoon period of January-April is more productive with regard to live-bait fishery when compared to the post-monsoon months.

In Minicoy, a wide variety of bait fishes collected from the vicinity of the reefs and from the lagoon are used for pole and line fishery, whereas in other islands of the Lakshadweep mostly *Spratelloides* spp. are in common use and apogonids and atherinids are used only when the former is not available in good quantities. The present exploitation of tuna live-bait and consequently that of skipjack by pole and line fishing at Amini, Chetlat, Kalpeni and Kiltan is low when compared to that of Suheli Par, Agatti, Minicoy and Kavaratti.

SPAWNING OF LIVE-BAITS

Information on the spawning of tuna live-baits is restricted to only three or four species (Madan Mohan and Kunhikoya, 1986; Madan Mohan *et al.*, 1986 and Pillai *et. al.*, 1986). The blue sprat, *Spratelloides delicatulus* is found in scattered shoals in clear water in the shallow regions of the lagoon. Specimens in all stages of maturity were recorded at Minicoy and ripe group of ova ranged in diameter from 0.44 mm to 0.76 mm with a discernible mode at 0.61mm. Based on the information on the avilability of fishes in different maturity stages in different months, it is presumed that the species spawns in Minicoy lagoon more than once in a spawning season which is during March-April to December.

The silver sprat, *S. gracilis* occurs in Minicoy waters during post- and pre-monsoon months. Specimens in all stages of maturity were recorded and in mature ovaries ova ranged in diameter from 0.38 mm to 0.61 mm with a mode at 0.51 mm. The species spawns more than once in a spawning season which is from September to April.

Madan Mohan *et al.* (1986) observed that mature specimens and juveniles of the blue puller, *Chromis caeruleus* almost throughout the year and indicated that breeding in this species is continuous from August to April. Spent fishes were not observed during January to April and based on the occurrence of "high percentage of matured and ripe spawning fishes along with recovering stages" it was also presumed that spawning takes place during the above period.

HABIT AND HABITAT OF TUNA LIVE-BAITS

In all the islands, live baits are mostly caught from the lagoon. Only occasionally, tuna boats have been found to catch live-baits outside the reef on the north eastern side of Minicoy island. Some species like *Caesio coerulaureus*, *Dipterygonotus leucogrammicus*, *Gymnocaesio argenteus* and *Lepidozygus tapeinosoma* and *Dipterygonotus leucogrammicus* which formed the major constituents of live baits at Minicoy some years ago failed to appear in good quantities from 1981-82 fishing season onwards. These are found in the deeper parts of the lagoon and also on the north-eastern

side of Minicoy. *Caesio* spp. are found in deeper areas of the northern part of Minicoy lagoon and in the reef area. They are generally fished towards the close of the fishing season from the outer part of the lagoon and northern side of Ragandi point. These migrant species cause high fluctuations in the live-bait fishery and their disappearance from the lagoon during some fishing seasons is probably due to adverse changes in environmental conditions.

Some live-bait species inhabit the lagoon throughout their life. *Spratelloides delicatulus* generally occurs in scattered shoals near the inner reef area in the lagoons of the islands. Young fish found on shoal sand and coral flats in clear water are easily caught by encircling net. Mature specimens have been observed to occur occasionally in the coastal area of the lagoon. The species begins to appear in the lagoon of the islands just after the south-west monsoon. *S. japonicus* found in the lagoon near coral colonies have been found to move to deeper waters during low tide. Apogonids which show wide annual fluctuations in the live-bait catches often live in the vicinity of coral colonies in the lagoon of most of the islands. Atherinids, especially *Paranesus pinguis, Stenatherina temminicki* and *Allanetta barnesi* are found mostly closer to the shore in the lagoon of the islands. These are sometimes caught in good quantities during the peak tuna fishing season and towards the close of the fishing season. Sometimes *Allanetta barnesi* and *Spratelloides delicatulus* have been observed in mixed schools. Many species found in the reef areas are used as live-bait in Minicoy. Whichever species is available in the bait collections at Minicoy are used as bait fish even though only a few of them are considered good for pole and line fisheries.

EXPLOITATION PRESSURE AND ENVIRONMENTAL DAMAGE

In the absence of live-bait landing data from different islands over a long span of years, it is difficult to find out whether there is a decline in the live-bait catch or not. Silas *et al.* (1986) were of the view that scarcity of live-baits is a limiting factor for the expansion of tuna fishery and James et al. (1986) have adduced several reasons for the acute shortage of live-baits like desertion of live-bait populations resulting from damage caused to coral reef, lack of recruitment of young ones to the population and increased demand for live-baits.

Coral colonies which are ideal for the survival of live-bait fishes are prone to natural senescence. Blasting the reefs and dredging for deepening the boat channels in the islands results in siltation in the areas of coral growth, thereby causing the death of coral colonies and the associated live-bait species. However, the present survey indicates that resources of live-baits, both migrant and resident forms available around Kadmat, Bitra, Agatti, Suheli Par, Bangaram, Minicoy and Perumal Par are not fully exploited.

The requirement of live-bait for pole and line fisheries has increased considerably in recent years owing to the increased use of mechanised boats in pole and line fishing operations in most of the islands. Tuna fishing by pole and line using live-baits in an organised manner was in vogue only in Minicoy island till 1963. The pole and line fleet which consisted of 9 boats in 1963 (exclusively in Minicoy) has now increased to about 130 boats and the tuna landing has reached 4807 tonnes in 1986. There is a greater demand for live-baits than in the past and the fishermen exploit the easily accessible stocks of resident species to the possible extent. This is evident from the exploitation pressure on *Chromis caeruleus* at Minicoy and *Spratelloides delicatulus* in the northern islands, especially at Agathi, Bangaram, Suheli Par and Bitra. The production of live-baits at Minicoy has recorded an increase of about 130% from the level of 2799 kg in 1981-82 to 6457 kg in 1986-87 which shows that there is no scarcity in availability. There is only a marginal increase of five tuna fishing boats at Minicoy from those present in 1981-82 (31) and hence it is clear that the catch per boat in 1986-87 is much higher than in 1981-82. Due to the fluctuations in abundance of different live-bait species during different seasons, it is possible that the major species generally preferred are not available easily to the fishermen and this gives an impression that ther is shortage of live-baits for the existing tuna fishing boats. It is probable that seasonal viriation in the recruitment of migrant species such as *Caesio*

spp., *Dipterygonotus leucogrammicus* and *Lepidozygus tapeinosoma* into the lagoonal environment is due to the altered habitat which is not conducive for their survival Consequently there will be increased fishing pressure on the available stocks of resident forms in the lagoon.

CONCLUSION

Generally, live-baits remaining after the day's fishing are stored in the storage tank floated in the lagoon. Mortality of live-baits stored in the bait tank of the boat and also in the storage tank floated in the lagon is very high due to overstocking. Measures have to be taken to find out the optimum requirement of tuna live bait for a day's tuna fishing as well as the maximum storage capacity of fhe storage tanks in order to avoid wastage.

From the extensive coral boulders and coral debris found along the reefs and also close to some of the islands, it appears that the damage to the coral colonies and thereby to the live-bait populations by cyclonic storms and siltation caused by the fury of nature is much more deleterious than the damage to corals by dredging the boat channel.

For obtaining maximum sustainable yield of tuna from Lakshadweep waters which is reportedly as high as 50,000 tonnes (George *et al.* 1977), knowlege of exploited and potential resources of live-baits is required. The total area of the lagoons in the Lakshadweep is not very extensive (420 km) to support live-baits sufficient enough to capture the skipjack resources available in the Laccadive sea. It would appear that suitable live-bait resources are also available in the islands of Lakshadweep in regions not exploited at present as is evident from the fact that mostly *Spratelloides* spp. and atherinids are only collected by pole and line fishermen from islands other than Minicoy. The leeward side of the islands which is generally more protected from strong winds and currents are likely to harbour some migrant species and the possibility of exploiting the same by lift nets as used in Minicoy when other bait fishes are scarce in the lagoons have to be explored.

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6. RESOURCES OF ORNAMENTAL FISHES

V. Sriramachandra Murthy, M. Kumaran and R. S. Lalmohan

INTRODUCTION

Among the fishes of Lakshadweep islands, those of ornamental value (aquarium fishes) are very abundant: of the 601 species of marine fishes belonging to 126 families reported from these Islands (Jones and Kumaran, 1980), at least 300 species belonging to over 40 families are ornamental fishes. In addition to the taxonomic account of fishes of Lakshadweep islands by Jones and Kumaran (1980), information on ornamental fishes of these islands is restricted to the works of Pillai *et al*. (1983), Madan Mohan *et al* (1986). and Kumaran and Gopakumar (1986). There is, however, no information on the relative abundance or areas of abundance of different species of ornamental fishes from different islands. There is considerable demand for live ornamental fishes in several countries (Tomey 1985, 1986) and the present export market price of each fish, depending on the species, ranges from Rs. 16.10 to Rs. 272.25 with an average of Rs. 90.60 in Netherlands and from Rs. 4.96 to Rs. 148 with an average of Rs. 34.85 in South East Asian Countries. In West Germany, each specimen of some of the species of ornamental fishes from India can fetch from Rs. 99 to Rs. 810 (Anon 1986). In view of the demand for the ornamental fishes and the possible earning of foreign exchange through export of live ornamental fishes and also in view of the lack of adequate information on distribution and abundance of different species in different islands, a survey was conducted during January-March 1987 and the results with reference to ornamental fishes are presented here.

MATERIAL AND METHODS

The survey was conducted by three teams as follows:

I team: Chetlat, Kiltan, Kadmat and Amini islands during 5.1.1987-6.2.1987.

II team: Bitra, Thinnakara, Bangaram and Agatti islands during 9.2.1987-25.2. 1987.

III team: Androth, Kavaratti, Suheli, Kalpeni and Minicoy during 6.3.1987-1.4. 1987.

In all the islands the fishes were collected using drag net, encircling net and cast net. In the lagoons, the collections were made by encircling nets Fig. 15 A-D and those in the reef flats with drag nets Fig. 15. E : the drag net was laid in a semicircular fashion on the flats in suitable areas and stones were placed in the net to provide hiding space for fishes; the fishes were driven into the net from the open end and then the net was hauled. Every effort was made to collect all the species available in the area. Cast net was also operated on the reef flats during low tide periods ; the net was laid over a big stone and then the stone was moved several times or lifted up, the fishes underneath the stone get entangled in the net and thus caught. Observations on the distribution and abundance of ornamental fishes were also made visually and through underwater surveys in deeper areas of the lagoons.

Collections were made from the lagoons and reef flats by dividing them into arbitrary zones so that representative samples of the species inhabiting the "zones" could be collected, Each zone was intensively studied: specimens were collected from different areas in each "zone" to get a general picture of distribution and abundance of different groups of fishes in the lagoons and reef flats. After collection, the fishes were taken to the shore, identified in fresh condition, photographs taken and then preserved in 5% formalin. All the collections were brought to the main land.

ORNAMENTAL FISHES OF LAKSHADWEEP ISLANDS

Jones and Kumaran (1980) recorded about 300 species of ornamental fishes belonging to over 40 families (Fig. 1). The most dominant group is Labridae with 45 species, followed by Pomacentridae (35), Apogonidae (22), Muraenidae (22) Serranidae (21), Blenniidae (20),

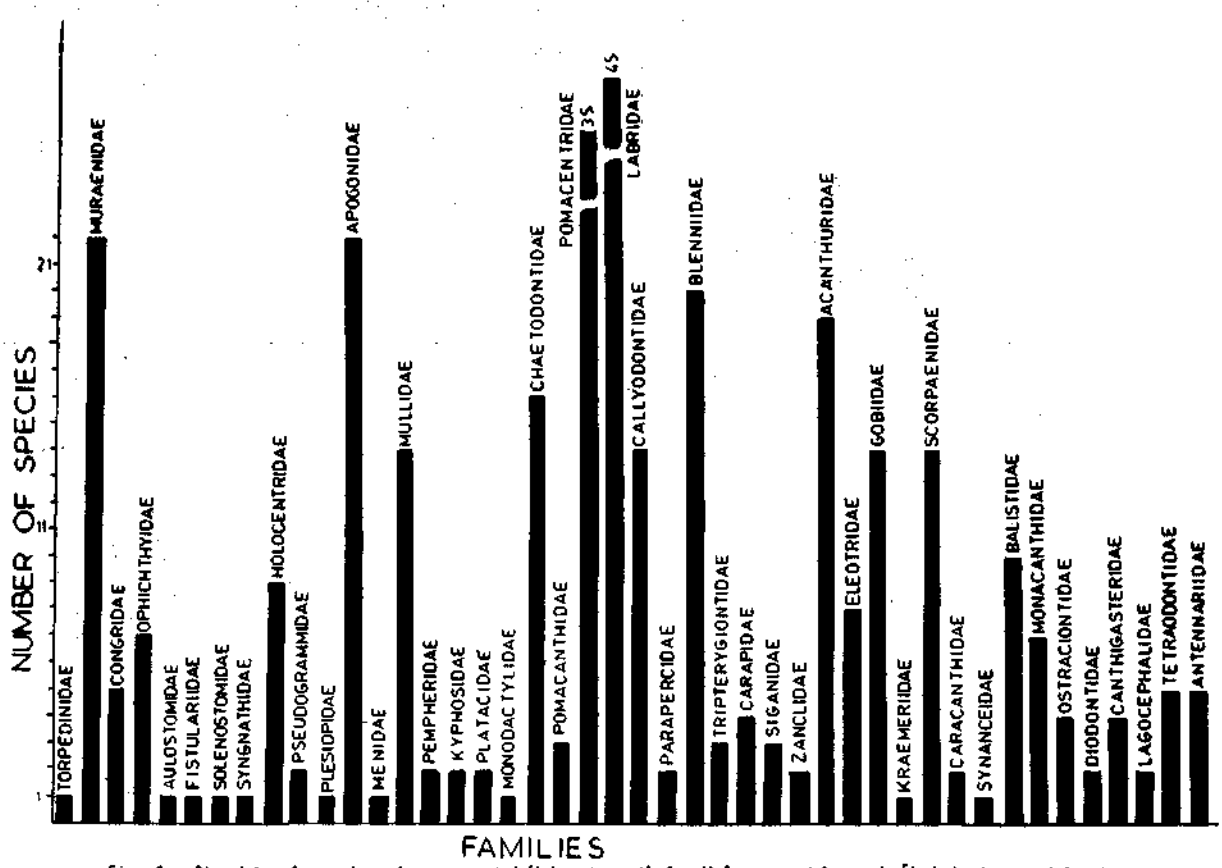

Fig. 1. Number of species of ornamental fishes in each family reported from the Lakshadweep islands.

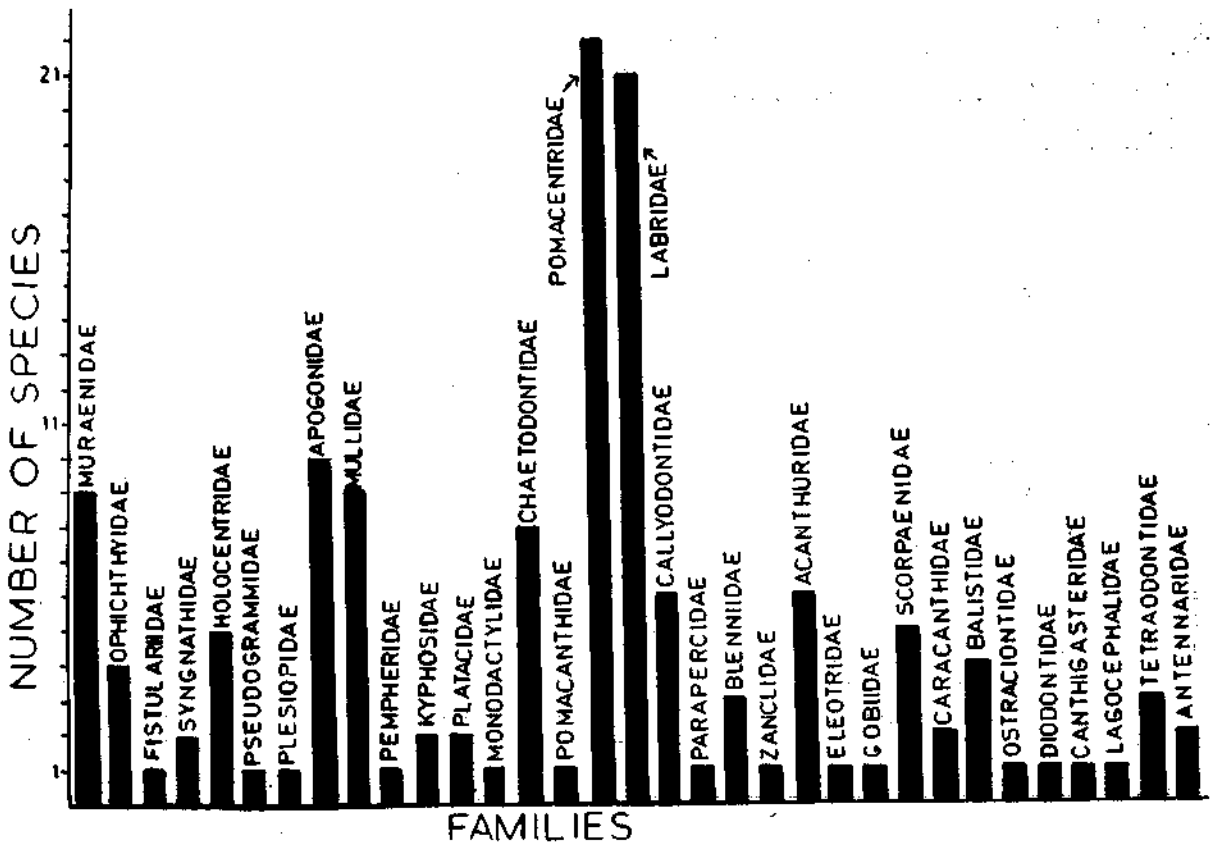

Fig. 2. Number of species of ornamental fishes in each family collected from the Lakshadweep islands during January-March 1987.

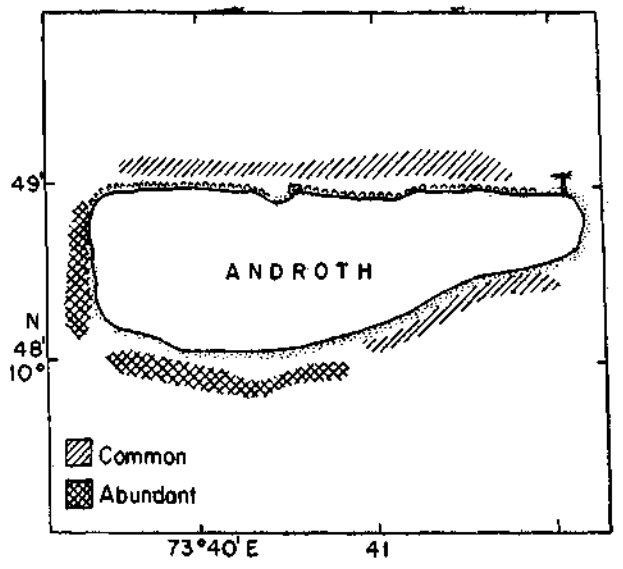

Fig. 10. Map of Androth island showing the distribution of ornamental fishes.

lagoons of different islands are shown in table 1 and in Figures 3-14 (the areas of abundance of ornamental fishes are shown by shaded areas).

1. *Chetlat*: At this island, pomacentrids are most dominant followed by acanthurids,

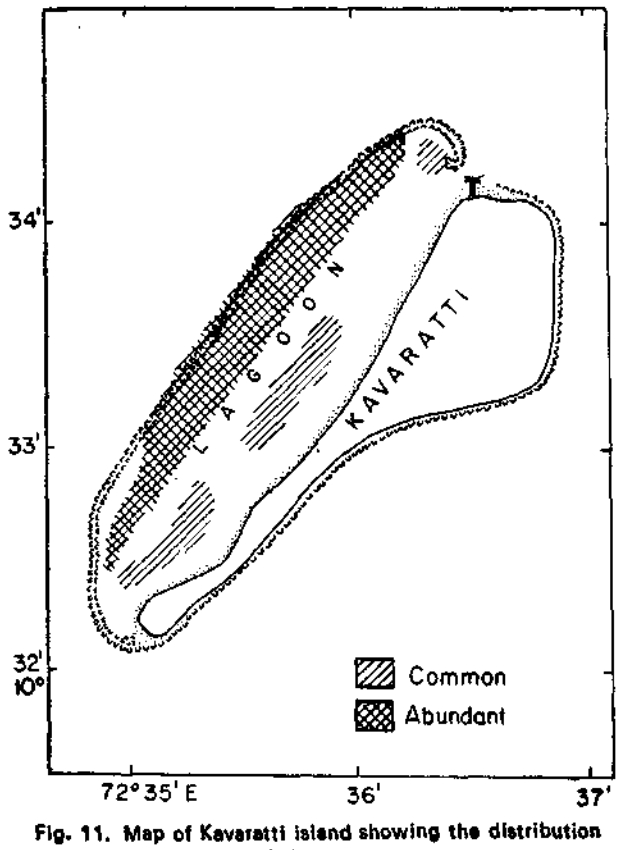

Fig. 11. Map of Kavaratti island showing the distribution of ornamental fishes.

apogonids and holocentrids. Pomacentridae are abundant both in the lagoon and reef flat, acanthurids in the reef flat and Holocentridae and Apogonidae are abundant in the lagoon.

2. *Kiltan*: At this island Pomacentridae, Labridae, Holocentridae and Acanthuridae are abundant. Of these pomacentrids are more abundant in the lagoon whereas Labrids in the reef flat.

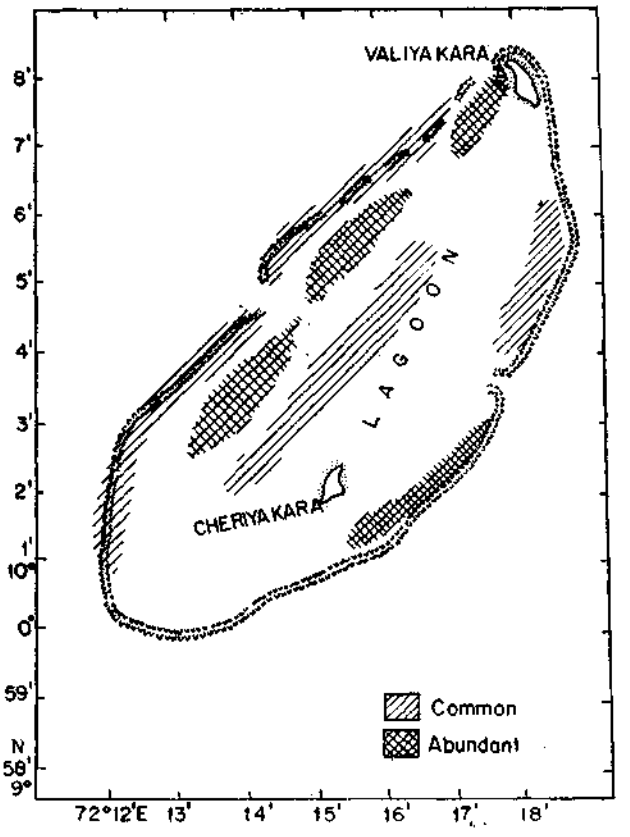

Fig. 12. Map of Suheliper showing the distribution of ornamental fishes.

3. *Kadmat*: At this island also, pomacentrids are more abundant followed by labrids, holocentrids, and blenniids, the former two groups being more abundant in the reef flat.
4. *Amini*: Only two families, Pomacentridae and Labridae are abundant in this island, both in the reef flat. Eels of the family Muraenidae are common in the reef flats of this island.
5. *Bitra*: Labridae, and Scorpaenidae are most abundant in the reef flat. Only one species each of the first two families is abundant in the lagoon whereas scorpaenids were not seen in the lagoon.

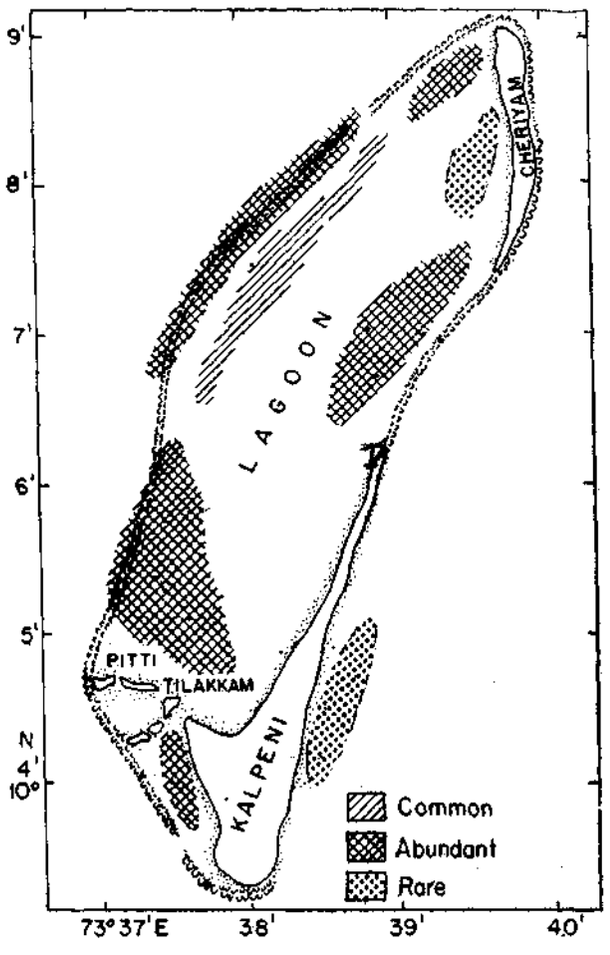

Fig. 13. Map of Kalpeni island showing the distribution of ornamental fishes.

6. *Thinnakara*: Pomacentridae, Mullidae Labridae and Acanthuridae are abundant in this island: three species of Pomacentridae, 2 each of Mullidae and Acanthuridae are abundant in the lagoon whereas two species each of the above four families are abundant in the reef flat.

7. *Bangaram*: Pomacentridae, Labridae, Chaetodontidae, Mullidae, and Balistidae are abundant in this island; except pomacentridae, the fishes of all the above families are abundant in the reefs.

8. *Agati*: Pomacentrds are the most abundant group here followed by Labridae, Scorpaenidae and others. In all these cases, reef flat is richer in ornamental fishes than the lagoon.

9. *Androth*: Only two species of pomacentridae and one species of Labridae are abundant in the reef flat.

10. *Kaveratti*: Only Labridae and Acanthuridae are abundant, particularly on the reef flat of this island.

11. *Suheli*: Labrids and apogonids are abundant in this island.

12. *Kalpeni*: Labridae is the only abundant group here both in the lagoon and reef flat.

13. *Minicoy*: Pomacentridae, Labridae and Acanthuridae are abundant both in the reef flat and lagoon of this island.

The above observations show the following:

a. In 9 of the 13 islands surveyed, there are more number of ornamental fish species in the reef flats than in the lagoons, though some species are abundant in the lagoon and some in the reef flat, in almost all the islands reef flat is richer in ornamental fishes than the lagoon.

b. Species of Pomacentridae and Labridae are not only more in number but they are also abundant in almost all the islands.

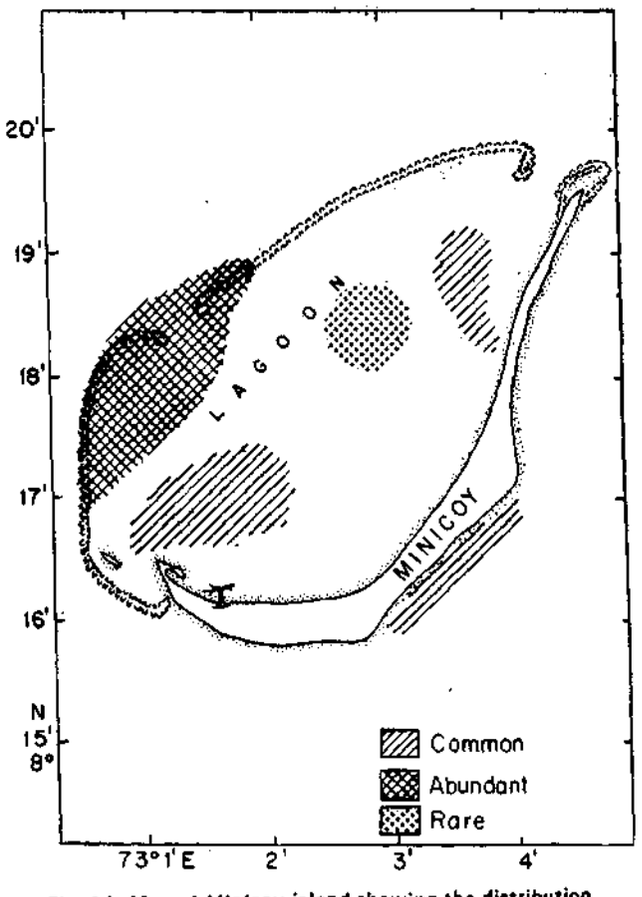

Fig. 14. Map of Minicoy island showing the distribution of ornamental fishes.

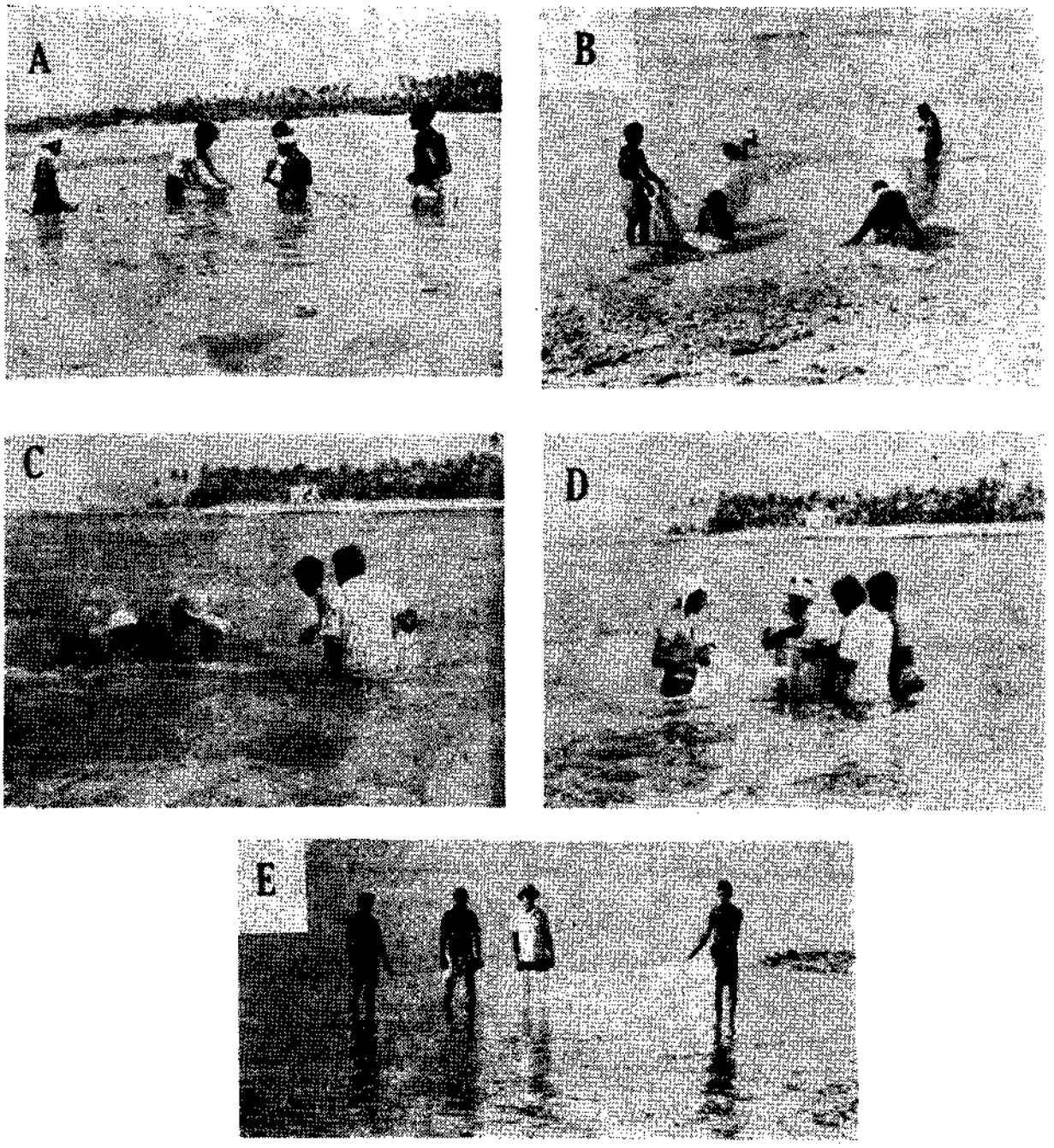

Fig. 15. A-D. Collection of fishes using encircling net in the lagoons. The drag net used in collection of fish in the reef flat.

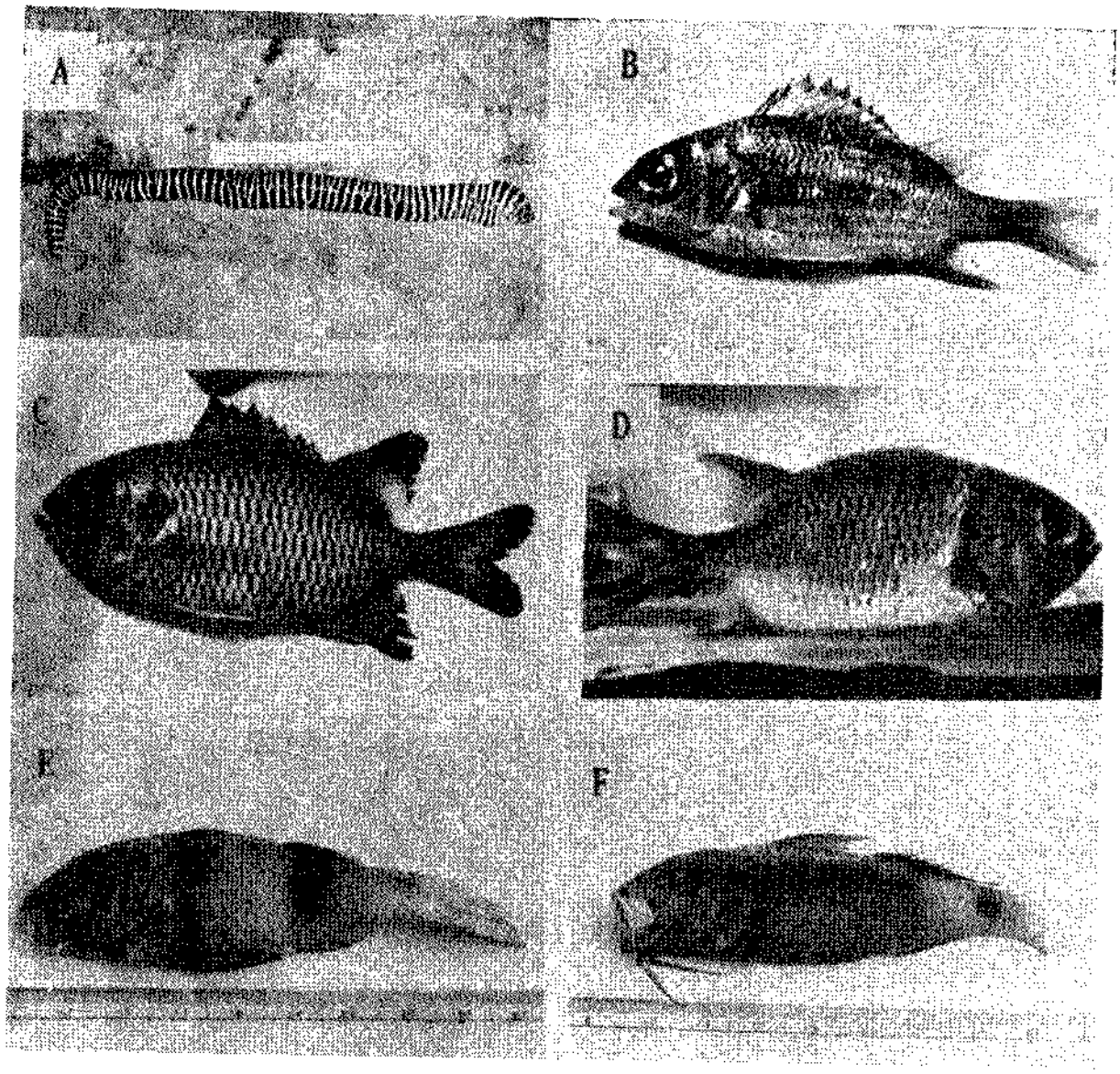

Fig. 16. *A. Echidna zebra, B. Holocentrus diadema, C. Myripristis adustus D. M. murdjan, E. Parupeneus bifasciatus, F. Pnacronemus*

c. Agati and Bitra have very rich resources of ornamental fishes as revealed by the total number and abundance of species followed by the group of four islands Kadmat, Chetlat, Kiltan and Amini. Agatti and Androth respectively are the richest and poorest islands in regard to the abundance of ornamental fish species. It is also clear that the western and northern group of islands are rich in ornamental fishes.

d. The abundant species are : *Abudefduf sordidus, A. sexfasciatus, A. cingulum, A. biocellatus, A. uniocellatus, A. xanthozona, A. zonatus, A. glaucus, Chromis caeruleus, C. ternatensis, C. chrysurus., Dascyllus aruanus, Halichoeres scapularis, Stethojulis axillaris, S. strigiventer, S. albovittata, Thalassoma hardwickii, Labroides dimidiatus, Acanthurus triostegus, A. lineatus, Holocentrus diadema, Ostorhynchus novemfasciatus, O. endekataenia, Archamia fucata, Chaetodon auriga, Aspidcnotus tractus, Mulloidichthys samoensis, M. auriflamma, Pterois volitns Dendrochirus zebra, Rhineaconfhus aculeatus* and *R rectangulus*. All these fishes range in length from 2.5 cm to 22.0 cm. Some species of ornamental fishes collected from different islands are shown in Figs. 16-21.

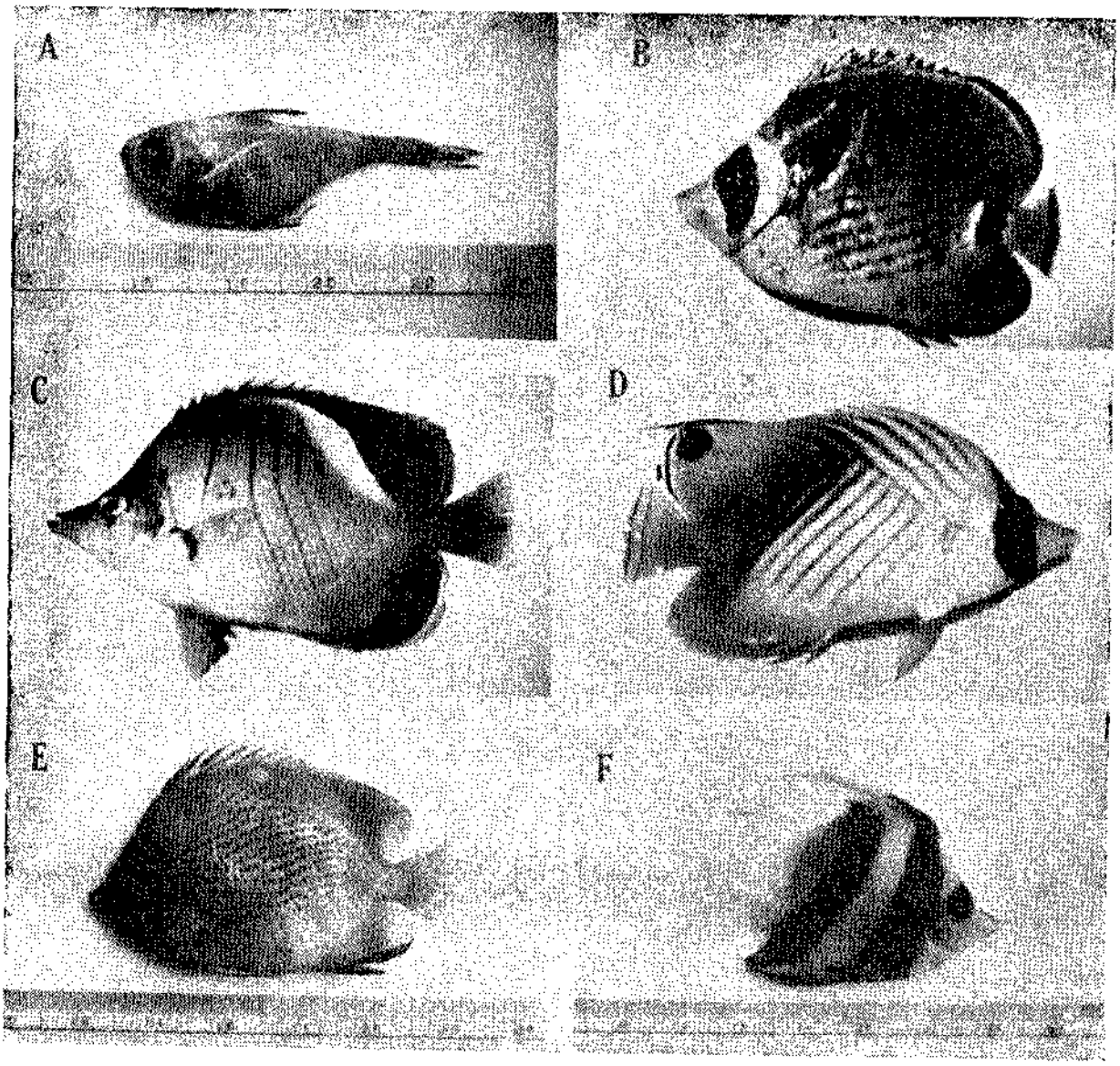

Fig. 17. *A. Pempheris owalensis, B. Chaetodon lunula, C. C. xanthocephalus D. C. auriga, E. C. citrinellus, F. Heniochus acuminatus*

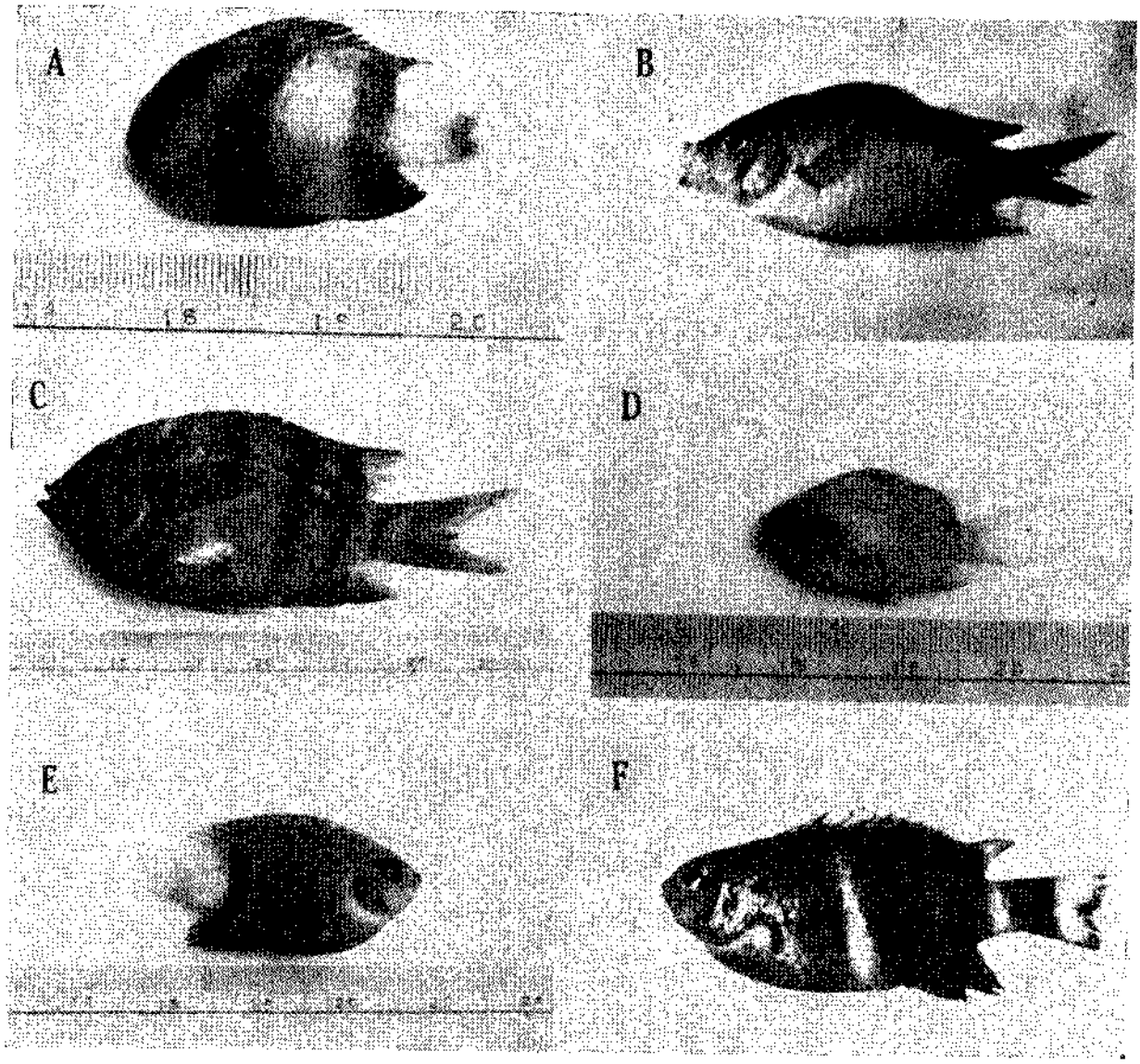

Fig. 18. *A. Dascyllus aruanus, B. Chromis caeruleus, C. Abudefduf saxatilis D. A. sordidus, E. A. dickii, F. A. xanthozona*

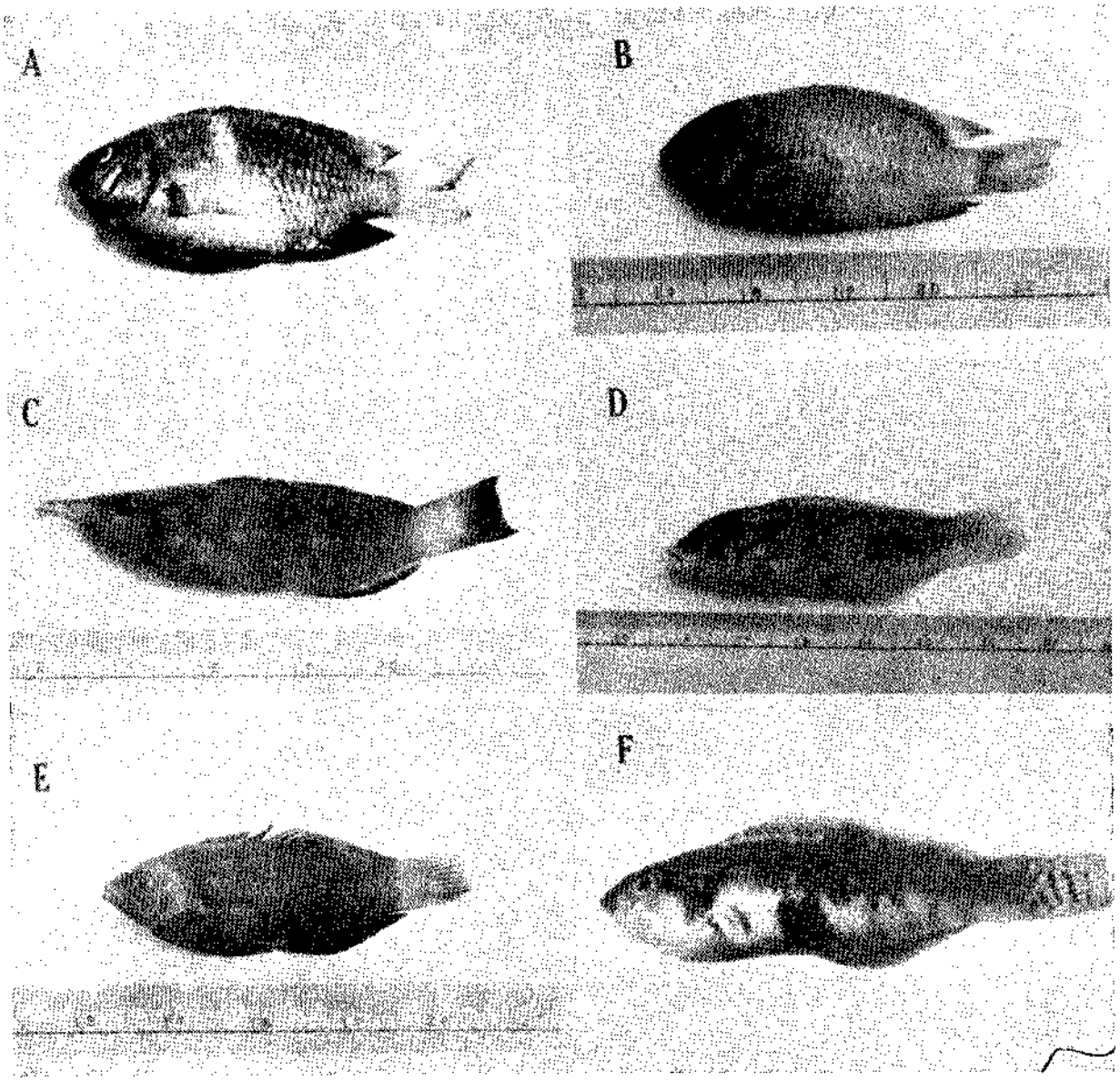

Fig. 19. *A. Abudefduf biocellatus, B. A. glaucus, C. Gomphosus varius D. Halichoeres capularis, E. H. notopsis, F. H. kawarin*

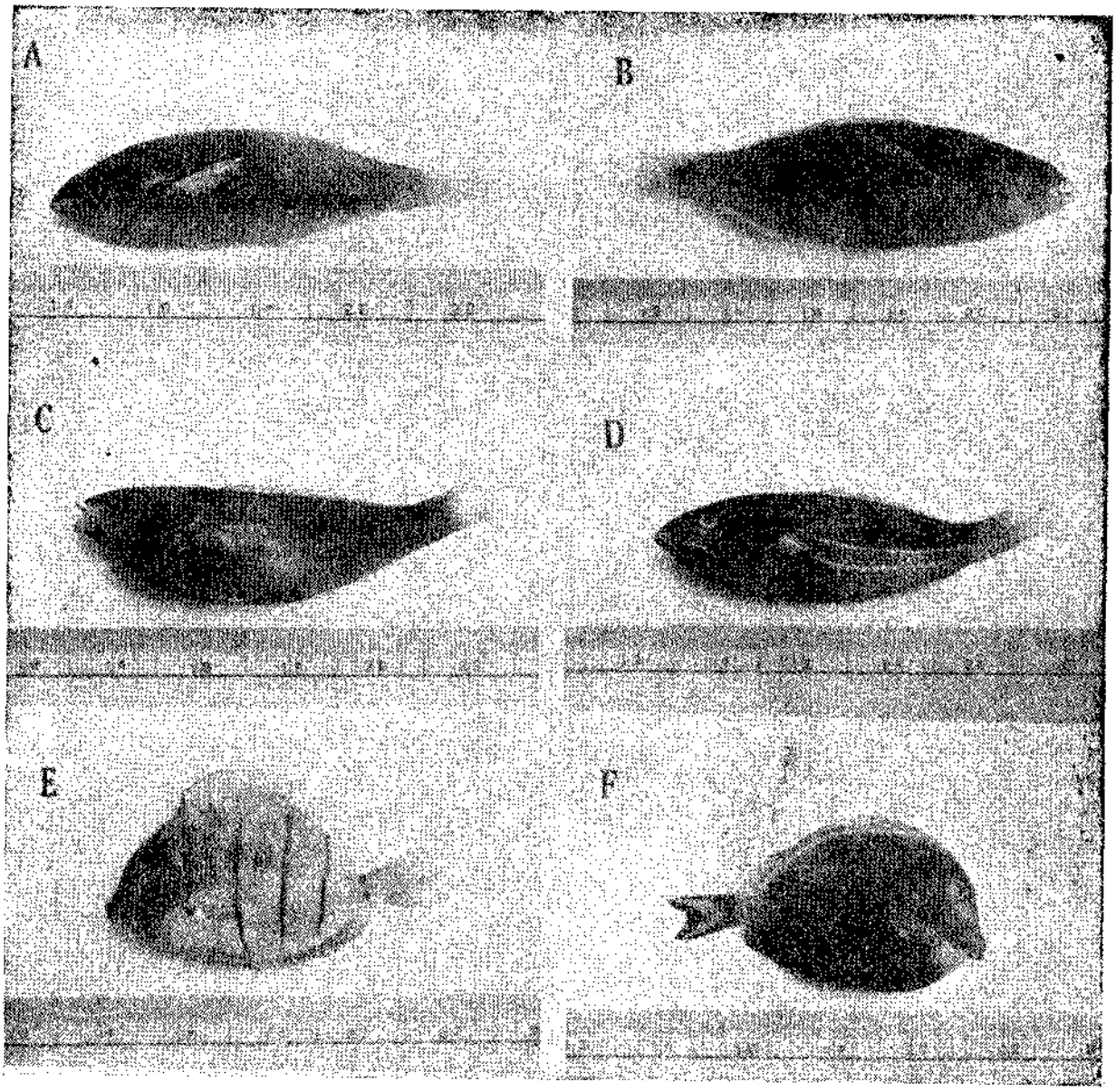

Fig. 20. *A. Stethojulis axillaris*, *B. S. phaekadopleur*, *C. S. Strigiventer* *S. albovittata*, *E. Acanthurus triostegus*, *F. A. leucosternon*

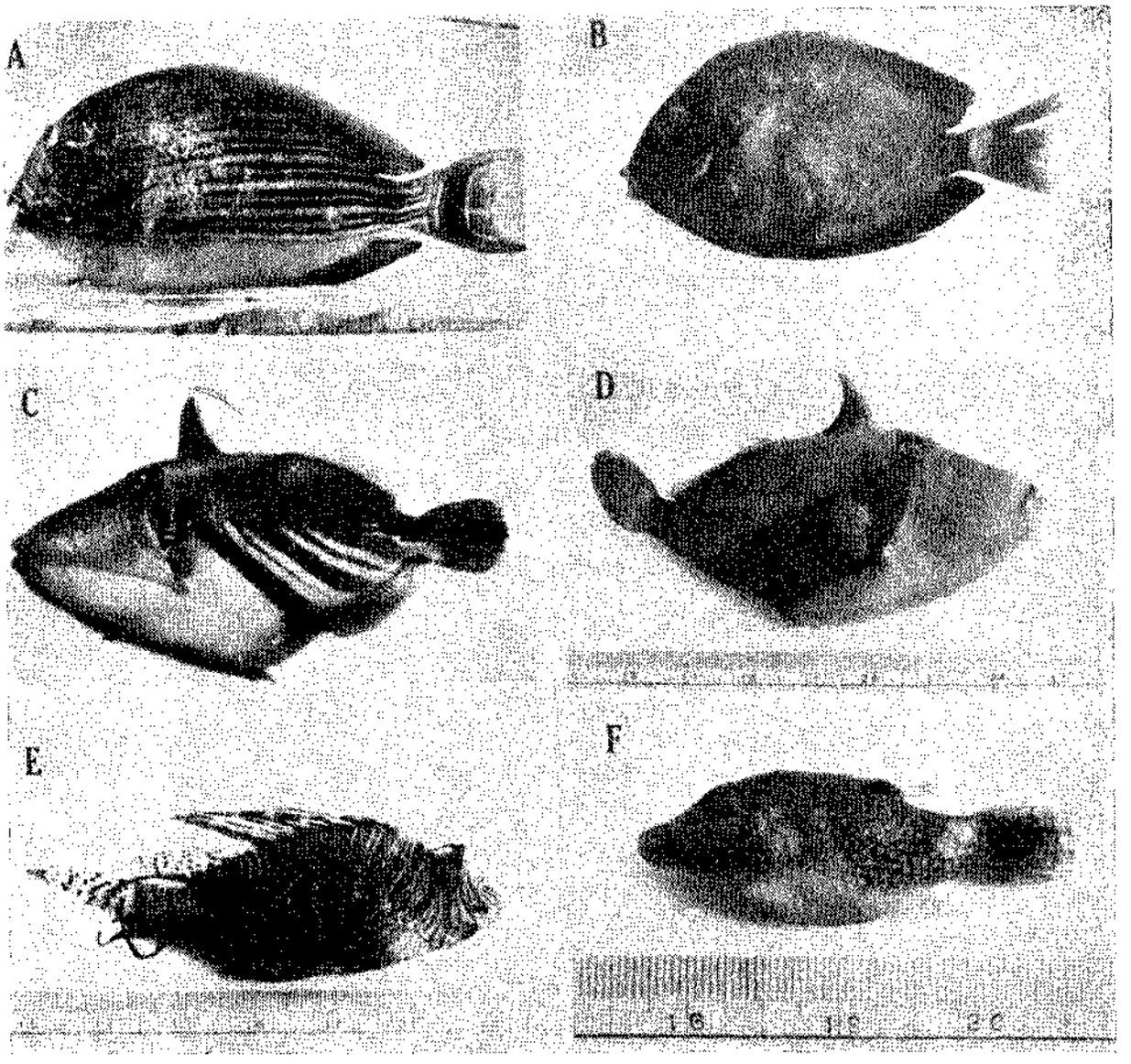

Fig. 21. *A. Acanthurus lineatus, B. A. matoides, C. Rhineacanthus aculeatus D. D. R. rectangulus, E Pterois volitans, F. Canthigaster margaritatus*

HABITAT OF IMPORTANT GROUPS

It is observed that labrids and callyodontids are abundant in areas where sea grass is abundant; thus the reef flat along the eastern side of Amini these fishes are very abundant. Pomacentrids, particularly *Chromis caeruleus* and *Dascyllus aruanus* and some labrids are abundant in the lagoons where corals are abundant. Lagoons with sandy bottom are generally poor in ornamental fishes but goat fishes are available in considerable quantities during night time particularly in Kadmat and Chetlat. Ornamental fish fauna is also poor along the near-shore sandy portions of the lagoons. The reef flats are particularly rich in pomacentrids, serranids, holocentrids, acanthurids and in some islands labrids. The different species of eels are residents of crevices in the reef flats. Pomacentrids represented by *Abudefduf sordius, A. saxatilis, A. sexfasciatus* and *A. glaucus* and chaetodontids, ostraciontids, canthigasterids and some acanthurids are abundant in areas under the Jettys and in areas protected by large rocks.

TABLE 1: *List of ornamental fishes with information on relative abundance of each of them in the reef flats and lagoons of different islands.*

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thin-nakara	Ban-garam	Agatti	And-roth	Kava-ratti	Suheli	Kalpe-ni	Mini-coy
1	Muraenidae	*Echidna zebra*	X	—	—	—	—	—	—	—	—	—	—	—	—
2		*E. nebulosa*	—	—	—	XX	X	—	X	XX	—	X	X	—	—
3		*E. polyzona*	—	—	—	—	X	—	—		—	—	—	—	—
4		*Uropterygius marmoratus*	—	—	—	—	—	—	—	—	—	—	X	—	—
5		*Gymnothorax pictus*	XXX	—	—	X	XXX	X	X	X	X	X	X	—	—
6		*G. pseudothyrsoidea*	—	—	—	XX	—	—	—	—	—	—	—	—	—
7		*G. pictus*	—	—	—	—	—	—	—	—	—	—	—	—	—
8		*G. fimbriatus*	—	—	—	—	XXX	XX	X	XXX	—	X	X	—	—
9		*G. petelli*	—	—	—	—	X	—	X	—	—	—	—	—	—
10	*Ophichthyidae*	*Myrichthys colubrinus*	—	—	—	—	X	—	—	X	—	—	—	—	—
11		*M. maculosus*	—	—	—	—	—	—	—	—	—	—	—	—	—
12		*Callechelys melanotaenia*	—	—	—	—	—	—	—	—	—	—	X	—	—
13		*Leiuranus semicinctus*	—	—	—	—	—	—	—	—	—	XX	XX	—	—
14	Fistulariidae	*Fistularia petimba*	—	—	XXX	—	X	XX	XXX	XXX					
15	Syngnathidae	*Choeroichthys sculptus*	—	—	—	—	X	X	XX	XX	—	—	—	—	—
16		*C. intestiualis*	—	—	—	—	XX	X	X	X	—	—	—	—	—
17	Holacentridae	*Holocentrus sammara*	XX	—	—	—	XX	—	X	XXX	—	—	—	XX	X
18		*H. diadema*	XXX	XXX	XX	X	—	—	—	—	—	—	—	—	X
19		*H. lacteoguttatum*	—	—	—	—	—	—	—	—	XX	—	—	—	—
20		*Myripristis adustus*	—	XX	—	X	—	—	—	—	—	—	—	—	—
21		*M. murdjan*	XX	—	XX	—	XX	XX	X	XX	—	—	—	—	—
22	Pseudogrammdae	*Pseudogramma polyacanthus*	—	—	—	—	X	X	XX	—	—	—	—	—	—
23	*Plesiopidae*	*Plesiops caeruleolineatus*	XX	—	X	—	XX	—	X	XX	—	—	—	—	—
24	Apogonidae	*Pristiapogon fraenatus*	XX	—	—	—	—	—	—	—	—	—	—	—	—
25		*P. snyderi*	—	—	—	—	—	—	—	—	—	—	X	—	—
26		*Ostorhynchus savayensis*	XX	—	—	—	—	—	—	—	—	—	—	—	—
27		*O. novemfasciatus*	XXX	—	—	XX	—	—	—	—	—	—	XX	X	—
28		*O. endekataenia*	—	—	—	—	XX	—	X	XXX	—	—	—	—	—

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thinna-kara	Ban-garam	Agatti	Androth	Kava-ratti	Suheli	Kal-peni	Mini-coy
29		*O. moluccensis*	—	—	—	—	—	—	—	—	—	x	x	—	—
30		*Archamia fucata*	—	—	xxx	—	—	—	—	xx	—	—	—	—	—
31		*Apogon leptacanthus*	—	—	—	—	xx	x	xx	xx	—	—	—	—	—
32		*Cheilodepterus lachneri*	—	—	—	—	x	—	—	—	—	—	—	—	—
33		*Paramia quinquelineata*	—	—	—	—	—	—	—	—	—	—	xx	—	—
34	Mullidae	*Upeneus tragula*	—	—	—	—	x	xx	xxx	xxx	—	—	—	—	—
35		*U. vittatus*	—	—	—	—	—	xx	xx	x	—	—	—	—	—
36		*U. arge*	—	—	—	—	—	xx	—	x	—	—	—	—	—
37		*Mulloidichthys samoensis*	—	—	xxx	—	—	—	—	—	—	—	—	—	xx
38		*M, auriflama*	xxx	xxx	xxx	—	—	xx	—	xx	—	—	—	—	—
39		*Parupeneus barberinus*	xx	xx	xx	xx	xx	x	x	x	—	—	xx	x	—
40		*P. bifasciatus*	—	—	xx	x	—	—	—	—	—	—	—	—	—
41		*P. trifasciatus*	—	—	—	—	xxx	—	—	x	—	—	—	—	—
42		*P. macronemus*	—	—	xxx	—	—	—	x	xx	—	—	—	—	—
43	Pempheridae	*Pempheris oualensis*	—	—	—	xx	—	—	—	—	—	—	—	—	—
44	Kyphosidae	*Kyphosus cinerascens*	—	—	—	—	—	x	x	—	—	—	—	—	—
45		*K. raigiensis*	—	—	—	—	x	—	x	—	—	—	—	—	—
46	Platacidae	*Platax orbicularis*	—	—	—	—	xxx	—	—	xxx	—	—	—	—	—
47		*P. tiera*	—	—	—	—	xxx	—	x	xx	—	—	—	—	—
48	Monodactylidae	*Monodactylus argenteus*	—	—	—	—	xx	—	—	x	—		—	—	—
49	Chaetodentidae	*Chaetodon lunula*	—	xx	—	—	—	—	—	—	—	—	—	—	—
50		*C. citrinellus*	—	xx	xx	—	—	—	—	—	—	—	—	—	—
51		*C. xanthocephalus*	—	xx	—	—	—	—	—	—	—	—	—	—	—
52		*C. auriga*	—	xx	—	x	xx	—	xx	xxx	x	x	—	—	—
53		*C. melanotus*	—	—	—	—	—	—	—	—	x	x	—	—	—
54		*C, meyeri*	—	—	—	—	—	—	xx	x	—	—	—	—	—
55		*C. trifasciatus*	—	—	—	—	—	—	—	xx	—	—	—	—	—
56		*Heniochus acuminatus*	—	xx	—	—	—	—	—	—	—	—	—	—	—
57	Pomacanthidae	*Pomacanthodes semicirculatus*	—	—	—	—	x	—	xx	—	—	—	—	—	—
58	Pomacentridae	*Amphiprion nigrepes*	—	—	—	—	—	—	x	x	—	—	—	—	—
59		*Lepidozygous tapeinosoma*	—	—	—	—	—	—	xx	xx	—	—	—	—	—
60		*Dascyllus aruanus*	xxx	xxx	xx	—	xxx	xx	x	xxx	—	—	—	xx	xxx

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thinna-kara	Ban-garam	Agatti	Androth	Kava-ratti	Suheli	Kal-peni	Mini-coy
61		*D. trimaculatus*	—	—	—	—	—	xx	xx	—	—	—	—		x
62		*D. reticulatus*	—	—	—	—	—	—	—	—	—	—	—	—	xx
63		*Chromis chrysurus*	—	xxx	—	—	—	—	x	xxx	xx	—	—	—	—
64		*C. caeruleus*	xx	xxx	xxx	—	xxx	xxx	xxx	xxx	xx	—	—	—	—
65		*C. ternatensis*	—	—	—	—	xxx	x	xxx	xxx	xxx	—	—	—	—
66		*Pomacentrus nigricans*	x	—	xxx	—	—	—	—	xx	—	—	—	—	—
67		*P. littoralis*	—	—	—	x	x	—	—	xx	—	—	—	—	—
68		*Abudefduf saxatilis*	—	xx	xx	xx	—	—	—	—	—	—	—	—	—
69		*A. sexfasciatus*	xxx	xxx	—	—	—	—	—	xx	—	—	—	—	—
70		*A. sodidus*	xxx	xx	—	—	—	—	—	—	—	—	—	—	—
71		*A. septemfasciatus*	xx	—	xx	—	—	—	—	—	—	—	xx	—	—
72		*A. cingulum*	xxx	—	—	—	x	—	x	—	—	—	—	—	—
73		*A. dickii*	—	—	xx	—	—	—	—	—	—	—	—	—	—
74		*A. biocellatus*	xxx	—	—	—	—	—	—	—	x	—	—	—	—
75		*A. uniocellatus*	xxx	xx	xxx	x	—	—	—	—	—	—	—	x	x
76		*A. xanthozone*	xxx	—	—	—	—	—	—	—	x	—	—	—	—
77		*A. zonatus*	xxx	—	xx	xx	xx	x	—	—	x	—	—	—	—
78		*A. glaucus*	xxx	xxx	xxx	xx	—	—	—	—	x	—	—	—	—
79		*A. bengalensis*	—	—	—	—	—	—	—	—	x	—	—	—	—
80	Labridae	*Gomphosus varius*	—	xx	—	—	—	—	xx	x	—	—	—	—	—
81		*G. caeruleus*	—	—	—	—	x	—	—	x	—	—	—	—	—
82		*Cheilio inermis*	—	—	—	—	—	—	—	—	—	xx	—	—	—
83		*Halichoeres scapularis*	xxx	—	—	—	—	x	xx	—	—	—	—	xx	x
84		*H. notopsis*	—	xx	—		—	—	—	—	—	—	—	—	—
85		*H. kawarin*	—	—	xx	xx	x	x	xx	—	—	—	—	—	—
86		*H. centriquadrus*	—	—	—	—	—	—	—	—	—	xx	—	xx	—
87		*Stethojulis axillaris*	xxx	xxx	xx	xxx	xx	xx	x	xx	—	xx	xx	xx	—
88		*S. strigivener*	—	—	xxx	xxx	—	—	—	—	—	—	—	—	—
89		*S. trilineata*	—	xx	—	—	—	—	—	—	—	—	—	—	—
90		*S. albovittata*	xxx	xx	xx	—	—	—	—	—	—	—	—	xx	—

Sl. No.	Family	Species	Chetlat	Kiltan	Kad-mat	Amini	Bitra	Thin-nakara	Ban-garam	Agatti	And-roth	Kava-ratti	Suheli	Kalpe-ni	Mini-coy
91		*S. phaekadopleura*	—	—	—	—	XX	X	—	X	—	—	—	—	X
92		*Thalassoma amblycephalus*	—	—	XX	—	—	—	—	—	—	—	XX	—	—
93		*T. hardwicki*	—	—	—	—	XX	XX	X	XXX	—	—	—	—	—
94		*T. quinquivittata*	—	—	—	—	—	—	—	—	—	—	—	XX	—
95		*Labroides dimieiatus*	—	—	—	—	X	X	—	XX	XX	XXX	XX	XXX	XX
96		*Macropharyngodon meligris*	—	—	—	—	XX	XX	—	X	—	—	—	—	—
97		*Cheilinus chlorurus*	—	—	—	—	XX	—	X	—	—	—	—	—	—
98		*C. trilobatus*	—	—	—	—	—	X	—	XX	—	X	—	XX	X
99		*Cymolutes lecluse*	—	—	—	—	—	—	XX	X	—	—	—	—	—
100		*Novaculichthys taeniourus*	—	—	—	—	—	—	—	—	—	—	—	X	—
101	Callyodontidae	*Cryptotomus spinidens*	—	—	—	—	—	—	—	XX	—	—	—	—	—
102		*Callyodon taeniurus*	—	—	—	—	—	XX	XX	XX	—	—	—	X	—
103		*C. harid*	—	—	XX	—	—	—	—	—	—	—	—	—	—
104		*C. bataxiensis*	—	XX	XX	—	—	—	—	—	—	—	—	—	—
105		*C. sexvittatus*	X	—	—	—	—	—	—	—	—	—	—	—	—
106		*C. ghobban*	—	—	—	—	—	—	—	—	—	X	—	—	—
107	Parapercidae	*Parapercis hexophthalma*	—	—	—	—	—	—	—	—	—	XX	—	—	—
108	Blennidae	*Aspidonotus tractus*	—	—	XXX	—	XX	X	—	—	—	—	—	—	—
109		*Petroscirtes pindae*	—	—	XX	—	—	—	—	—	—	—	—	—	—
110		*Istiblennius edentulus*	XX	XX	XX	—	—	—	—	—	—	—	X	—	—
111	Zanclidae	*Zanclus cornutus*	—	—	—	—	—	—	—	—	X	X	—	XX	X
112	Acanthuiidae	*Ctenochaetus strigosus*	—	XX	—	—	—	—	—	—	—	—	—	—	—
113		*Acanthurus triostegus*	XXX	XXX	XXX	XX	XX	XX	X	XXX	X	XX	X	X	X
114		*A. leucosternon*	X	—	—	—	—	XX	X	—	X	XX	X	X	XX
115		*A. lineatus*	XX	XX	XXX	X	—	—	—	—	—	—	—	—	—
116		*A. matoides*	—	XX	—	—	—	—	—	—	—	—	—	—	—
117		*A. elongatus*	XX	—	—	—	—	—	—	—	—	—	—	—	—
118	Electridae	*Electroides sexguttatus.*	—	XX	—	—	—	—	—	—	—	—	XX	—	—
119	Gobiidae	*Acentrogobius ornatus*	—	XX	—	—	—	—	—	—	—	—	—	—	—
120	Scorpaenidae	*Pterois volitans*	—	—	xx	x	xx	—	—	xxx	—	—	—	—	—

Sl. No.	Family	Species *P. antennate*	Che-llat	Kittan	Kad-mat	Amini	Bitra	Thinna-kara	Banga-ram	Agatti	And-roth	Kava-ratti	Suheli	Kal-peni	Mini-Coy
121		*Scorpaenodes guamensis*	—	—	—	—	xx	—	—	x	—	—	—	—	—
122		*Dendrochirus zebra*	—	—	—	—	x	xx	x	xx	—	—	—	—	—
123		*Sebastapistes strongia*	—	—	—	—	xx	x	x	xxx	—	—	—	—	—
124		*Caracanthus unipinnus*	—	—	—	x	—	—	—	—	—	—	—	—	—
125	Caracanthidae	*C. maculatus*	—	—	—	—	—	—	—	—	—	—	—	xx	—
126		*Rhineacanthus aculeatus*	—	—	—	—	—	—	—	—	—	—	—	xx	—
127	Balistidae	*R. rectangulus*	x	—	—	x	—	x	xxx	xx	—	xxx	xxx	xxx	xx
128		*Balistoides viridescens*	xx	—	—	—	xx	x	xx	xxx	—	—	—	—	—
129		*Melichthys niger*	—	—	—	—	—	—	—	—	—	—	—	xx	—
130		*Ostracion tuberculatus*	—	—	—	—	—	—	—	—	—	—	xx	—	—
131	Ostracanthidae	*Lophodiodon calori*	—	xx	—	—	—	—	—	—	—	—	—	—	—
132	Diodontidae	*Canthigaster margaritotus*	x	xx	—	x	xx	xx	x	xx	—	—	—	—	—
133	Canthigasteridae	*Sphoeroides hypselogeneion*	—	x	x	—	—	—	—	—	—	—	—	—	—
134	Lagocephalidae	*Tetraodon nigropunctatus*	xxx	—	—	—	—	—	—	—	—	—	—	—	—
135	Tetrandontidae	*T. meleagris*	—	—	—	xx	x	—	—	—	—	—	—	—	—
136		*T. hispidus*	—	—	—	xx	x	x	x	—	—	—	—	—	—
137		*Antennarius chironectes*	—	—	—	—	—	—	—	—	—	—	x	—	—
138	Antennaridae	*A. coccineus*	—	—	—	—	—	—	—	—	—	—	xx	—	—

XXX : Abundant; XX : Common: K : Rare - not seen

REMARKS

The survey as mentioned above was conducted during a short period of three months and thirteen islands were covered during the survey. The results are very useful for an appraisal of the availability of different species of ornamental fishes in different islands and for planing a comprehensive future research on the resources of ornamental fishes of different islands. The data collected, however, are not sufficient for estimation of resource potential of these fishes. In this connection the following points need consideration:

i. The Information on population characteristics is restricted to one or two species that too from Minicoy only. There is also no information on seasonal variations of important species. There is therefore need to study various aspects of biology of dominant species of ornamental fishes from different islands to enable a detailed study of stock assessment of these fishes. Initially, the study should be undertaken for at least two years to enable advice on the exploitation pattern.

ii. Presently the exploitation of ornamental fishes is only on a sustenance basis and there is no organised exploitation for commercial purpose. Since the ornamental fishes are associated with corals and associated fauna and flora in the islands, any exploitation on a commercial scale can result in destruction of the environment which in turn can also eventually affect the fish populations inhabiting these areas. Further, since the areas are easily accessible, the exploitation of reef fishes is likely to quickly lead to depletion of stocks and therefore utmost caution has to be exercised before planning exploitation and export trade of ornamental fishes. Fishing with traps is suitable for ornamental fishes; this is not likely to lead to destruction of habitat and therefore can be encouraged. However exploitation of ornamental fish species from the lagoons and reef flats can be undertaken on a smaller scale, and the same should be closely monitored.

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7. OTHER FIN-FISH RESOURCES

M. Kumaran, R. S. Lal Mohan and V. Sreeramachandra Murty

INTRODUCTION

Fishing is a profitable source of livelihood for the people of Lakshadweep where traditional methods of capture are still in vogue to a great extent. The traditional fishing methods and fishery of Lakshadweep consisting of 27 small islands of which only ten are inhabited have been briefly described by Hornell (1910), Ayyangar (1922), Ellis (1924), Mathew and Ramachandran (1956), Jones and Kumaran (1959), Verghese (1974), and Koya *et. al.* (1956). The exploited resources have been dealt with by Silas *et. al.* (1986) and Kumaran and Gopakumar (1986). Even though 603 species of fishes are known from the Lakshadweep (Jones and Kumaran, 1980), only about thirty species contribute to the commercial fishery. Fish landings in some of the islands were not even sufficient for local consumption before 1958. The efforts made during the past two and half decades to exploit the tuna resources by using pole and line has started paying good dividends. The remarkable increase in the landings of tunas especially skipjack is responsible for the present prosperity of some of the islands like Minicoy, Agatti, Kavaratti and Bitra. Though the islands have only an area of about 32 sq. km. the lagoons, reefs and submerged banks extending over an area of 42,000 sq. km. is endowed with several commercially important fishes. With the limited land area and a high density of population, the possiblities for developing other industries is limited, but the sea offers good scope for the progress of the islands. The vast difference in the estimates of fisheries potential of the Laccadive Sea which is reportedly of the order of 90,000 tonnes (Jones and Banerji, 1973) and the present annual landings (5,524 tonnes in 1986) indicates that further intensive exploitation is called for in the region.

The present account on the resources of fishes other than tunas is the result of a survey of the fisheries resources conducted for a period of three months from January to the first week of April 1987. Fish collections were made from the lagoons, reef flats and also around the islands for the purpose. Fishes were collected by drag net, cast net, pole and line, hook and line and other indigenous methods during the course of the survey. Fish landings of commercial fishermen were also considered to have an idea of the magnitude of abundance.

CRAFT AND GEAR IN OPERATION

The traditional fishing methods of the islands have been described by earlier workers Ayyangar, (1922); Ellis, (1924); Mathew and Ramachandran, (1956); Jones and Kumaran, (1959) and Koya *et al.* (1986). All the fish landings in the islands before mechanisation were by primitive indigenous crafts and gears. The details of the number of crafts and gears available at the time of the survey in different islands are given in Table 1. There are in all 251 mechanised boats in operation in all the islands. However, all of them are not used for fishing even during the peak fishing season as some are required for transport purposes especially for transporting passengers and luggage from the ship. Mechanised boats are being increasingly used for pole and line fishing, but many are used for the capture of other fishes also. Trolling and drift long lining are mostly done by mechanised boats of 7.6 m OAL which are more popular with the fishermen. The number of boats in Agatti, Kavaratti and Minicoy exceeds the total number of boats in all other islands and the lowest number is in Kalpeni. The plank built country crafts vary from 5 to 7 m in length. There are altogether 691 country crafts of which 118 are in Agatti, 110 in Kavaratti and 108 in Kalpeni. Bitra and Kadmat have only a few country crafts, 27 and 28 respectively. In all 154 country crafts are provided with outboard engines. Kalpeni and Minicoy leads in the mechanisation of country crafts.

TABLE 1. *Details of craft and gear available in different islands**

Island	Crafts			Gears			Remarks
	Mechanised boat	Country craft with outboard motor	Country craft	Shore seine/ drag net	Gill net	Drift long line	
Agatti**	49	19	99	48	38	31	** Occasionally some mechanised boats go to Suheli and Bitra for a few days when there is good fishing in these areas
Ameni@	19	—	38	6	—	16	
Androth	23	18	64	30	40	70	
Bitra***	17	14	13	4	—	6	@ Some of the boats are often engaged for transport purpose.
Chetlat@	19	20	30	5	—	47	
Kadmat@	14	16	12	20	4	16	
Kalpeni	9	28	80	20	100	60	*** The number of mechanised boats at Bitra varies greatly as boats from Chetlat and Agatti come here for short periods during peak fishing season.
Kavaratti	45	5	105	6	80	90	
Kiltan@	24	10	52	8	—	62	
Minicoy	32	24	44	10	30	—	
Total	251	154	537	157	292	398	

*Number of troll lines and pole and line not included.

Drag nets, gill nets, drift long lines and troll lines are the most important gears for the capture of other fin-fishes. Drag nets operated mostly in the lagoons for the capture of fishes like goat-fishes, lutianids, lethrinids, balistids, mullets etc. There are 157 shore seines/drag nets of varying dimensions in the islands. The highest number is found in Agatti viz., 48 followed by Androth 30. Only very few drag nets are found in Bitra and Chetlat. Lutianids, lethrinids, carangids, rainbow runner, serranids etc. are caught by drift nets operated mostly in the lagoon. There are 292 gill nets in all the islands. Drift long lines locally known as 'Bayp' for the capture of sharks and other large fishes are found in all the islands except Minicoy. The totol number of drift long line is about 400 and the highest number of 90 is in Kavaratti. Harpoons are used for the capture of devil rays *(Manta birostris), Aetobatus narinari, Dasyatis* spp., sharks etc. from the open sea around all the islands. Large carangids, bill fishes, wahoo, rainbow runner etc. are caught by surface trolling. Apart from the gears, varying number of cast nets, hand lines, iron spikes, 'Chilla' with spikes and fish traps are operated depending on the abundance of suitable species and favourable seasons. It would only be appropriate to point out that the use of indigenous gears is decreasing year after year due to the popularity of pole and line fishing for tuna and this is becoming evident by the decline in the landings of other fishes.

STATUS OF OTHER FIN-FISH RESOURCES

The general abundance and distribution of different species other than tunas collected during the survey and contributing to the commercial fishery are given in Table 2. All the species listed in the table are present around all the islands, but their abundance may vary Species belonging to seventeen families form the major share of other fin-fish landings. The important groups constituting the commercial fishery and widely distributed are sharks, rays, belonids, half-beaks, serranids, lutianids, lethrinids, wahoo, dolphin fish and rainbow runner. From the groups-wise fish landings at Lakshadweep for the years 1973-'86 given in Table 3, it is seen that the annual average landings of fishes including tunas is 3,707.2 tonnes of which only 1022.4

TABLE 2. *Abundance of other fishes (other than tunas) in different islands*

Species	Agatti	Ameni	Androth	Bangaram	Bitra	Chetlat	Kadmat	Kalpeni	Kavaratti	Kiltan	Minicoy
1. *Eulamia melanoptera*	XX	XX		XX	XX			XXX			
2 *Strongylura strongylura*	XXX	XX	XX	XXX	XXX	XXX			XX	XX	XX
3. *Belone platyura*	XXX	XX			XX		XX		XX		XX
4. *Hemirhamphus dussumieri*	XXX		XX	XXX	XX	XXX		XX		XX	
5. *Hemirhamphus marginatus*		XX	XX				XXX				
6. *Fistularia petimba*	XXX			XXX	XXX		XXX				
7. *Eleotheronema tetradactylum*	XXX	XX		XXX	XX	XX		XX			XX
8. *Epinephelus merra*	XX	XXX		XX	XX	XXX	XXX		XXX	XXX	XX
9 *Epinephelus merra*			XX		XX	XXX	XXX		XX	XX	XXX
10. *Cephalopholis argus*	XX				XX	XXX		XXX			XX
11. *Cephalopholis rogaa*	XXX		XX	XX	XX			XXX		XX	XX
12. *Caranx sexfasciatus*	XX	XX		XX		XX	XX		XXX		XX
13. *Caranx stellatus*	XX	XX						XX	XX		XXX
14. *Caranx lugubris*		XX		XX	XX	XX		XX			XXX
15. *Trachinotus bailloni*			XX	XX		XXX			XX	XXX	
16. *Trachinotus blochii*		XX			XX		XXX	XX			XX
17. *Lutianus gibbus*	XX		XXX	XX	XX	XX	XX			XX	XX
18. *Lutianus kasmira*	XX				XX	XX		XX	XX		XX
19. *Lutianus russelli*		XXX	XX	XX	XX		XX	XX		XX	
20. *Lutianus bohar*	XX	XX			XX					XX	
21. *Mulloidichthys auriflamma*	XXX	XX		XXX	XXX	XXX	XXX	XxX	XXX	XX	XXX
22. *Mulloidichthys samoensis*	XX	XX		XX		XXX	XXX	XX	XX	XX	XX
23. *Parupeneus barberinus*		XX			XXX	XX	XX		XXX	XX	XX
24. *Parupeneus macronemus*	xx		xx	xxx		xxx			xxx	xx	xx
25. *Lethrinella xanthocheilus*	xx			xx	xx	xx		xxx	xx	xx	xx
26. *Acanthurus triostegus triostegus*	xxx	xxx		xxx	xx	xxx	xxx	xx	xx	xxx	xxx
27. *Elagatis bipinnuatus*	xxx	xx	xxx	xx	xx	xx		xxx	xxx	xx	xxx
28. *Coryphaena hippurus*	xx	xx	xx	xx	xx	xx	xx		xx		xx
29. *Acanthocybium solandri*	xx		xxx		xx			xxx	xxx		xxx
30. *Gerres oblongus*	xxx		xx	xx	xx	xx	xx				
31. *Gerres lucidus*		xx		xxx		xxx			xx	xx	
32. *Callyodan ghobban*	xx			xx		xx		xxx	xx	xx	xx
33. *Aphareus furcatus*	xx	xx	xxx	xx	xx		xx	xx	xx	xx	xx

xxx Abundant
xx Common

tonnes (27.58%) consist of other fishes- The total landings in 1986 has reached 5,524 tonnes, but the landings of other fishes was only 717 tonnes (15.52%) which is the lowest during the 12-year period. The landings of other fishes has been gradually decreasing from 1983, whereas the tuna catch as well as the total catch generally showed an increasing trend for the past few years. Fishes other than tuna in the commercial landings in the order of abundance for the 12-year period are: sharks and rays (26.52%), perches (20.50%), carangids (8.39%), belonids and half beaks (7.42%), wahoo (5.22%) and goat fishes (3.13%).

The island-wise production of other fishes for the period 1981-85 are given in Table 4. The average annual landings of other fishes for the period 1981-85 was 1049.4 tonnes which formed 24.02% of the total landings. The landings of other fishes was highest at Androth (25.77%), followed by Agatti (13.51%), Kadmat (10.50%), Ameni (10.02%) and Kavaratti (9.59%), and very low at Chetlat (4.73%) and Minicoy (4.10%). A declining trend in the

TABLE 3 *Marine fish Landings in Lakshadweep during 1973-'86 (in tonnes)*

Group	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Average 73-'86	Percentage*
Elasmobranchs	325	354	296	198	364	284	211	240	332	287	228	134	271.1	26.52
Belonids & Half beaks	29	33	58	144	101	99	113	87	103	62	39	43	75.9	7.42
Flying fish	30	41	30	33	16	29	16	25	25	15	6	13	23.3	2.28
Perches	186	193	211	163	203	376	315	230	252	205	109	72	209.6	20.50
Goat fishes	34	58	29	27	27	27	25	27	32	24	28	46	32.0	3.13
Carangids	61	94	65	60	58	80	105	21	147	45	50	51	85.8	8.39
Wahoo	66	87	41	41	24	21	50	99	59	59	58	36	53.4	5.22
Barracuda	17	20	15	18	11	15	12	10	19	14	8	8	13.8	1.35
Miscellaneous	232	361	281	201	233	206	203	239	237	265	318	314	257.5	25.19
Total (excluding tuna)	980	1241	1026	885	1037	1136	1050	1171	1206	976	844	717	1022.4	(27.58)
Tuna	1932	1291	1166	1875	2794	1760	2236	2966	3303	4313	3775	4807	2684.8	(72.42)
Grand total	2912	2532	1192	2760	3831	2896	3286	4137	4509	5289	4619	5524	3707.2	

*Percentage to the total (excluding tuna)

Percentage indicated in brackets is percentage to the grand total.

TABLE 4. *Island-wise fish landings (excluding tuna) in Lakshadweep during 1981-85 (in tonnes)*

Island	1981	1982	1983	1984	1985	Average	Percentage
Agatti	137	180	186	123	83	141.8	13.51
Ameni	157	100	128	81	60	105.2	10.02
Androth	303	385	335	192	137	270.4	25.77
Bitra	56	47	66	58	28	51.0	4.86
Chetlat	50	51	56	61	30	49.6	4.73
Kadmat	100	116	80	76	179	110.2	10.50
Kalpeni	53	58	92	96	116	83.0	7.91
Kavaratti	111	110	105	112	65	100.6	9.59
Kiltan	38	79	94	150	112	94.6	9.01
Minicoy	45	45	64	27	34	43.0	4.10
Total (excluding tuna)	1050	1175	1206	976	844	1049.4	100
% of total catch	31.95	28,31	26.75	18.45	18.27	24.02	

other fish landings from 31.95% in 1981 to 15.52% in 1985 has been observed. This obviously is due to the deployment of more units for pole and line fishing which is more economical to the fishermen who neglect the exploitation of other fin-fish resources when tuna fishery is good. As tuna fishing by pole and line for skipjack is practised in Minicoy From very early times, the landings of other fish resources there has been low all along. According to Kumaran and Gopakumar (1986) the landings of other fishes is usually higher when the tuna catch is poor in a particular season.

Even though only ten islands are inhabited, fishermen from some islands go to the neighbouring uninhabited islands and reefs for fishing and return after fishing for a few days. The boats from Kavaratti visit Suheli par during peak fishing season there and other fish catches are salted and dried there itself. The fishermen from Agatti and Chetlat go to Bitra during good weather for catching tuna and other fishes. Occasionally boats from the northern islands go to Perumal par for catching large fishes, sharks and rays. Cheriya Kalpeni; a small coral bank near Androth is a good fishing ground for *Acanthocybium solandri, Elagatis bipinnulatus, Coryphaena hippurus* and flying fish. There is good potential for sharks, groupers and carangids around the islands, but these are exploited only on a very limited scale.

The main fishing seson in the islands extend from November to May, the peak period being February-March. The month of March accounted for about 16% of the landings. Fishing is poor during June to September. The season for goat-fish, serranids, lutianids, lethrinids and sharks is generally from May to November. The season for *Acanthocybium solandri* and *Elagatis bipinnulatus* is November to April. Coral fishes which form about 19% of the catches at Kalpeni is caught almost in all the months. About 38% of the catches at Kalpeni is landed during November and December. In Androth fishing is good during October to February with the peak during November. In Minicoy the highest catch is in March with about 18.5% of the annual catch and the fishing was poor during June to October. In Kavaratti fishing was good during November and May with a peak landing during April-May. The fishery was poor during June to September. Fishing at Suheli par generally starts in November and comes to a close by April and the fishing is very good from December to March. There is no fishing at Suheli par from May to October as the fishermen have to come from Kavaratti for fishing after the south-west monsoon.

PROSPECTS FOR DEVELOPMENT

The widespread adoption of pole and line fishing for tunas has resulted in considerable increase in the tuna catch in the Lakshadweep

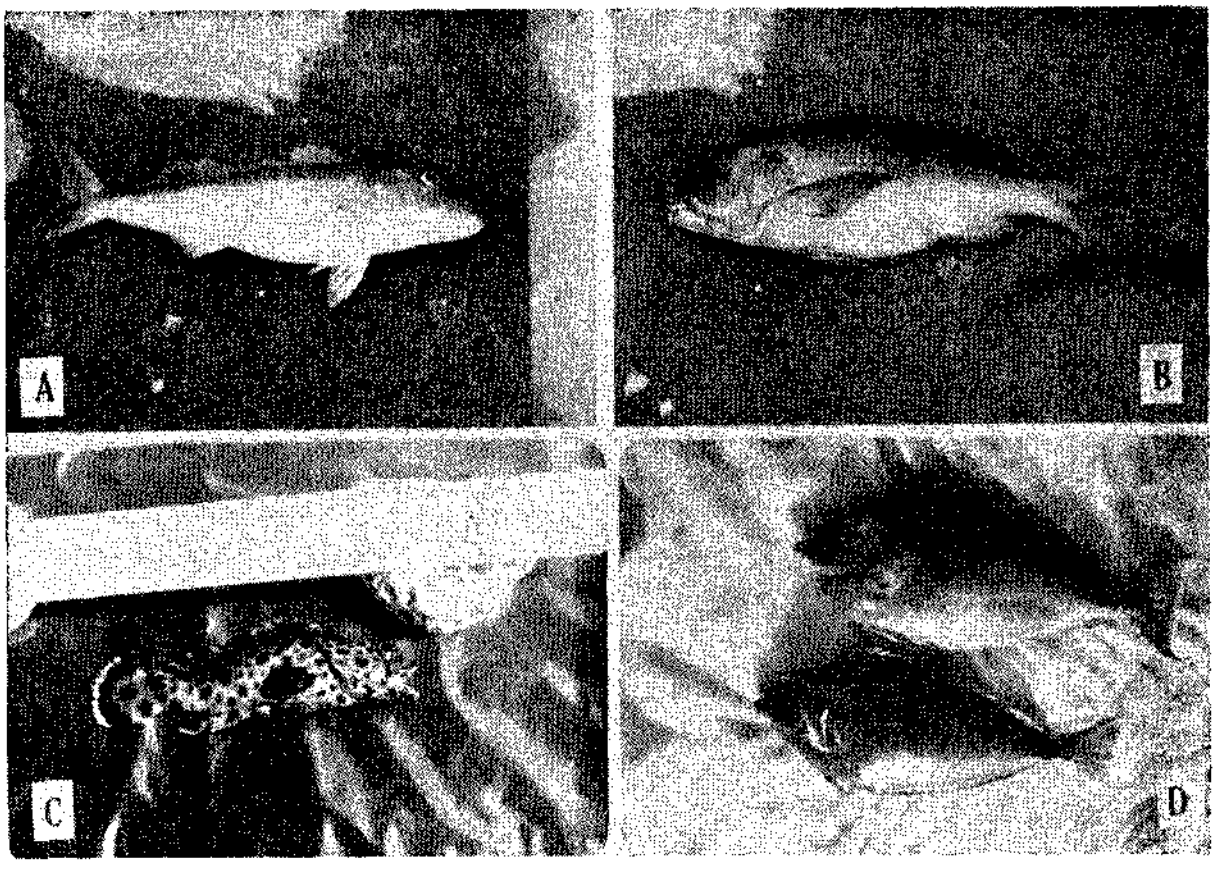

FIG. 1 A. *Abrion virescens* from Minicoy island. B. *Lutianus bohar* from Minicoy island. C. *Epinephelus merra* from Minicoy island. D. *Naso unicornis* from Kavaratti island.

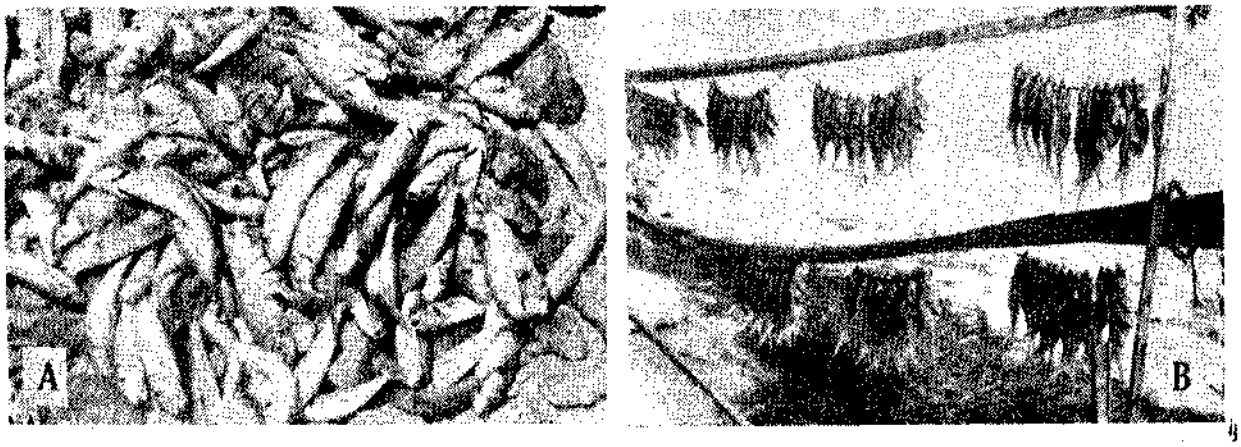

FIG. 2 A. Fish collections of drag net, consisting mostly of *Mulloidichthys auriflamma*. B. Fishes being dried at Suheli par.

with a per capita availability of more than 120kg of fish per year which is the highest when compared to other States and Union Territories. At the same time the exploitation of other fish resources is rather neglected as evidenced by the decline in their landings during the past few years. The landings of traditional gears like drag nets, cast nets, trolling and harpooning etc. amounts to less than one fourth of the total fish landings. Nair *et al.* (1986) has opined that the presence of divergence and convergence zones in the open sea, the presence of upwelling, eddy systems and relatively low saline waters in the surface layers during November-December period contribute to the high productivity around Lakshadweep. Concentrations of oceanic zooplankton and micronecton have been observed by Silas (1972) in the Laccadive sea. These feature should be conducive for the concentrations of larger fishes like tunas, bill fishes, *Acanthocybium solandri, Elagatis bipinnulatus, Coryphaena hippurus* etc. in the open sea during first quarter of the year. The lagoons of the islands are ideal for a variety of fishes of commercial importance which could be easily exploited by hook and line and nets. Larger fishes in the deeper waters around the islands could be exploited by trolling, long lining and gill netting. Suheli par has been a good fishing centre for the past several years for the islanders, especially those of Kavaratti. Androth has no lagoon, but the resources of other fishes around the island is important when compared to that of other islands as the landings of other finfishes there is higher than in any other island. Bitra which is only less than 2 hectares in extent has the largest lagoon with various kinds of fishes. There is good possibility for the capture of sharks and billfishes by long lining and rays by harpooning in the Lakshadweep sea.

Diversification of fishing effort with improvement in gears to suit local condi ions aimed at generating employment opportunities will naturally pave the way for increasing the production of other fishes. The area of fishing operations need to be simultaneously increased by adopting modern technology. Resource surveys by long lining and gill netting have to be carried out to locate productive areas for other fish resources and to evaluate the suitability of different gears. There is sufficient manpower in the islands itself for the expansion of fishing activities as there are many unemployed youths who are now reluctant to take up fishing as a profession. Increasing the development activities in the fisheries sector will solve the problem of unemployment and lead the islands to prosperity. The chances of getting Government employment for all the educated youth of the Territory in the islands itself is meagre. The establishment of a Fisheries Development Corporation or Fisheries cooperatives with public participaion for the exploitaion of oceanic fishes will accelerate the progress of fisheries development and increase the percapita income which is at present probably the highest in India.

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8. CRUSTACEAN RESOURCES OF THE LAKSHADWEEP ISLANDS

G. Sudhakara Rao, C. Suseelan and M. Kathirvel

INTRODUCTION

Information on the crustacean resources of Lakshadweep is limited to only a few faunistic reports on crabs, prawns, lobsters and stomatopods (Alcock, 1895, 1896, 1998, 1899, 1900; Borradaile, 1903a, 1903b, 1903c, 1903d, 1906a, 1906b; Sankarankutty, 1961; Thomas 1970a, 1970b, Meiyappan and Kathirvel, 1978; Pillai *et al*, 1984 and Shanbhogue, 1986). A total of 132 species of brachyuran crabs mostly belonging to Calappidae, Majidae, Parthenopidae, Portunidae, Xanthidae, Ocypodidae and Grapsidae, 4 species of palinurid lobsters, 2 species of scyllarid lobsters, 5 species of penaeid prawns and 7 species of stomatopods have been recorded so far from these islands.

The present account deals with the crustacean fishery potential of Lakshadweep based on the survey conducted in 15 islands, namely, Minicoy, Kalpeni, Suheli Par, Pitti, Kavaratti, Androth, Bangaram, Agatti, Parali, Amini, Kadmat, Kiltan, Bitra and Chetlat extending from latitude 8'17'N to '1141' N and longitude 72'10'E to '73'41'E during January to March 1987. During the present investigation attempts were made to collect data on the availability, fishing season, fishing gear employed, abundance, habitat and utilisation of commercially important groups of crustaceans from all the 15 islands.

METHOD OF SURVEY

For qualitative and quantitative studies of the various crustacean groups, sampling was made at stations in different ecological zones of the islands. In each zone transects of 10x10 m were surveyed in detail for the abundance of different groups of crustaceans. The number of transects sampled varied depending on the extent of different zones. A minimum of 4 transects were sampled in each zone. Data were collected by operating velon screen drag net, scoop net, cast net, shore seine, grab and dredge wherever possible. Hand picking was found to be more effective than many of these methods. Visual counting was also adopted for estimating the number of animals present in

the exposed intertidal zones. The availability and population density of different groups in the lagoons was studied by diving and observing the population in their natural habitats since other methods were not found to be effective in these areas.

OBSERVATIONS

Penaeid prawns, sergestids, caridean prawns, crabs, lobsters, hermit crabs and stomatopods form the chief constituents of the crustacean fauna associated with these islands. As one could expect on account of the great dissimilarities in habitat, the crustaceans that have colonised these islands evince considerable differences in quality as well as quantity as compared to the crustaceans inhabiting the coastal areas of the mainland. Table 1 gives a list of penaeid prawns, sergestids, lobsters, brachyuran crabs and stomatopods recorded during this survey.

TABLE 1: *List of penaeid prawns, sergestids, lobsters, brachyuran crabs and stomatopods collected from the Lakshadweep Islands*

PENAEID PRAWNS

Metapenaeopsis borradailei (De Man)
Penaeus latisulcatus Kishinouye
Trachypenaeopsis minicoyensis Thomas

SERGISTIDS

Sergestes armatus Kroyer
Acetes sp.

LOBSTERS

Panulirus homarus (Linnaeus)
Panulirus penicillatus (Olivier)
Panulirus versicolor (Latreille)

CRABS

FAMILY : DYNOMENIDAE
Dynomene pilumnoides Alcock

FAMILY : DORIPPIDAE
Ethusa indica Alcock

FAMILY : CALAPPIDAE
Calppa calappa (Linnaeus)
Calappa hepatica (Linnaeus)
Matuta banksi Leach

FAMILY : MAJIDAE

Huenia brevifrons Ward
Huenia proteus De Haan
Hyasfenus diacanthus (De Haan)
Hyastenus elongatus Ortmann
Mecippa philyra (Herbst)
Menaethius araneus De Haan
Schizophrys aspera (H. Milne-Edwards)
Tylocarcinus styax (Herbst)

FAMILY : LEUCOSIIDAE
Nucia speciosa Dana

FAMILY : PARTHENOPIDAE

Actaeomorpha erosa Miers

FAMILY : PORTUNIDAE

Charybdis erythrodactyla (Lamarck)
Charybdis obtusifrons Leene
Portunus emarginatus Stephenson & Cambell
Portunus granulatus (H. Milne-Edwards)
Portunus orbicularis Crosnier
Portunus orbitosinus Rathbium
Portunus petreus (Alcock)
Tualamita admete (Herbst)
Thalamita picta Stimpson
Thalamita pilumnoides Borradaile
Thalamita poissoni (Audouin & Savigny)

FAMILY : XANTHIDAE

Actaea cavipes (Dana)
Actaeodes hlisutissimus (Rupell)
Atergatis subdentats De Haan
Atergatopsis singnatus (Adams & White
Carpilius convexus (Forskal)
Carpilius maculatus (Linnaeus)
Chlorodella cytherea (Dana)
Cymo andreossyi (Audouin)
Cymome lanodactylus De Haan
Daira perlata (Herbst)
Demania intermedia (Guinot)
Domecia glabra Alock
Eriphia sebana sebana (Shaw & Nodder)

Etisus laevimaus Randall
Euxanthus exsculptus (Herbst)
Glabropilumnus dispar (Dana)
Globopilumnus globosus (Dana)
Hetropilumnes integra Miers
Lachnopodus subacutus (Stimpson)
Leptodius sanguineus (H. Milne-Edwards)
Liomera bella (Dana)
Liomera caeleta (Odhner)
Liomera cinctimana (White)
Liomera margarita A. Milne-Edwards)
Liomera mentculosa H. (Milne. Edwards)
Liomera rugate H. (Milne-Edwards)
Liomera stimpsoni (A. Milne-Edwards)
Maldivia triunguiculata (Borradaile)
Ozius tuberculosus (H. Milne-Edwards)
Paracaea rufopunctata (H. Milne-Edwards)
Phymodius unguletus (H. Miline-Edawards)
Pilodius pilumnoides White
Pilodius pugil Dana
Pilumnus longicornis Hilgendrof
Pilumnus orbitosyinis Rathbun
Pilumnus vespertilio (Fabricius)
Platypodia anaglypta (Heller)
Pseudozius caystrus (Admas & White)
Quadrellia boopsis Alcock
Tetralia glaberrima (Herbst)
Trapezia cymodoce (Herbst)
Trapezia ferruginea Latreille
Trapezia guttata Ruppell
Xanthias lamarcki (H. Milne-Edwards)
Zozymodes cavipes (Dena)
Zozymus aeneus (Linnaeus)

FAMILY : OCYPODIDAE

Ocypoee ceratophthalmus (Pallas)
Ocypode cordimana Desmarest

FAMILY : GRAPSIDAE

Geograpsus crinipes (Dana)
Geograpsus grayi (Dana)
Grapsus tenuicrustatus (Herbst)

STOMATOPODS

Gonodactylus chiragara (Fabricius)
Gonodactylus falcatus (Forskal)
Gonodactylus platysoma Wood-Mason
Gonodactylus smithi Poccok

Penaeid prawns and sergestids

During the present survey, no penaeid prawn could be collected on the leeward reefs and windward reefs of the islands. They were observed only in the lagoons and could be collected by cast nets, shore seines and dredge. Five species of prawns were recorded. *Penaeus latisulcatus* was represented by five specimens collected from Chetlat, Kiltan and Suhelipar. The size range of this species was 45-110 mm in total length. A total of 8 specimens of *Metapenaeopsis borradailei* was collected from Kavaratti, Suheli par, Agatti and Chetlat. *Trachypenaeopsis minicoyensis* was encountered only at Agatti and that too only two specimens. The sergestid shrimp, *Sergestes armatus*, was recorded from Agatti and Bitra. This is the first record of the species from the Indo-pacific region. Two specimens of *Acetes* sp were also collected from Chetlat.

Earlier records of penaeid prawns include numerous specimens of *P. latisulcatus P. canaliculatus, Trachypenaeus curvirostris, Trachypenaeopsis, minicoyensis* and *M. borradailei* from minicoy. The present study shows that *P. latisulcatus, T. minicoyensis* and *M. borradailei* are widely distributed in the Lakshadweep Sea.

At present there is no commercial exploitation of prawns around these islands. However, it is learnt from the migrant fishermen that *P. latisulcatus* is caught in small numbers in ihe drag net operations from the lagoon of Suheli Par during monsoon months. It is evident from the meagre representation of penaeids in the present collections and the other available information that there is no scope of developing a fishery based on penaeid prawns in these islands.

Caridean prawns

The coral reefs of the islands are very rich in caridean prawn fauna. The species belong-

ing to Atyidae, Alpheidae, Palaemonidae, Hippolytidae and Processidae abound these islands in association with dead and living corals. At some stations each Kilogram of coral rock contained as many as 20-30caridean prawns. However, all these species are very small and hence it is not possible to develop any fishery based on these prawns.

Brachyuran crabs

A rich fauna of brachyuran crabs has been observed in all the islands. Although most of these species are small in size, a few of them are sufficiently large to be used as food. Particular interest in this regard is the large sized xanthid crabs like *Eriphia sebana, Aterigatis subdentatus* and *Liomera caelata*. Crabs of 30-60 mm in carapace width were observed in abundance in all the islands. Portunids were poorly represented in the reefs. All the portunids observed were from the lagoons. The commercial portunids such as *Scylla serrata, Portunus pelagicus, P. sanguinolentus* and *Charybdis cruciata* were not encountered in these islands. Although it is not possible to develop any commercial fishery, scope is there to develop a sustenance fishery on these crabs.

Among the shore crabs, the most abundant and widely distributed species is the ghost crab, *Ocypod ceratophthalmus*. This is found in all the islands surveyed in varying degrees of abundance. Nocturnal in habit, the ghost crab appears plentiful on the beaches during night. In fact, the beaches are littered with these crabs althrough the night. Its maximum abundance is recorded at Bangaram, where the average number per square metre works out to about 6 on the lagoon shore. Though this crab is believed to have some food value among the coastal fishermen of Tamilnadu no commercial importance is attached to it in any part of the islands.

Hermit crabs

Hermit crabs are in good abundance in the sandy beaches and intertidal regions of the reefs. Most of these hermit crabs scavenge on the beaches during night. They are rarely seen during day. They are a menace to the coconut processors, since they invade the processing yards along the beaches. In some of these islands the crabs are seen crawling on the roads in the heart of the islands. The different species display a variety of colours making them a good choice for aquarium purposes. Since their maintenance in aquarla poses very few problems when compared to the other marine animals, they could be popularised as aquarium animals.

Lobsters

A Limited populaion of spiny lobsters belonging to the family Palinuridae is found to exist around all the islands. They are not commercially fished by the islanders at present. However mainlanders inhabiting the islands fish them for food in Kiltan, Suheli Par and Minicoy in small numbers. Three species of lobsters, namely, *Panulirus versicolor. P. penicillatus*, and *P. homarus* were observed during the course of the survey. Of these *P. versicolor* is more abundant than the other species.

P. versicolor was collected from Kadmat, Kiltan, Chetlat, Agatti, Kalpeni, Bitra and Kavaratti while *P. penicillatus* was observed at Agatti, Kavaratti, Suheli Par Kalpeni and Androth. *P. homarus* was observed only at Minicoy. The size of lobsters ranged from 50-325 mm in total length (20-140 carapace length).

Earlier records of lobsters from Lakshadweep were from Minicoy, Kavaratti and Kiltan (Meiyappan and Kathirvel, 1978 and Pillai *et al.*, 1984). The present study reveals that *P. versicolor* and *P. penicillatus* are widely distributed in these islands.

In Kiltan one or two people collect *P. versicolor* during day time and use it as food and also for ornamental purpose after stuffing. Species like *P. penicillatus* are said to be fished occasionally from the ship wreckage in the leeward reef of Cheriya Kare island (Suheli Par) and the scyllarid lobster *Parribacus antarticus* from the coral crevices in the lagoon of Suheli Par.

Stomatopods

Stomatopods are found to be of common occurrence in the lagoons and coral reefs of Amini, Kadmat, Kiltan and Chetlat. They are mainly represented by *Gonodactylus Chiragara, G. platysoma, G. smithi* and *G. falcatus*. The size ranged from 16 mm to 73 mm.

Shanbhogue (1986) reported seven species of stomatopods from Minicoy, The species are *G. chiragara, G. falcatus, G. platysoma, G. smithi, Pseudosquilla ciliata, Hetreosquilla jonesi* and *Alima hyalina*. Only four of these species are observed in the present collections made from Amini, Kadamat, Kiltan and Chetlat. The present study extends the distributional range of the species of *Gonodactylus* to these islands.

CONCLUSIONS

It is seen from the present study that these islands do not possess any substantial resource of crustaceans which could be exploited in commercial scale. The small populations of shrimps encountered in the lagoons of the islands are very small in size and therefore can not be economically useful.. Though a few species of lobsters and penaeid prawns do occur in the region their numbers appear to be too limited to support a commercial fishery. Among crabs *Ocypode ceratophthalmus, Eriphia sabana, Atergigatis subdentata* and *Liomera caelata* might prove to be a potential resource to develop into sustenance fishery. Hermit crabs are of interest as ornamental animals in the aquaria.

The hard bottom and other environmental conditions prevailing in the lagoons do not appear to be congenial for the growth of prawns. Therefore, there is no scope for propagating prawn culture also in these waters.

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9. MOLLUSCAN RESOURCES

K. K. Appukuttan, A. Chellam, K. Ramdoss, A. C. C. Victor and M. M. Meiyappan

INTRODUCTION

A critical review of literature on the fauna of Lakshadweep reveals that there is only scanty reports on the occurrence of molluscs from various islands (Smith, 1906; Appukuttan, 1973; Nair and Dharmaraj, 1983 and George *et al.*, 1986). A survey on the fisheries potential of Lakshadweep was undertaken by the scientists of Central Marine Fisheries Research Institute to provide adequate informations on the molluscan fisheries potential of the islands for future planning and development. The present status of fishery of potentially important molluscs, fishing methods, occurrence and abundance are dealt with in the present account. The island surveyed for molluscan resources are Minicoy, Suheli pear, Kalpeni, Kavaratti, Androth, Agathi, Bangaram, Amini, Kadamat, Kiltan, Bitra and Chetlat. To understand the distribution pattern, population density and habitat, transect method of sampling was adopted uniformly in all the islands. The sampling areas were broadly classified intointertidal area, lagoon, reef crest in the lagoon side and leward side and reef slopes of both sides. Quadret method of sampling for few bivalves and gastropods were done for quantitative estimates. By diving and hand-picking, samples were collected from various stations and relative abundance were noted by visual estimates. The maps of islands shows the distribution of commercially important molluscs.

PRESENT STATUS OF MOLLUSCAN FISHERY

As such, large-scale exploitation and utilization of molluscs from islands are remote. Three species of octopuses two species of cowries and one species of bivalve are being exploited at present in minor quantities. The details of fishery, exploitation method and utilization of these molluscs were studied and the occurrence and abundance of other commercially important molluscs are describe d.

CEPHALOPOD

1. *Octopus*

Three species of Octopuses *viz. Octopus vulgaris, O. membranaceus* and *O. cyaneus* are found to occur in various islands of Lakshadweep. The Octopus production from 1981-1985 and the average of each quarter of the year are given in Table 1 and Table 2 respectively. Though there is no information on species-wise catch composition, *O. vulgaris* seems to rank first in abundance followed by *O. cyaneus* and *O memoranaceus*. Fishing for Octopus is observed year round, the IInd and IIIrd quarter shows lesser landings which coinsides with the monsoon months. Active fishing for Octopus in each month is also confined to the days with good low tide, providing opportunity to fishermen to locate the hideouts of the animals. Men, women and children are involved in fishing and there is no full time Octopus fishermen in any of the islands and hardly 6 to 10 expert Octopus fishermen are observed in each island.

Octopus are cought during low tide from the crevices/burrows in the coral boulders in the reef flats on the lagoon side and also in the leward side Fig. I A. These crevices are easily detected by expert fishermen noting the presence of loosely kept coral stones in front of the crevices and also by the presence of discarded freshly eaten crab shells in the exposed reef flats during low tide. In deeper waters they use mask to detect the burrows before capturing them. The gear for capturing Octopus consist of 1 to 1.5 m long m. s. rods of 6-8 mm diameter having sharpend edges, sometime curved at the tip Fig. I B. When the Octopus is located, it is pinned down with one rod and retrieved with the other and an expert fisherman can take out the animal with a single rod locally known as 'appal kol'. As soon as the animal is caught, the mantle is turned inward out, popularly known as - turning the cap - and remove the ink sac and alimentary canal. It is understood from local fishermen that eels are

TABLE 1. *List of Molluscs collected from Lakshdweep Islands Duriug January to March 1987*

Family & Species	Mini-coy (1)	Suheli par (2)	Kalpeni (3)	Kava-ratti (4)	Androth (5)	Agatti (6)	Ban-garam (7)	Amini (8)	Kad-mat (9)	Kiltan (10)	Bitra (11)	Chetlat (12)
Gastropods												
Family Haliotidae												
Haliotis sp.	—	—	—	—	—	—	—	—	—	—	x	—
Family Patellidae												
Cellana radiata	x	—	—	x	—	x	x	x	x	x	x	x
Family Trochidae												
Trochus radiatus	x	x	x	x	x	xx	x	x	x	x	x	x
T. pyramis	xx	x	x	x	x	—	x	x	x	x	—	xx
T. stellatus	x	—	—	—	—	x	—	—	—	x	—	—
Family Turbinidae												
Turbo petholatus	x	—	—	—	—	x	x	—	—	—	x	—
Family Neritidae												
Nerita albicella	x	x	x	x	x	x	x	x	x	x	x	x
N. chameleon	x	—	—	—	—	xx	xx	x	—	x	xx	x
N. maura	x	—	—	—	—	x	x	—	—	x	x	—
N. plicata	x	x	xx	x	x	xx	xx	x	x	x	x	xx
N. polita	x	x	x	x	—	xx	xx	—	x	x	—	x
Family Littorinidae												
Littorina kraussi	x	x	x	xx	—	xx	xx	—	—	xx	x	xx
L. scabra	x	x	x	xx	—	xx	xx	—	—	xx	x	xx
L. undulata	x	x	—	—	—	x	x	—	—	xx	x	—
Nodilittorina Pyramidalis	x	—	—	—	—	x	x	—	—	—	xx	—
Family Planaxidae												
Planaxis virgatus	—	—	—	—	—	xx	—	—	—	x	—	—

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Family Cerithidae												
Cerithium articulatum	—	—	—	—	—	x	—	—	—	—	—	—
Cerithium asper	—	—	—	—	—	x	—	—	—	—	—	—
C. hanleyi	x	x	x	x	x	xx	xx	—	—	xx	xx	xx
C. nodulosum	—	—	—	—	—	x	x	—	—	—	x	—
C. obeliscus	—	—	—	—	—	x	—	—	—	—	x	—
Cerithium sp.	—	—	—	—	—	x	—	—	—	—	—	—
Family Strombidae												
Lambis chiragra	x	x	x	x	x	x	x	x	xx	xx	x	xx
L. lambis	x	x	x	x	—	xx	xx	xx	xx	xx	x	xx
L. truncata	xx	x	x	—	—	xx	xx	xx	xx	xx	xx	xx
Strombus gibberulus	xx	—	xx	—	—	xx	xx	x	x	x	xx	xx
S. lentiginosus	—	—	—	—	—	x	x	—	—	—	—	—
S. urceus	x	x	x	x	x	xx	xx	—	—	—	x	x
Strombus sp.	—	—	—	—	—	x	x	—	—	—	—	—
Family Cypraeidae												
Cypraea annules	—	—	—	—	—	x	—	—	—	—	—	—
C. arabica	x	—	x	—	—	xx	x	—	—	x	x	—
C. caputserpentis	x	—	x	—	—	xxx	xxx	—	—	xx	xx	xxx
C. coffea	—	—	—	—	—	x	—	—	—	x	—	—
C. erosa	—	—	—	—	—	x	x	—	—	x	x	—
C. histrio	—	—	—	—	—	—	—	—	—	x	—	—
C. isabella	—	—	—	—	—	x	—	—	—	x	—	—
C. lynx	—	—	—	—	—	x	—	—	—	x	—	—
C. moneta	xx	—	—	—	—	xxx	xxx	x	xx	xx	xx	xxx
C. nucleus	x	—	—	—	—	x	—	—	—	—	—	—
C. pulchra	—	—	—	—	—	—	—	—	—	x	—	—
C. scurra	—	—	—	—	—	x	—	—	—	—	—	—
C. tigris	x	—	—	x	—	x	x	—	—	—	x	x

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Family Naticidae												
Polyuices mammilla	x	—	x	x	—	x	x	—	—	x	x	xx
Family Cassididae												
Casmaria erinaceus	—	—	—	—	—	x	—	—	—	—	—	—
Cassis cornuata	x	—	x	—	—	x	—	x	—	—	—	—
Cypraecassis rufa	x	—	x	—	—	x	—	x	—	—	—	x
Family Cymatiidae												
Charonia tritonis	—	—	—	—	—	x	—	x	—	—	—	x
Cymatium lotorium	—	—	—	—	—	x	—	—	—	—	—	—
Cymatium sp.	—	—	—	—	—	x	—	—	—	—	—	—
Family Tonnidae												
Malea pomum	—	—	—	—	—	x	—	—	—	—	—	—
Family Muricidae												
Murex ramosus	—	—	—	—	—	—	—	—	—	—	x	x
Drupa heptagonalis	xx	x	—	—	—	xx	xx	x	—	x	xx	xx
D. lobata	—	—	—	—	—	x	—	—	—	—	—	—
D. margariticola	x	—	x	x	—	—	x	—	—	x	—	x
D. morum	x	—	—	—	—	x	x	—	—	xx	x	x
D. ricinus	—	—	—	—	—	x	—	—	—	—	—	—
D. tuberculata	x	—	—	—	—	x	—	—	—	xx	—	x
Thais intermidia	—	—	—	—	—	x	—	—	—	—	—	—
T. rudolphi	—	—	—	—	—	x	—	—	—	x	—	—
T. rugosa	—	—	—	—	—	—	—	—	—	x	x	—
Family Buccinidae												
Phos senticosus	—	—	—	—	—	x	—	—	—	—	—	—
Engina mendicaria	x	x	x	x	x	xxx	xxx	—	—	xx	xxx	xx
E. pulchra	—	x	—	—	—	x	—	—	—	—	x	x
E. zonalis	x	—	x	—	—	xx	xx	—	—	—	x	—
Pisania ignea	—	—	—	—	—	x	—	—	—	—	—	—

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Family Pyrenidae												
Pyrene versicolor	x	x	—	—	—	xx	xx	—	—	—	x	xx
Family Nassaridae												
Nassarius arcularius	x	x	x	x	x	xx	xx	—	—	—	xx	x
N. fidus	—	—	—	—	—	x	—	—	—	—	x	—
N. gemmulatus	—	—	—	—	—	x	—	—	—	—	—	—
Family Fasciolariidae												
Fasciolaria filamentosa	—	—	—	—	—	x	—	—	—	—	—	—
Family Olividae												
Oliva erythrostoma	—	—	—	—	—	x	—	—	—	—	—	—
O. nobilis	x	—	—	—	—	x	—	—	—	—	—	—
Family Mitridae												
Vexillum exasperatum	—	—	—	—	—	X	—	—	—	—	—	—
Mitra mitra	X	X	X	—	—	X	—	—	—	—	—	—
Family Visidae												
Vasum ceramicum	X	X	X	X	X	X	X	—	X	—	X	—
V. turbinellum	X	X	X	X	X	X	X	—	X	—	X	—
Family Conidae												
Comus arenatus	—	X	—	—	—	X	X	X	X	XX	—	X
C. capitaneus	—	—	—	—	—	X	—	XX	XX	XX	—	XX
C. chaldeus	X	—	—	—	—	X	—	—	—	—	—	—
C. cinereus	—	—	—	—	—	X	—	—	—	—	—	—
C. coronatus	—	—	—	—	—	X	—	—	—	—	—	—
C. distans	X	—	—	—	—	X	—	—	—	—	—	—
C. ebraeus	X	—	—	—	—	X	—	—	—	X	—	—
C. eburneus	—	—	—	—	—	X	—	XX	XX	XX	X	XX
C. flavidus	X	X	X	—	X	—	—	—	—	—	—	—
C. geographus	—	—	—	—	—	X	—	—	—	—	—	—
C. glans	—	—	—	—	—	—	—	—	—	X	—	X

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
C. *gubernator*	X	X	—	X	—	X	—	—	—	—	—	—
C. *imperialis*	—	—	—	—	—	X	—	—	—	—	—	—
C. *leopardus*	XX	X	X	X	X	XX	XX	XX	X	X	XX	X
C. *litteratus*	X	X	X	X	—	XX	XX	—	—	—	—	—
C. *lividus*	—	X	—	—	—	X	—	—	—	X	—	—
C. miles	—	—	—	—	—	—	—	—	—	X	—	—
C. monile	—	—	X	X	X	—	—	—	—	X	—	—
C. mustelinus	—	—	—	—	—	x	—	—	x	—	—	x
C. tessulatus	—	—	—	—	—	x	—	—	—	—	—	—
C. textile	x	x	—	—	—	x	—	—	—	—	—	—
C. vexillum	—	—	x	x	—	x	—	—	—	—	—	—
C. vitulinus	—	—	—	—	—	—	—	—	—	x	—	—
C. zonatus	—	x	—	x	x	x	—	x	xx	x	—	xx
Family Terebridae												
Terebra affinis	x	—	x	—	—	x	x	—	—	—	—	—
T. areolata	—	—	—	—	—	x	x	—	—	—	—	—
T. cerethina	x	x	x	—	—	x	x	—	—	—	—	—
T. dimidiata	—	—	—	—	—	x	x	—	—	—	—	—
T. maculata	x	—	x	—	—	x	x	—	x	x	x	x
T. subulata	x	—	x	—	—	x	—	—	—	—	—	x
T. crenulata												
Family Bulliade												
Bulla ampulla	x	—	—	—	—	x	x	—	—	—	x	x
Bivalvia												
Family Arciadae												
Arca complanata	x	—	—	—	—	xx	—	—	—	x	x	x
Family Mytilidae												
Brachiodontus modiolus	—	—	—	—	—	—	—	xx	x	x	—	xx
Lithophaga nigra	x	—	—	—	—	x	x	—	x	x	x	x

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
L. gracilis	x	—	—	—	—	x	—	—	-	—	—	—
Modiolus metcalfei	—	—	—	—	—	-	—	—	—	x	—	—
M. tulipa	x	—	—	—	xx	xx	—	—	—	—	—	—
Family Pteriidae												
Pinctada sugillata	—	x	x	x	x	xx	xx	—	x	x	x	x
Family Pectinidae												
Pecten sp.	x	—	—	—	—	x	—	—	—	—	—	—
Family Spondylidae												
Spondylus layardi	x	—	—	—	—	x	—	—	—	—	x	—
Family Ostreidae												
Saccostrea cucullata	—	—	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Family Lucinidae												
Lucina nassula	xxx	—	—	—	—	—	—	—	—	—	—	—
Codakia orbicularis	—	x	x	—	—	—	—	—	—	—	—	
Codakia punctata	x	—	—	—	—	—	—	—	—	—	—	—
Divaricella dentata	xxx	—	xx	—	—	—	—	—	—	—	—	—
Family Chamidae												
Chama sp.	x	—	—	—	—	x	—	—	—	x	x	—
Family Tridacnidae												
Tridacna maxima	xxx	xx	xx	xx	—	xx	x	xx	xx	xx	x	xx
T. squamosa	—	—	—	—	—	x	x	—	x	—	x	x
Family Mactridae												
Mactra cuneata	—	—	—	—	—	—	—	—	x	—	—	—
Femily Mesodsmalidae												
Mesodesma sp.	xx	xxx	xxx	xx	—	xxx	xx	x	x	x	xx	x
Family Tellinidae												
Tellina radiata	—	x	—	—	—	—	—	—	—	—	—	—
T. idae	—	x	x	—	—	—	—	—	—	—	—	—
Family Donacidae												
Donax faba	—	—	—	—	—	x	—	—	—	—	—	—

Family & Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Family Venaridae												
Asaphis deflorata	—	—	—	x	—	—	—	—	—	—	—	—
Venus reticulata	—	—	—	—	—	—	—	—	x	—	—	—
Tapes philippinarum	—	—	—	—	—	—	—	—	x	—	—	—
Family Petricolidae												
Petricola divergens	x	—	—	—	—	—	—	—	—	—	—	—
Family Gastrochaena												
Gastrochaena giqantea	x	—	—	—	—	x	—	—	—	—	x	—
Family Pholadidae												
Martesia sp.	—	—	—	—	—	x	x	x	—	—	x	—
Family Teredinidae												
Teredo sp.	—	—	—	—	—	x	—	—	—	—	x	—
Cephalopoda												
Family Loliginidae												
Sepioteuthis lessoniana	—	—	x	x	—	—	—	—	—	—	x	—
Family Octopodidae												
Octopus cyaneus	—	—	—	—	x	x	x	x	x	x	x	x
O. membranaceus	xx	—	—	—	—	xx	xx	x	x	x	xx	xx
O. vulgaris	xx	x	x	xx	—	xx	xx	xx	xx	x	xx	xx

— = Nil, X = rare, XX = Common, XXX = Abundant.

TABLE 2 *Octopus production (kg) in Lakshadweep Islands*

Island	1981	1982	1983	1984	1985	Average
Kadmat	5499	7917	3401	2680	1970	4294
Agatti	1325	5637	954	2421	2158	2499
Kalpeni	1365	1803	1412	2309	2662	1911
Kavaratti	1135	2830	850	998	1917	1547
Amini	3245	829	1469	1377	200	1424
Androth	894	970	2312	757	390	1065
Chetlat	480	1124	704	918	611	767
Kiltan	194	325	807	745	971	607
Bitra	108	555	200	999	216	416
Minicoy	25	30	12	165	—	46
Total	14,270	22,020	12,121	13,369	11,121	14,576

the predators of Octopus and often Octopus caught were not having all their arms intact due to eel attack.

Octopus locally known as 'appal' are considered as a delicacy in most of the islands and usually consumed fresh. The meat is also sundried (Fig I C) and is kept for longer periods especially by the fishermen of Agathi. The fresh meat is used as bait for the hooks and line and trolling. Island-wise occurrence of Octopus has shown that Kadamat ranks first in abundance and *Octopus vulgaris* and *O cyaneus* are usually caught from this island. At Agatti, all the three species were found to occur, of which *O. vulgaris* ranks first in abundance. The areas where Octopus fishing is done are marked in the map. One specimen of *O. cyaneus* measuring 75 mm in dorsal mantle length (DML) with 650 g weight and *O. membranaceus* measuring 70 mm in DML with 500 g were caught from the reef crest in the eastern side of Agathi. From Kalpeni specimens of *C. cyaneus* of 50 mm to 55 mm DML were collected. From Kavaratti *O. vulgaris* with 70-165 mm DML with weight ranging from 0.2 to 1.4 kg were collected during the survey. From Suheli paar live materials could not be

TABLE III *Quarterwise Octopus Production (kg) In Lakshadweep Islands*
(Averages for 1981-1985)

Island	I Q	II Q	III Q	IV Q	Total	% contribution to total production
Kadmat	1442	1219	897	736	4294	29
Agatti	723	465	479	832	2499	17
Kalpeni	496	354	451	610	1911	13
Kavaratti	437	214	382	514	1547	11
Amini	354	417	248	405	1424	10
Androth	205	233	172	287	1064	7
Chelat	230	143	223	172	768	5
Kiltan	189	65	111	242	607	4
Bitra	156	63	71	126	416	3
Minicoy	—	1	37	8	46	1
Total	4232	3174	3238	3932	14576	

collected but dried specimens of *O. vulgaris* were available with the islanders. At Androth *O. cyaneus* was found abundant and is caught in good numbers by the fishermen. At Minicoy there is no active fishing for Octopus, but *O. vulgaris* and *membranaceus* were found to occur in the reef flat. In general, Octopus weighing 0.5 kg to 3.5 kg are usually caught by the fishermen from all these islands for consumption.

Kadmat Island ranks first in the Octopus production followed by Agatti Kalpeni, and Amini. The average production for 5 years from 1981 to 1985 in each island is given in Table 2. The total production ranged from 11 to 22 t/year with maximum during 1982. The average total production was 14.6 t and the maximum share given by Chetlat (4.29 t). Quarter-wise analysis (Table 3) shows that January to March period contribute 29% of catch followed by October--December (27%) and the other two quarters contribute 22% each. The production rate shows a declining tendency from 1983 onwards and the lowest (11 t) was observed in 1985. Island-wise contribution of catch is as follows: Kadmat

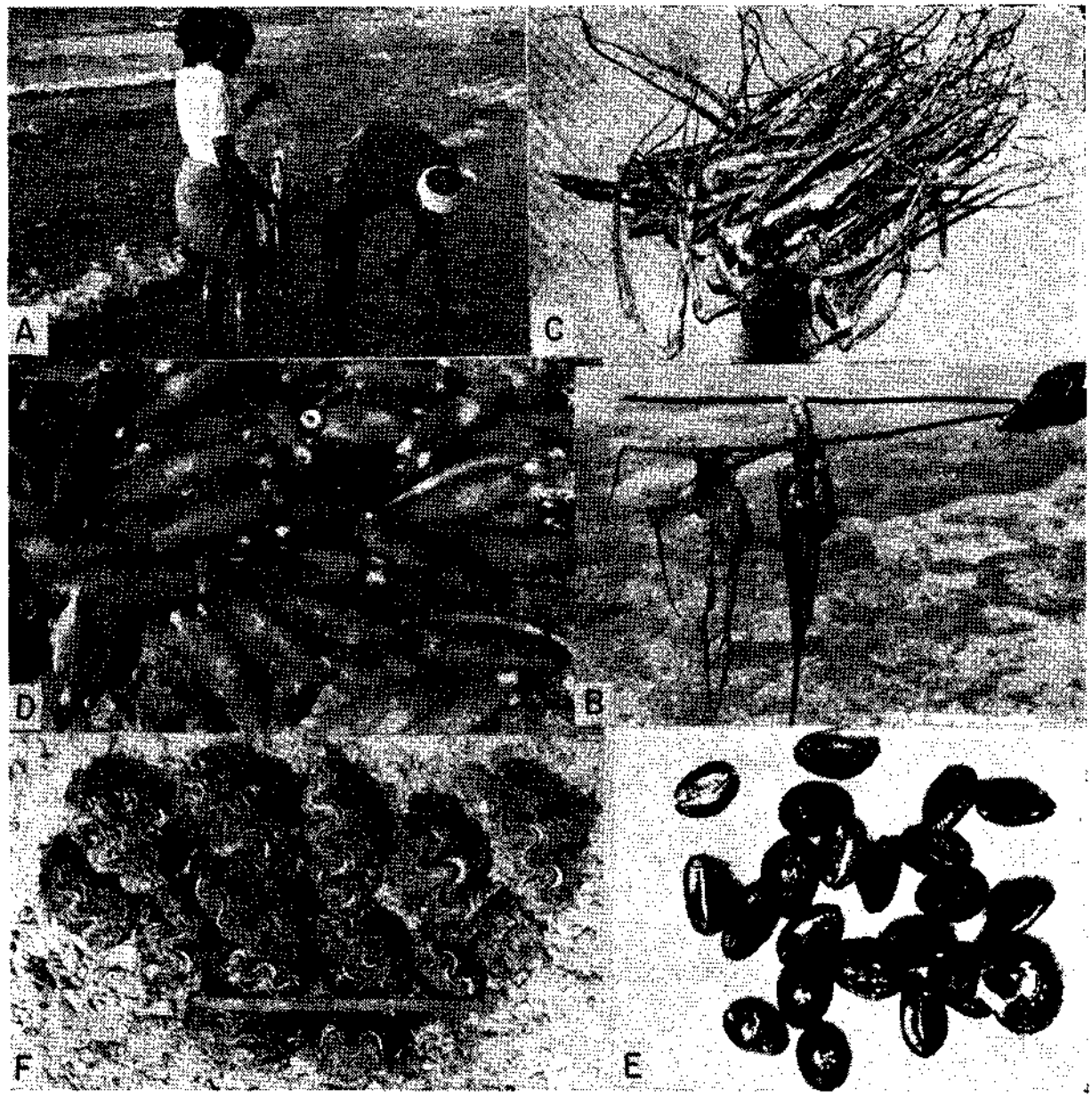


Fig. 1. A. Octopus being caught from the reef crest ; B. Octopus fishing gear - M S. rod with sharp bended end and octopus caught by this iron rod; C. Dried Octopus; D. *Sepeofeuthis lessoniana* caught from Bitra lagoon; E. *Cyprea caputserpentis* Snakehead cowry- F. *Tridacna maxima*.

29%, Agatti 17%, Kalpeni 13%, Kavaratti 11%, Amini 10% and all other islands together 20% of the total production. Good catches were obtained at Kadmat during the first two quarters and at Agatti, Kalpeni and Kavaratti first and the last quarters of the year are good.

2. *Sepioteuthis lessoniana* (*Palk Bay Squid*)

This squid was found in small shoals inside the lagoons of Kavaratti, Kalpeni and Bitra (Fig. I D). From Kalpeni about 50 numbers of squid with 90-180 mm DML were caught in drag net during March 1987. At Bitra 150 numbers of specimens ranging from 90-150 mm DML weighing 50-180 g were collected by drag net from the western side of the island in the lagoon area near the harbour jetty during February, 1987. Though squids are not being exploited from these islands, the very presence of this species is quite interesting since they are reported early from Vizhinjam and Veraval only in the west coast. The occurrence of this species in Lakshadweep indicate the distribution of the species to a wider area along the west coast of India.

The cuttle bones of *Sepia pharonis* and *S. aculeata*, ranging from 180-300 mm length were found washed ashore along the sandy shores of Androth, Agatti, Bengaram and Bitra indicating the presence of cuttlefishes in the nearby waters of Lakshadweep.

GASTROPODS

1. *Cowries*

Cyprea caputserpentis (Fig. I E), *C. moneta* and *C. tigris* are the important species of cowries exploited in a sustenance level for trade. Along with Octopus fishing, cowries are also collected by the island fishermen throughout the year with a peak from September to December and a lean season during southwest monsoon. Men, women and children go for cowry picking during low tide in the reef crest and usually go as a group in hired canoes and do the collection for 2-3 hours every day especially during days when there is good low tide, mostly 6-8 days every month The shells are collected from underneath the coral stones in the lagoon and reef crest. A Suheli Par the method of fishing involved, depositing coconut leaves in the lagoon water for few days, where the *Cyprea moneta* used to aggreate and attach to leaves. In reef area fishermen collect *C. caputserpentis* and *C. tigris* by diving. The shells collected by the fishermen everyday is deposited in closed cement tanks or sand pits for disintegration of body parts. After 10-15 days shells are cleaned and sold to the merchants.

Active fishing for cowries are noted at Agatti, Bangaram, Chetlat, Valiapanium, Thinnakara and Suheli Par At Agatti 30-40 persons are actively engaged in cowry picking during peak season, apart from the part time collection by women and children. At Bangaram fishermen from Agatti go usually and collect cowries during low tide. At Suheli Par there was once a flourishing fishery for *C. moneta*. But during the present survey, only few specimens were collected from this area. From enquiry it is understood that 3000-4000 numbers of *C. caputserpentis* per month for atleast 4 months every year and 24000-35000 numbers per month of *C. moneta* and 50-75 numbers per month of *C. tigris* are collected from Agatti-Bengram area. The estimated production of *C. moneta* varies from 5-7 lakh/year and *C. caputserpentis* 2-3 lakhs/year. The price of the first species ranges from Rs. 25-30/kg and for the latter Rs. 30-35/100 numbers. *C. tigris* which is fairly big is sold for Rs. 2-3/shell. The cowries collected by the merchants are taken to Mangalore and sold at higher value. Enquiry with local merchants reveal that bulk of the cowries taken to Mangalore come from Agatti-Bengaram area followed by Chetlat. Northeast side of Agatti and southwest side of Bangaram are potentially good areas for serpenthead cowry, *C. caputserpentis* and money cowry, *C. moneta*.

2. *Edible gastropods*

During the present survey it was found that meat of *Strombus* sp. and *Nerita plicata* are extracted for edible pupose at Kalpeni. These gastropods are found occurring in the reef crest, intertidal area and lagoons of all the islands surveyed. *Strombus* sp. was found to occur in 2-3/m^2 in a area of 200x200 m at Kalpeni lagoon *Nerita plicat* was found 5 numbers/m^2 in the reef crest, whereas at Agatti and Bitra reef crest the concentration was 10-15 numbers/m^2.

3. *Ornamental gastropods*

A variety of large shells especially Cone shells, cowries, spider conchs, scorpion shells, trumpet shells, Murex shells, top shells and helmet shells, are available in the reef crests of the islands surveyed. 24 cone shells were found to occur in various islands and among them *Conus leopardus* and C. *litteratus* are common in most of the islands. These shells reache 10-14 cm in size. Out of the 13 species of cowries recorded, 2 forms sustenance fishery and 2 species of larger cowries *viz.* *Cyprea tigris* and *Cyprea arabica* are also collected for ornamental purposes. Three species of Spider conchs, *Lambis lambis*, *L. truneata* and *L. chiragra* are recorded from the reef crests and lagoons of various islands. *L. truncata* was found to aggregate in good numbers at Minicoy. Larger shells of *L. lambis* and *L. truncata* are abundant in Minicoy, Agatti Bengaram, Bitra, Kadmat, Kalpeni and Suheli Par. *Cassis cornuata* and *Cyprea rufa* are two rare and beautiful shells found in the reefs of Minicoy, Agatti, Kalpeni and Amini. Trumpet shell, *Chaonia tritonis* is also very rare and found to occur in Agatti, Amini and Chetlat. This is used for blowing in mosques. Among top shells, *Trochus pyramis* reaches larger size and has got a thick nacreous layer, which is similar to *Trochus niloticus*. found in Andaman and Nicobar Islands. Murex shells and olive shells were also found rarely in few islands. Among all these shells, none of them was found to occur in a commercially exploitable quantity.

BIVALVES

1. *Edible bivalves.*

Mytilid bivalve *Modiolus tulipa* found in the reef flats of few islands are considered as edible and known locally as 'Kallumaikai'. This is recorded from Minicoy, Androth and Agatti. The density of population at Androth was 15 numbers/m^2 and at Agathi 5 numbers/m^2. From enquiry with fishermen it was understood that in the lagoon side there were good settlement of this species at Minicoy in certain years. During lean fishing season *Modiolus* is collected and then boiled meat is extracted and eaten by the islanders. The size of *Modiolus* collected ranged from 16-40. 4 mm. *Mesodesma* sp. a venerid bivalve, which is also considered as edible is widely distributed in the islands surveyed. The density of population observed at Minicoy was 20 numbers/m^2, at Suheli Par 2 numbers/m^2, at Kalpeni 100 numbers/m^2, at Agatti 32-205 numbers/m^2, at Bangaram 5-15 numbers/m^2 and 10-35 numbers/m^2 at Bitra. The size of this bivalve collected ranged from 6-33.9 mm. Another bivalve found in good concentration was *Tellina idea* in the lagoon of Kalpeni Islands. The denisty was 40 numbers/m^2. It is understood that during lean period local fishermen consume the meat of this bivalve. The size ranged from 44.3-67.2 mm. At Minicoy and Kalpeni lagoon *Lucina nassula* was found at a density of 100-1000 numbers/m^2 with a size range of 3.85-12.24 mm. Though this is not being consumed, the concentration of this species in the lagoon is quite interesting. *Donax faba*, a wedge clam known as an edible bivalve was found along with *Mesodesma* sp at Agati with a size range of 19-27.4 mm. The density was 2 3 numbers/m_2 *Saccostrea cucullata* the common rock oyster was found to occur in all the islands in the concrete pilings and other harbour structures in the intertidal areas. *Tridacna maxima* Fig. 1F and T. *squamosa* were found in good numbers in the reef crests of all the islands, the former species being abundant. The density veries from 1-10 numbers/100 m^2. Though all these species were found to occur in various density, there was no possibility of large-scale exploitation of them from any of the islands.

2. *Pearl oysters*

The occurrence of pearl oyster *Pinctada sugillata* spat in good numbers in 10 islands surveyed indicate the possibilities of farming pearl oysters in Lakshadweep for commercial pearl production. Already preliminary experiments are being done by the Fisheries Department in this line. The spat collected during the present survey ranged from 6.2-28.6mm with a density ranging from 1-50 numbers/100m^2. This was often found attached to dead coral colonies and over the *Tridcana* shells, which are common in the lagoon and reef crest.

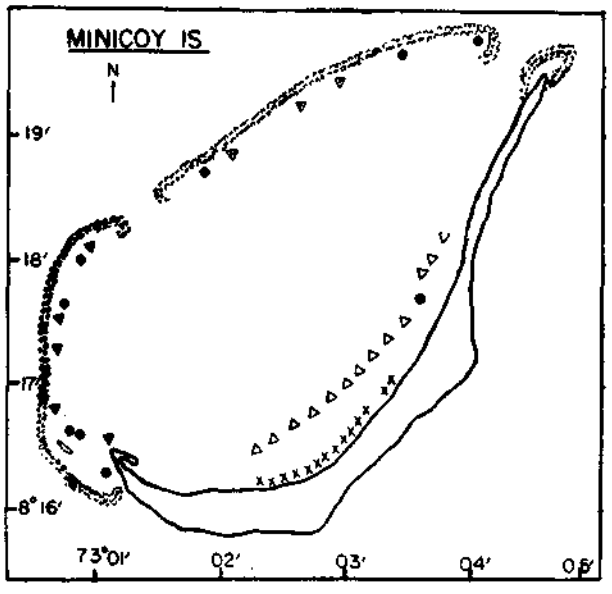
3. *Boaring bivalves*:

Teredo sp., *Lithophaga* spp, *Gastrochaena* sp., *Petricola* sp and *Martesi* a sp. were the common wood and coral boring bivalves recorded during the present survey. They cause

considerable amount of destruction to the harbour timber structures and also to the corals in the reefs, by boring deep into them and creating burrows.

DISTRIBUTION OF MOLLUSCS IN VARIOUS ISLANDS

Table I shows the abundance of gastropods, bivalves and cephalopods in 12 islands surveyed. Out of the 141 molluscs collected at present from these islands, 108 numbers were gastropods, 28 bivalves and 4 cephalopods. It is quite evident that gastropods rank first in the number of species and the analysis of occurrence indicate that gastropods are more abundant in all the islands. The distribution of molluscs is indicated by abundant (XXX), Common (XX), rare (X) and absent (—). The areas where the commercially important molluscs occur are marked in the maps (Figs. 2-13). The maximum number of molluscs collected were from Agatti followed by Minicoy, Chetlat and Kiltan. The maximum number of species was found in reef crests of various islands. The dead and live corala afford an excellent habitat for a variety of gastropods viz., Trochidae, Neritidae, Littorinidae, Cerithidae, Cypracidae Cassididae, Muricidae, Buccinidae, Pyremidae, Conidae,



X - *Mesodesma* sp.; O - Cowries; △-Ornamental molluscs, ● - *Tridacna* spp.; ⊙-*Sepioteuthis lessoniana*; ◎- *Modiolus tulipa*; □-*Tellina idae*; ⊗-Octopuses; ▲- Pearl oyster, *Pinctada sugillata*; △-*Lucina nassula*

Fig. 2. Distribution pattern of commercially important molluscs at Minicoy.

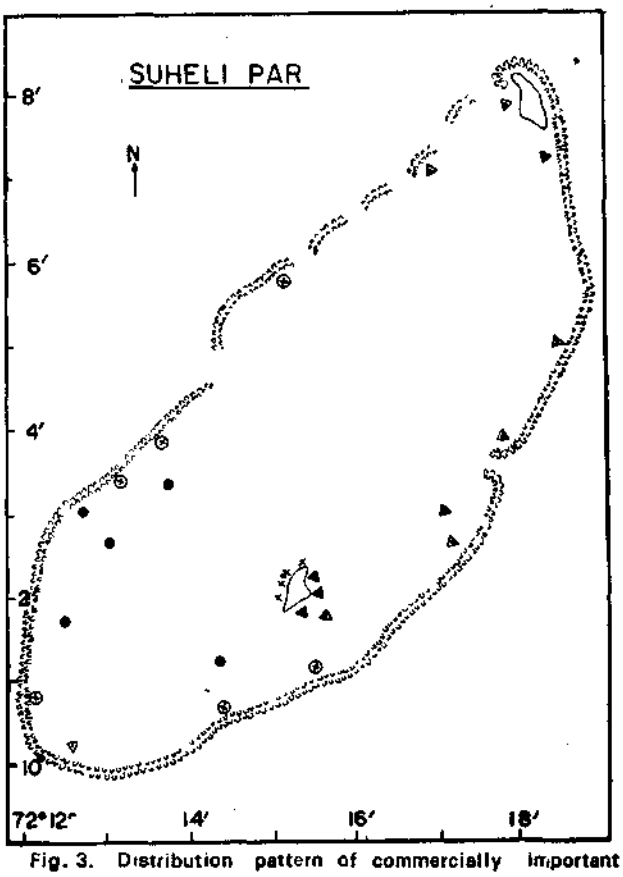


Fig. 3. Distribution pattern of commercially important molluscs at Suheli Par.

Arcidae, Mytilidae, Pteridae, Spondylidae, Tridacnidae, Petricolidae and Octopodidae. From the lagoon area, species belonging to Cerithidae, Strombidae, Cypracidae, Muricidae, Nassaridae, Olividae, Mitridae, Conidae, Teribridae, Pteridae, Lucinidae, Tridacnidae and Tellinidae were collected. In the intertidal sandy area *Mesodesma* sp was very common; in the rocky area members of Neritidae, Littorinidae and Ostracidae were present in good numbers.

DISCUSSION

Present survey has revealed that except Octopus and cowry fishing, there is no attempt for exploitation of molluscan resources from Lakshadweep. The observation on the occurrence and abundance of molluscs also indicate that large-scale exploitation of any of the commercially important species from this area is remote. The presence of pearl oyster spat (*Pinctada sugillata*) in the reef and lagoon of few islands and the successful rearing of *Pinctada fucata* in the lagoon of Bangaram and Agatti brought from Tuticorin indicate possibilities of initiating pearl oyster farming at Lakshadweep for taking

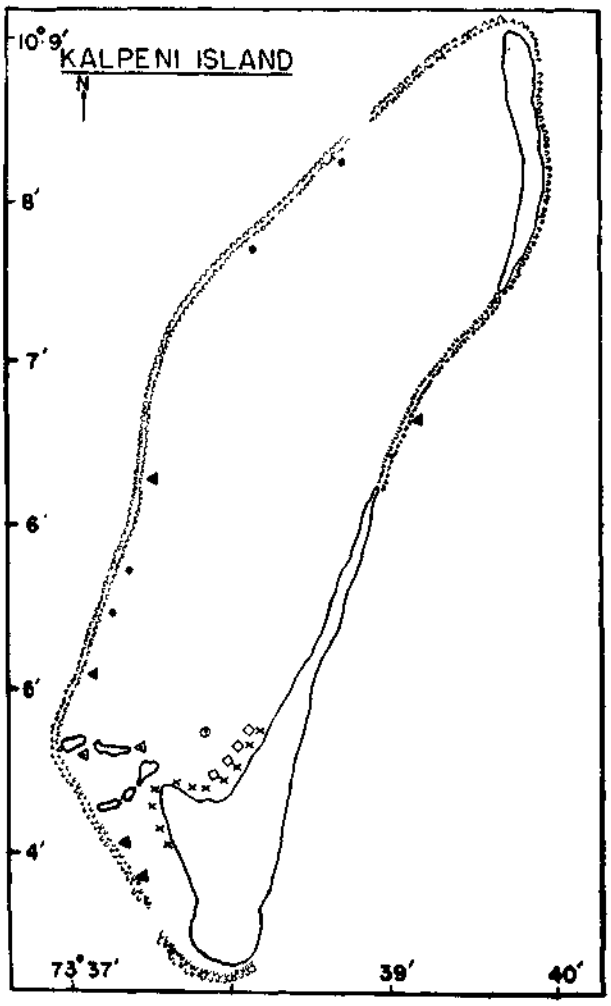


Fig. 4. Distribution pattern of commercially important molluscs at Kalpeni.

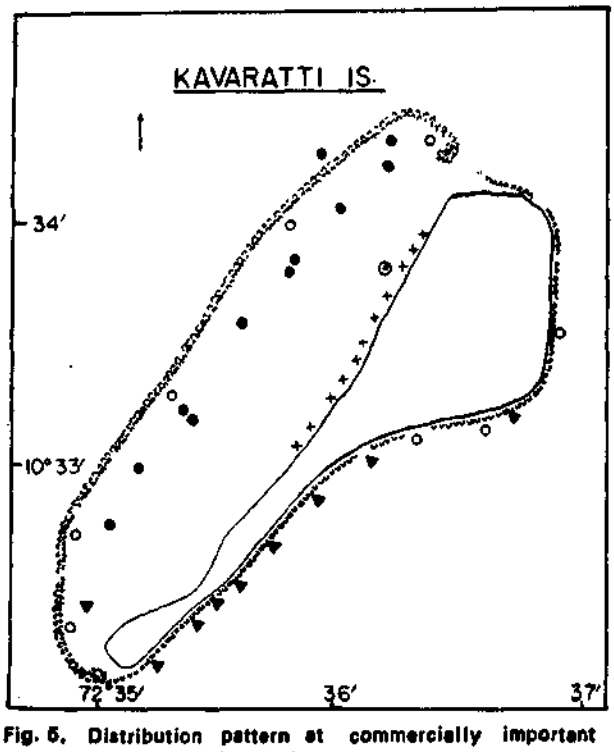


Fig. 5. Distribution pattern at commercially important molluscs at Kavaratti.

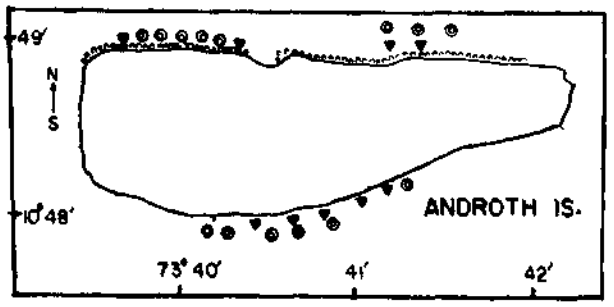


Fig. 6. Distribution pattern of commercially important molluscs at Androth.

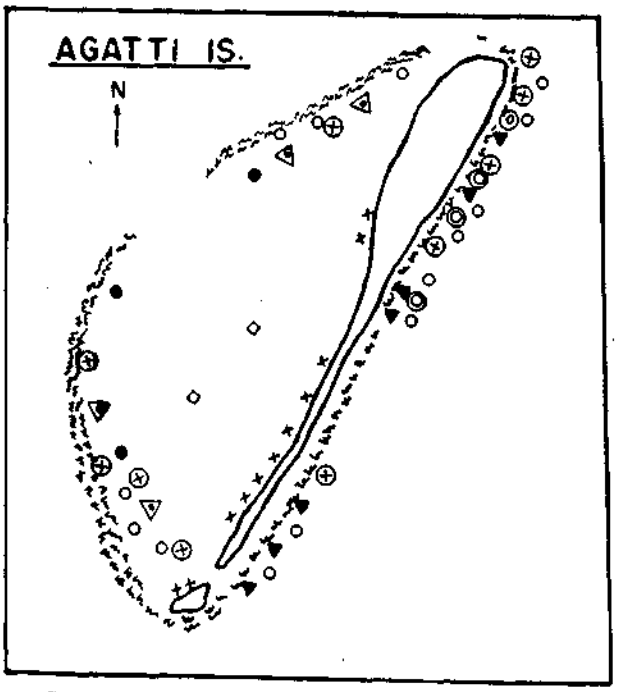


Fig. 7. Distribution pattern of commercially important molluscs at Agatti.

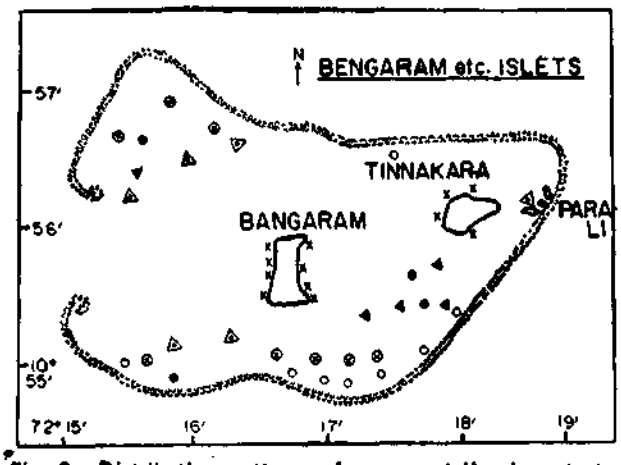


Fig. 8. Distribution pattern of commercially important molluscs at Bangaram, Tinnakara and Perali.

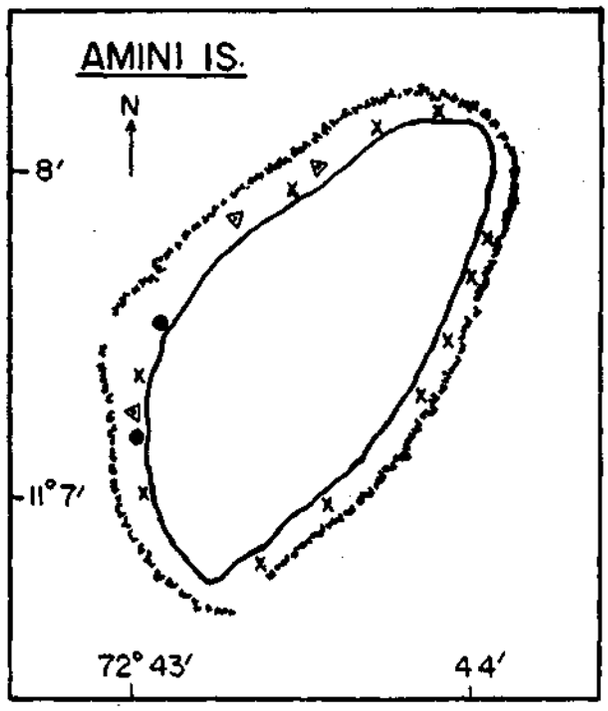


Fig. 9. Distribution pattern of commercially important molluscs at Amini.

up pearl culture. However, more serious efforts to conduct experiments on farming and raising a good stock of oysters is felt necessary to take up pearl culture at Lakshadweep especially in islands with larger lagoons like Bitra, Bangaram Agatti, Kalpeni and Minicoy. As *Modiolus tulipa* an allied species of mussel belonging to Mytilid is found in few islands, attempts to replant the spat of green mussel can be taken up in an experimental basis for initiating mussel farming in Lakshadweep. Female of *Octopus vulgaris* is known to produce 12,000 to 40,000 eggs. This species commands a good price in Japan market for fresh and dried meat. This is known to reach 1 kg in just 4 months and the maximum weight observed is 10 kg. *O. vulgaris* and *O. cyaneus* are found to occur in few islands of Lakshadweep and forms a sustenance fishery. As there is demand for fresh, frozen and dried and salted octopus meat, an attempt for octopus culture can be taken up to increase production. Silas (1985) has indicated that the availability of spawners and eggs of cephalopods in inshore waters, the rapid growth and short generation period and hardiness are some of the factors in favour of mariculture of cephalopods. Sea ranching programmes to increase the production of ornamental molluscs can also be done in selected islands. Smith (1906) recorded 87 molluscs from Minicoy, Appukuttan (1983) recorded 9 coral boring and Nair and bivalves Dharmaraj (1983) 19 woop boring bivalves from Lakshadweep. Many of the molluscs reported in the present paper are for the first reported time from Lakshadweep. As such there is not much variation in the molluscan fauna of various islands in Lakshadweep and the faunastic composition is almost similar to those seen in the southeast coast of India, especially the islands in the Gulf of mannar (Satyamurti, 1952). It is felt that more details on breeding behaviour of commercially important molluscs of the islands are to be collected for rational exploitation of molluscan resources.

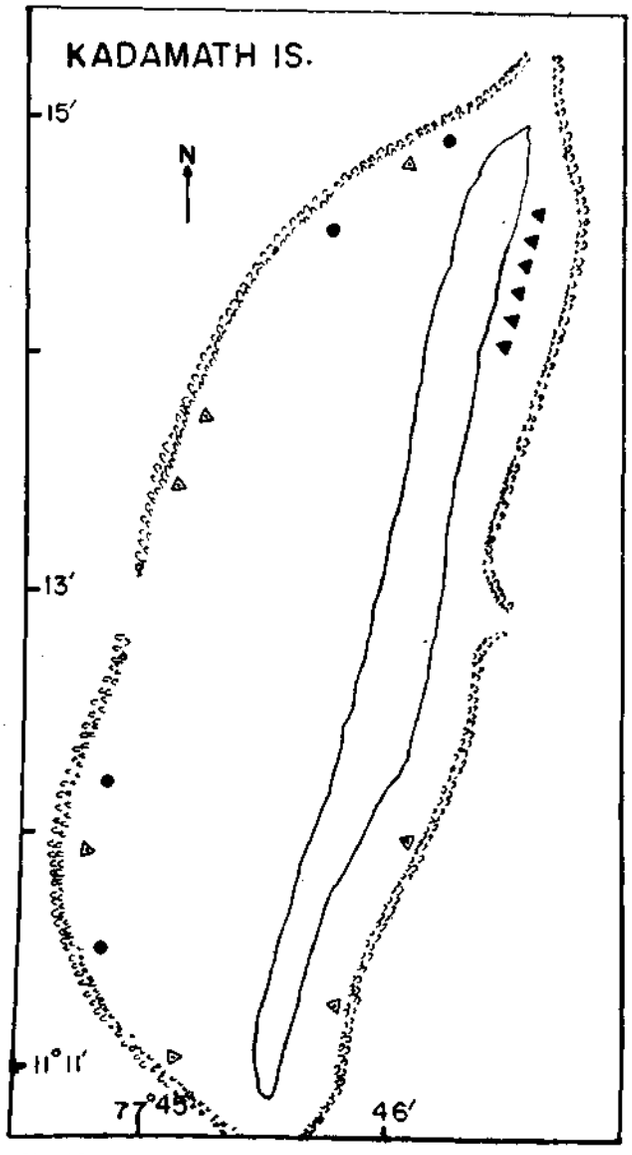


Fig. 10. Distribution pattern of commercially important molluscs at Kadmat.

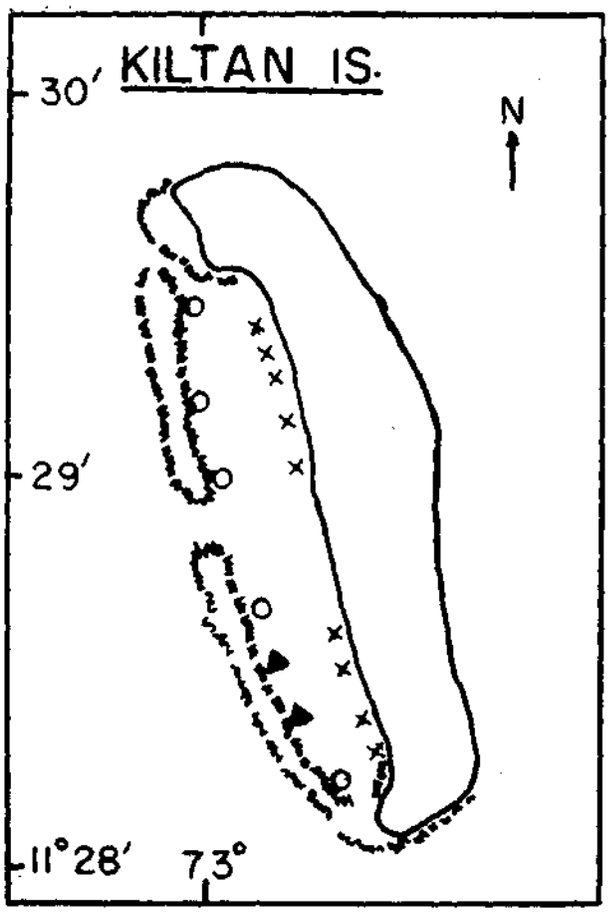


Fig. 11. Distribution pattern of commercially important molluscs at Kiltan.

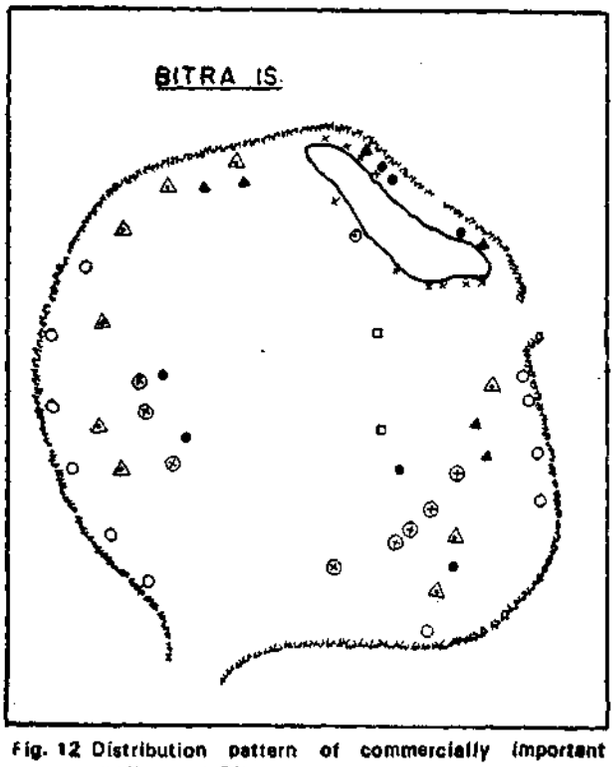


Fig. 12 Distribution pattern of commercially important molluscs at Bitra.

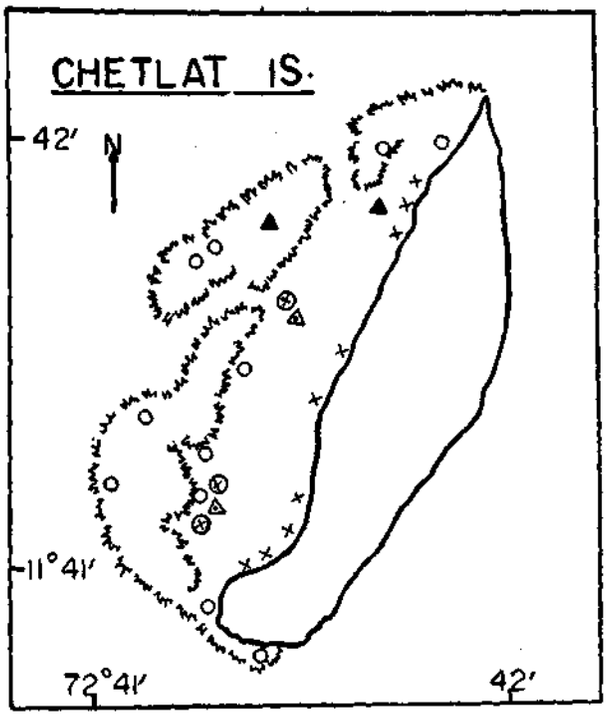


Fig. 13. Distribution pattern of commercially important molluscs at Chetlat.

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10. POTENTIAL FOR DEVELOPMENT OF PEARL CULTURE

K. Alagarswami, A. A. Chellam and A. C. C. Victor

INTRODUCTION

Subsequent to the development of technology for pearl culture by the Central Marine Fisheries Research Institute at Tuticorin in 1972 (Alagarswami, 1974), the Department of Fisheries of Lakshadweep evinced interest in exploring the possibility of establishing pearl culture in the islands. Pearl oysters were located in the islands, collected and reared from time to time. The programme took a more definite shape after some of the Officers of the Department of Fisheries were trained in pearl culture at the CMFR Institute at Tuticorin in 1979 and again in 1983 and 1986. Experimental pearl culture was initiated in Agatti and Bangaram and some cultured pearls have been produced. By way of fostering their effort further, the Institute supplied 10,000 spat of *Pinctada fucata* raised in the pearl oyster hatchery ar Tuticorin for transplantation in Lakshadweep. During the indicative survey of the fisheries potential of Lakshadweep carried out by the CMFR Institute during January-March, 1987, first-hand information was collected on the occurrence of pearl oyster in the islands and the status of experimental pearl culture being carried out in Agatti and Bangaram. The information is presented in this paper and potential for pearl culture in Lakshaweep is discussed.

OBSERVATIONS

Distribution of pearl oyster

During the survey, pearl oysters were collected from Androth, Kavarathi, Kalpeni, Suheli, Agatti, Bangaram, Kadmat, Kiltan, Chetlat and Bitra. Their distribution was very sparse in the intertidal flats and in the lagoons. In Agatti, pearl oyster was observed on the eastern side from the middle of the island to the southern end. The density was about 50/100m². A total of 51spat ranging between 5.2 to 22.2 mm was collected. In Kavarati, the density was still less at 1/100 m². Totally 8 spat in size range of 6.2-28.6mm were collected. In Kadmat and Kiltan, the population was very thin and the size range was 8-12mm.

Androth has no lagoon and pearl oyster was present on the northern and southern intertidal flats of the island. A total of 21 spat ranging 11-21.8 mm were collected. The density was about 3/100m².

In Suheli par pearl oyster was seen both in lagoon at a depth of 2m and in the shoreward area of the intertidal reef crests on the eastern side par. A total of 17 spat in the size range of 9.4-21.6 mm was collected. The density was about 2/100 m².

In the lagoons of Kalpeni' Bangaram, Bitra and Chetlat only a few spat could be collected. In Bangaram, 8 spat (8-23 mm), Bitra, 2 spat (5.8-12.0mm), Chetlat, 4 spat in Kalpeni. 5 spat (9.5-17.3 mm) were collected. The estimated population density was 2/100m² in Bangaram, Bitra and Kalpeni and 1/100 m² in Chetlat.

The survey indicated that except Minicoy and Amini. the other inhabited islands and some of the uninhabited islands have some pearl oyster settlement. Surprisingly enough, all the pearl oysters collected were spat measuring less than 30 mm which may be around 6-9 month old. Larger oysters, either live or dead could not be seen anywhere in the islands. All the spat collected are flat with poor shell cavity and may belong to two species, *Pinctada sugillata* and *P. albina* or *P. albina sugillata* (Reeve) vide Hynd, 1955;.At the size examined, it was difficult to determine the species identity.

Experience of the Department of Fisheries of Lakshadweep has shown that the growth rate of native pearl oysters in the Islands was very poor and they reached a size of 38-42mm (8.0-9.5 g) in a period of 2½ to 3 years. The nacre quality of these oysters is relatively poor.

Experimental transplantation of pearl oyster from mainland

An attempt was made in 1986 to transplant spat of *Pinctada fucata* produced in the hatchery at Tuticorin to Lakshadweep. The consignment consisted of a total of 10000 spat of which 7500 were in the size range 9.2-18.0mm with average

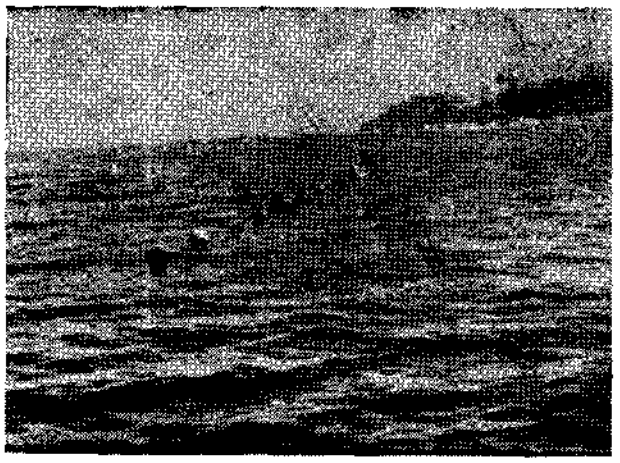

Fig. 1. Pearl oyster culture in the Agatti lagoon by long-line

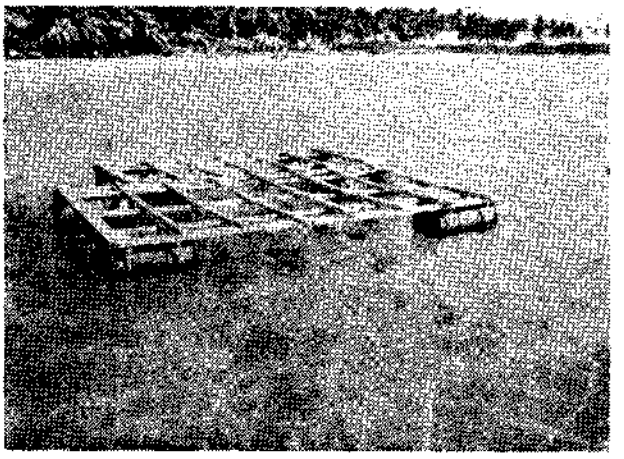

Fig. 4. Raft culture of pearl oyster in the Bangaram lagoon

Fig. 2. Pearl oyster spat are reared in plastic basket

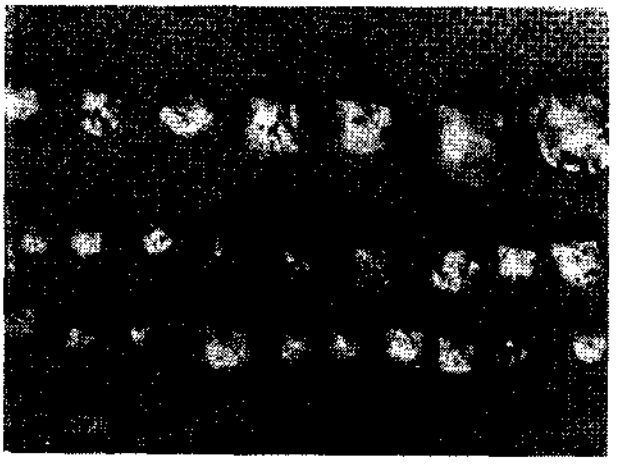

Fig. 5. Native pearl oyster spat of the intertidal reef flat of Agatti island

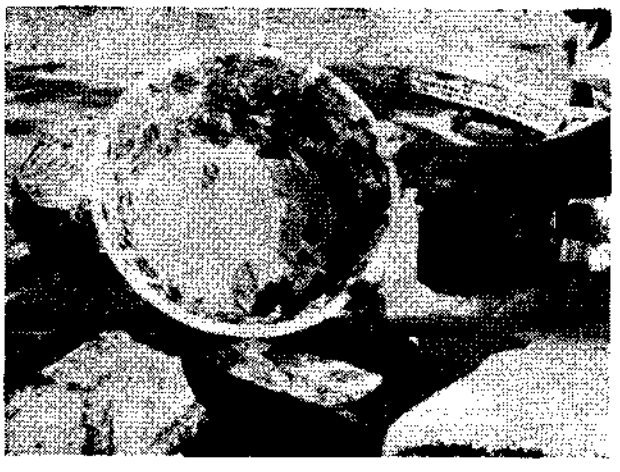

Fig. 3. A rearing basket with pearl oysters spat attached to the sides

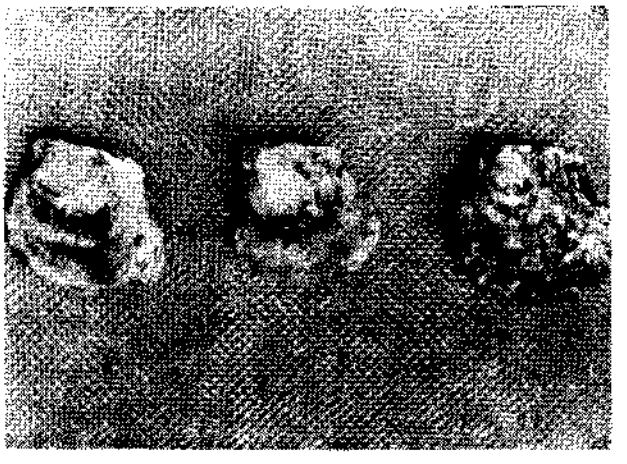

Fig. 6. Native pearl oysters after 2½ -3 years of rearing in the Agatti farm

weight of 0.5 g and 2500 were about 3.7 mm size and 0.025 g weight.

The spat were packed in leak-proof polythene bags of about 10 l capacity with 3 l of filtered sea water at the rate of 750 per bag. The bag was filled with oxygen and tied tightly. It was placed in tin container of 18 l capacity. The consignment was taken by road from Tuticorin to Cochin with a journey time of 12 h. On reaching Cochin, the spat were released in sea water in plastic basins and aerated. The spat were taken in open plastic basins on board a passenger ship. During the voyage of 27 h from Cochin to Agatti, sea water was frequently changed. The spat reached the destination without suffering any mortality. They were transplanted in the farms at Agatti and Bangaram.

Experimental pearl oyster culture in Lakshadweep

The Department of Fisheries, Lakshadweep had initiated a pearl culture programme at Agatti and Bangaram. The pearl oyster spat are collected from the intertidal reef flat on the eastern side of Agatti and are temporarily farmed in the lagoon on the western side of the island. Long-line is used to suspend the baskets with oysters. Glass and plastic floats of 12"-18" diameter numbering 12 are interconnected and anchored at both ends. The plastic basket is covered by a velon screen bag of mesh size 1 mm. The lagoon bottom is sandy with luxurious growth of seagrass. The depth is about 2.5 m at high tide. The bag and the basket had profuse growth of algae on the outer side. The main fouling organisms on the pearl oysters at Agatti were seaweeds, simple and compound ascidians and calcareous tube-dwelling polychaetes. Barnacles were absent. Due to high winds and waves, the farm in Agatti lagoon had to be dismantled during south-west monsoon season.

Bangaram island offered a suitable site for pearl culture in the Lakshadweep islands. Bangaram, Tinnakara and Parli are sand banks in the middle of the extensive lagoon. Bangaram is almast in the middle of the lagoon. The lagoon close to the estern shore of Bangaram is about 5-7m deep. The bottom is of calcareous sand. The northern shore extends eastwards as sand bank, giving additional protection. The area near the jetty is protected from winds and waves and is not affected by the monsoon currents. Year-round pearl oyster culture is possible here. The Department of Fisheries set up a pearl culture farm in Bangaram in 1982. Raft culture has been adopted to farm the pearl oysters. A good growth of algae was seen on the plastic baskets containing oysters. The fouling organisms on the oysters were calcareous tubes of polychaetes and simple and compound ascidians. The predators were *Cymatium*, a gastropod, and crabs and they gain entry into the oyster baskets in the larval stages. Destruction of spat by these predators had been sometimes very extensive.

During the present survey, observations were made on the pearl oyster spat transplanted from Tuticorin to Agatti and Bangaram. In 4 months, the oysters had reached an average length (dorso-ventral measurement) of 22.4mm and thickness of 6.6 mm in Agatti and length of 28.3 mm and thickness of 8.1 mm in Bangaram. The health of oyster and growth were found to be better in Bangaram than in Agatti.

PROSPECTS FOR PEARL CULTURE

Commercial pearl culture has been a common feature of some of the oceanic islands in the south-western Pacific. The lagoons and reef flats ot these islands have natural population of pearl oyster, particularly the black-lip *Pinctada margaritifera*, which are used in production of black pearls. Lagoons of oceanic islands have many advantages for farming of pearl oysters and production of cultured pearls, particularly from the environment view-point. Generally these relate to protection from winds and waves, depth, nature of bottom, sea water exchange between the ocean and the lagoon productivity and relativey greater efficiency with which a culture system in a semi-enclosed area can be managed. Marutea lagoon in the Tuamotu-Gambier Archipelago of French Polynesia is the centre of intense pearl culture activity for production of expensive black pearls (Ward 1985). Malanesia and Micronesia also have some pearl culture activity in the Pacific.

In the light of the above background of lagoon based pearl culture in oceanic islands, some of the islands of Lakshadweep would appear to have the potential for pearl oyster culture. Experience has shown that Bangaram

island has some of the ideal conditions. The lagoon is well protected and has a depth of 5-7m with a calcareous sandy bottam. Being a semi-enclosed lagoon oceanic water exchange is good The growth of pearl oyster is better in Bangaram than in Agatti, The shell colour and growth margins of transplanted oysters in Bangaram appear natural indicating that the environment is suitable for the health and growth of the farmed oysters. Due to protection and depth, raft culture is feasible throughout the year. However, further observations are necessary to see if the oyster attains its maximum growth potential in terms of size, weight and shell cavity in normal time.

The native pearl oyster resource in the islands has so far proved to be very scanty and is not of the species required for commercial pearl culture. The oysters are of the flat type, resembling some that have bean seen in the coastal areas and harbour basin of the mainland (Alagarswami, 1977) which are not suitable for pearl production owing to smaller size, flatness of shells and poor quality of nacre. The natural population has been seen to grow only to 38-42 mm (8-9.5 g) in 2½-3 years. It is not clear from this data whether the stock occurring in the islands has a very low growth potential in terms of size and weight. This can be clearly understood only after parallel culture of native stock of the islands and that of *P. fucata* transplanted from the mainland is carried out for about 3 years. Based on the current knowledge, it would seem that no worthwhile pearl culture is possible with the pearl oysters naturally occurring in Lakshadweep.

Transplantation of *P. fucata* from mainland to the islands has been carried out very successfully in the first instance in 1986. Detailled observations on their survival, growth and propagation on a continuous basis over a period of time is necessary. If the species establishes itself through spawning and spatfall, it will prove ideal for pearl culture. Otherwise periodic transplantation would be required. In future it may also be necessary to develop a routine quarantine procedure against possible transmittance of pathogenic organisms and predators from the mainland to the islands. The present stock of transplanted *P. fucata* may be partly used for nucleus implantation for production of cultured pearls. Pearl production should be evaluated using parameters such as rates of survival, nucleus retention and gross production and quality of pearls.

Besides *P. fucata* it is also proposed to test lagoon's potential for transplantation of *P. margaritifera* when the species is bred successfully in the hatchery at Tuticorin and high survival rate is achieved in future. The young spat of this species does not survive in the inshore farm at Tuticorin. The black-lip pearl oyster is native to Andaman and Nicobar Islands (Alagarswami, 1983) and would appear to prefer oceanic condition than the sub-continent's coastal condition. Perhaps, it may survive better in the lagoons of Lakshadweep and this hypothesis is to be checked by experimentation.

ACKNOWLEDGEMENTS

The authors are grateful to Shri George Varghese, Director of Fisheries, Kavaratti and other officials of the Fisheries Department of Lakshadweep for the data and the information on the experimental pearl culture in Agatti and Bangaram.

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11. ECHINODERMS OF LAKSHADWEEP AND THEIR ZOOGEOGRAPHY

D. B. James

Dr. Stanley Gardiner carried out an extensive survey in the Maldives and Minicoy Islands, the Southernmost of the Lakshadweep group of Islands. Echinoderms other than the holothurians were dealt by Bell (1902) who reported four species of starfishes from Minicoy Island. Corrections for some of the species have been given by A. M. Clark and Davies (1966). Koehler and Vaney (1908) reported three species of holothurians from the Lakshadweep. Holothurians of Gardiner's collection was dealt in a cursory manner by Pearson (1913, 1914). James (1969) recorded forty species of echinoderms from various Islands of the Lakshadweep. Naghabushanam and Rao (1972) reported 49 species of echinoderms from the Minicoy Island, the identity of some need to be checked. Mürty *et al.* (1979) reported the notorious starfish the crown of thorns *Acanthaster planci* from Minicoy Atoll. Recently Mukhopadhyay and Samanta (2983)' reported twelve species of holothurians from the Islands of Androth, Kalpeni and Minicoy.

Material collected by the three teams of CMFRI during January to march, 1987 form the main basis for this paper. Collections made by Mr. M. Ali Manikfan from Minicoy and other Islands and also by Mr. K. C. S. Panicker from Kavaratti and Agatti have also been included. Throughout this account, references are kept to a minimum by citing only original references, references pertaining to Lakshadweep and one or two standard references.

SYSTEMATIC ACCOUNT

Echinoderms belonging to all the five classes have been collected. A single specimen of crinoid which was collected at Kadmat was broken to small bits rendering identification impossible.

Class ASTEROIDEA

Species belonging to two orders are reported from the Lakshadweep.

Key to the orders of the class

Conspicuous marginal plates in two rows bordering the disc and arms; pedicellariae sessile or alveolar type; tubefeet in two rows, with or without suckers.....PHANEROZONIA

Conspicuous marginal plates forming a broad verticle edge to the arm usually wanting; aboral skeleton reticulate or imbricate; tubefeet in two rows with suckers; pedicellariae rarely present.... ..... SPINULOSA

ORDER : PHANEROZONIA

This order includes five suborders *viz.*, Pustulosa, Cribellosa, Paxillosa, Notomyota and Valvata. Members belonging to the suborder Pustulosa are completely extinct. Members belonging to the suborders Paxillosa and Valvata are known from the Lakshadweep.

Key to the suborders of the Order

Skeleton of dorsal surface with typical paxillae; tubefeet devoid of suckers.....PAXILLOSA

Skeleton of dorsal surface paxilliform or otherwise; tubefeet with suckers.....VALVATA

SUBORDER : PAXILLOSA

Species belonging to the Families Luidiidae and Astropectinidae are known from the Lakshadweep.

Key to Families of the Suborder

Long flexible arms with relatively small disc; arms 5-11 bordered with spiny fringe; supero-marginals reduced and appear identical with adjacent paxillae; infero-marginals much elongated transversely and cover greater part of the ventral side .....LUIDIIDAE

Body stellate with couspicuous marginal, plates, marginal plates covered with little spines that increase in size at the margin .....ASTROPECTINIDAE

Family : LUIDIIDAE

This family includes only one genus *viz. Luidia*.

Genus *Luidia* Forbes, 1839

Only one species *viz., Luidia maculata* Muller & Troschel is known from the Lakshadweep

Family : ASTROPECTINIDAE

Spices belonging to the genus *Astropecten* are recorded from the Lakshadweep.

Genus *Astropecten* Gray, 1840

Three species are known from the Lakshadweep.

Key to tha species of the genus

1. All the supero-marginal plates with long pointed spines; usually second plate small and spineless (sometimes plates 2-4 without spines) ....A. *Polyacanthus* Muller & Troschel, 1842
1'. All the supero-marginal plates with moderately developed spines.....2
2. Distal supero-marginal plate with a spine on the outer part of plate; tipes of arms more or less blunt .....*A. indicus* Doderlier 1889
2'. Distal supero-marginai plates rarely with any large spines; only diminitive spines below the main infero-marginal plate..... *A. monacanthus* Sladen, 1883

SUB-ORDER VALVATA

Species belonging to two Families are known from the Lakshadweep. Species belonging to the Family Asteropidae is recorded for the first time in this work.

Key to the Families of the Sub-Order

1. Dorsal skeleton reticulate with secondary plates joining the primary ones and leaving conspicuous large poriferous areas in between; marginal plates well developed but not conspicuous (except in specimens of *(Culcita)* and sometimes completely covered by thick skin.....OREAS TERIDAE
1'. Dorsal skeleton not reticulate; dorsal side either covered by granules or by membrane 2
2. Members with small disc, long flexible cylindrical arms with reduced and inconspicuous marginal plates with smooth surface although some species are warty; armament usually granuliform, sometimes increasing in size or modifed into tubercles; intermarginal plates if present occur only basally .....OPHIDIASTERIDAE
2'. Dorsal surface is membraneous; marginal plates are exposed and are more or less overlapping.....ASTEROPIDAE

FAMILY : OREASTERIDAE

Members belonging to this Family are usually large with reticulate skeleton. Two genera are known under this Family. A third genus *viz., Halityle* is recorded for the first time.

Key to the genera of the Family

1. Arms well developed; only the primary plates of the upper side with elevations; pore areas well defined .....*Pentaceraster* Doderlein, 1916
1'. Body pentagonal or almost circular in outline.....2
2. Marginal plates clearly seen even in large specimens; tubercles absent on the dorsal side; pore areas well defined and triangular in shape; granules of the actinal plates markedly flattened and forming a smooth plastering following the countours of the plates .....*Halityle* Fisher, 1913
2'. Marginal plates concealed by thickned skin; some enlarged tubercles often present on the dorsal side; pore areas irregular and sometimes indistict or more or less continuous; actinal granules mostly coarse and individually distinct, often obscuring the limits of the plates.....*Culcita* L. Agassiz, 1835

Genus *Pentaceraster* Doderlein, 1916

Under this genus only one species is collected.

Pentaceraster regulus (Muller & Torschel 1842)

Pentacerous regulus Muller & Troschel, 1842, p. 51: Bay of Bengal.

Pentaceraster australis James, 1969, p. 52: Gulf of Mannar, Palk Bay Lakshadweep.

Pentaceraster regulus A.M. Clark & Rowe, 1971, pp. 34,55: Bay of Bengal, East Indies, North Australia, Philippines, China and

Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 579: Lakshadweep & Maldives, Gulf of Manner and Palk Bay along the South East cost of India (Distribution Table).

Material: Bitra, one specimen, depth one metre:

Remarks This species was collected from Bitra in 1968 and during the present survey not a single specimen was collected. It is very rare and was recorded for the first time from Lakshadweep by the author in 1969.

Genus *Halityle* Fisher, 1913

One species is collected under this genus for the first time from the Lakshadweep.

Halityle regularis Fisher
(Fig. 1)

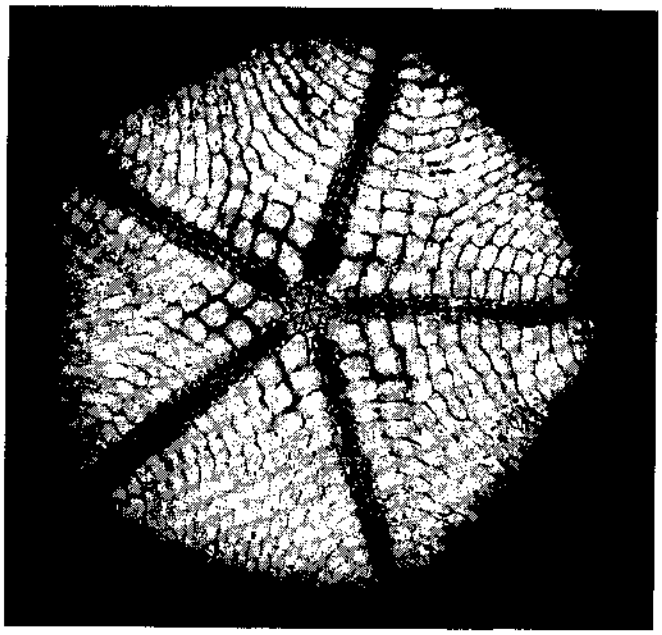

Fig. 1 *Halityle regularis*

Halityle regularis Fisher, 1913, p. 211: Philippines; James, 1973, p. 557: Gulf of Mannar; A. M. Clark & Rowe, 1971, pp. 34, 53: Philippines (Distribution Table)

Material: Kiltan, one specimen, washed ashore.

Remarks : It is a rare species and is recorded here for the first time from Lakshadweep.

Genus *Culcita* L. Agassiz, 1835

This genus is common in Lakshadweep. Only one species is known earlier, now a second species species is recorded for the fitst time here

Key to the species of the genus

No spines or spinlets on the pore areas.....
Culcita schmideliana (Retzius, 1805)
Some spines or tubercles present within pore areas ....*Culcita novaeguineaet* Muller & Troschel, 1842

Culcita Schmideliana (Retzius 1805)
(Figs. 2 & 3)

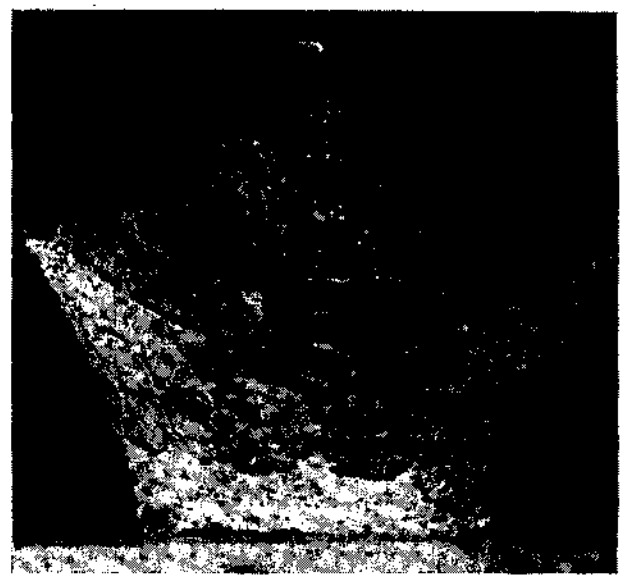

Fig. 2 *Culcita schemideliana* (Adult)

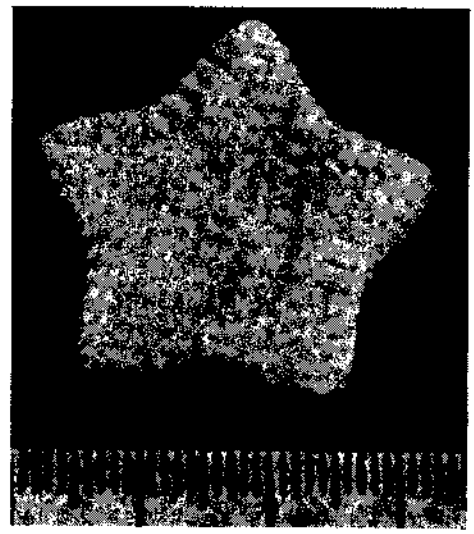

Fig. 3 *Culcita schemideliana* (Juvenile)

Asterias schmideliana Retzius, 1805; p. : Locality not known.

Culcita schmideliena A.M. Clark & Davies, 1986, p. 602: Maldives; A. M. Clark and Rowe, 1971, pp. 34, 53: Islands of Western Indian

Ocean, Mauritius, East Africa and Madagascar, S. E. Arabia, Maldives (Distribution Table); James, 1986, p. 579: Lakshadweep & Maldives area, Gulf of Mannar and Palk Bay along the South East Coast of India, Sri Lanka, Andaman and Nicobar Islands (Distribution Table)

Material : Kadamat, one specimen; Amini, two specimens; Kavaratti, one specimen, all collected from the lagoon, less than one metre in depth.

Remarks: This species is somewhat rare when compared to the other species *Culcita novaeguinease.*

Culcita novaeguineae Muller & Troschel

Culcita novaeguinea Muller & Troschel, 1842, p. 38: East Indies; H. L. Clark, 1921, p. 32: Torres Strait: A M. Clark & Rowe, 1971, pp. 34, 54: Bay of Bengal, East Indies, North Australia, Philippines, China and Southern Japan, Pacific Islands, Hawaaian Islands James, 1983, p. 89; Andaman and Nicobar Islands; (Distribution Table)

Material : Chetlat, one specimen ; Kiltan, two specimens; Agatti, two specimens; Kavaratti, two specimens; Minicoy, one specimen, all collected from the lagoon, less than one metre in depth.

Remarks: One small specimens of R 10 mm collected from Kiltan looks like a Goniasterid.

Family OPHIDIASTERIDAE

This is large family of star fishes occurring commonly in shallow waters and particularly associated with corals and rock slabs. The small disc and long, often cylindrical, sub-cylindrical arms are characterstic of the Family. The colours in life are often bright, red, blue. purple and variegated forms are common. Six Genera are known from the Lakshadeep. Of these five are collected during the survey.

Key to the Genera of the Family

1. Abactinal plates more or less arranged in regular longitudinal series for the whole length of arm 2
1'. Abactinal plates irregular in arrangement, though proximally there may be a tendency for regular arrangement.....4
2. Body entirely covered by thick smooth skin obscuring the limits of the plates ..... *Leiaster* Peters, 1852
2'. Granules or tubercles present on all the plates.....3
3. Armament restricted to a clustre of coarse granules or tubercles in the centre of each plate, the remaining surface covered with skin..... ..*Dactylosaster* Gray, 1840
3'. True granulation continuous all over the plates, skin not conspicuous, eight series of pore-areas .....*Ophidiaster* L. Agassiz, 1835
4. Adambulacral armament superficially appearing granuliform; arms cylindrical, disc small .....*Linckia* Nardoa, 1834
4'. Adambulacral armament spiniform, arms more or less flattened and wider basally....5
5. Papular pores present or the oral side, pores single, form more or less flattened, R rarely exceeding 40mm.....*Fromia* Gray, 1840
5'. No papular pores below the infero-marginals, Uniform granulation on the actinal, abactinal and supero-marginal plates; aboral reticulate skeleton not so well defined, marginal plates well defined .....*Pareferdina* James, 1973

Genus *Leiaster* Peters, 1852

Only two species are known from the Indian Seas.

Leiaster leachi (Gray)
(Fig. 4)

Fig. 4 *Leiaster leachi*

Ophidiaster leachi Gray, 1849. p. 284 ; Mauritus
Leiaster leachi H. L. Clark, 1921, pp. 73-74 : Torres Strait: A.M. Clark & Davies 1966 p. 598: Maldives: James, 1969, 53 Bitra Minicoy (Lakshadweep).
Africa, Maldives, East Indies. North Australia (Distribution Table) Nagabhushanam and Rao, 1972, p. 289: Minicoy Atoll, James, 1986, p. 579; Lakshadweep & Maldives, Sri Lanka (Distribution Table).
Material: Minicoy, one specimen R 172 mm; Bitra, one specimen, R 30 mm
Leiaster speciosus v. Martens, 1866, p. 70: East Indies; H. L. Clark, 1921, p. 74: Torres Strait; A.M. Clark & Rowe, 1971, pp. 36, 58 : East Indies, North Australia, Philippines (Distribution Table).

Remarks: *Leiaster leachi* and *L. speciosus* are separated from each other by the presence of pedicellariae in case of *L. leachi* but this character is found to be highly variable. Also the colour of *L. leachi* is given as variegated, orange yellow and red whereas in *L. speciosus* it is given as uniformly crimson by H. L. Clark (1946). These two characters are not of specific value and therefore the two species are considered here as synonymous. Earlier workers like H. L. Clark (1921), Hayashi (1938), A. m. Clark (1967) and A. M. Clark and Rowe (1971) have also expressed doubt about the validity of *L. speciosus*. James (1969). This species recorded for the first time from the Lakshadweep.

Genus *Dactylosaster* Gray, 1840

Only one species is known under this genus from the Indian Seas.

Dactylosaster cylindricus (Lamarck)
(Fig. 5)

Asteries cylindrica Lamarck, 1816, p. 567.
Ophidiaster cylindrica Bell, 1902, p. 227: Minicoy (Lakshadweep).

Dactylosaster cylindricus H. L. Clark, 1921, p. 85: Hawaii; A. M. Clark and Davies, 1966, p. 598: Maldives; James, 1969, p. 53; Port Louis (Mauritius), Minicoy (Lakshadweep); A. M. Clark and Rowe, 1971, pp , 34, 59: Islands of Western Indian Ocean, Mascarere Islands, East Africa & Madagascar, S. E. Arabia, Maldives, Sri Lanka, East Indies. South Pacific Islands, Hawaiian Islands (Distribution Table), Nagabhushanam and Rao, 1972, p. 289: Minicoy Atoll; James, 1986 p. 579: Maldives & Lakshadweep, Sri Lanka (Distribution Table)

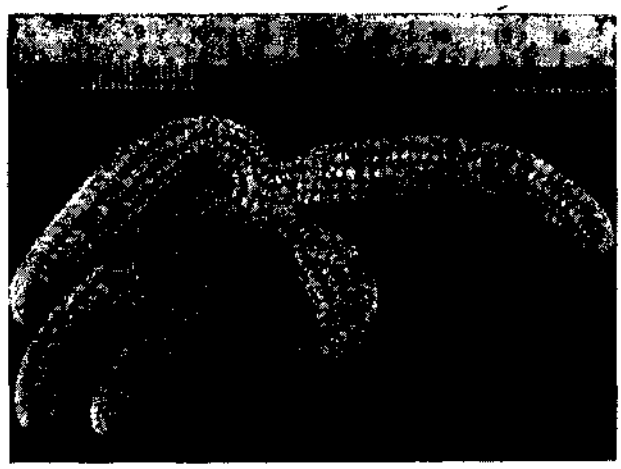

Fig. 5 *Dactylosaster cylindricus*

Material : Chetlat, several specimens; Kiltan, several specimens; Kadamat, two specimens; Amini, three specimens; Kavaratti, five specimens; Minicoy, several specimens, all collected from underside of coral stones.

Remarks : This is one of the common asteroids of Lakshadeep. One specimen collected from Kavaratti has seven arms. The arms are of dissimilar size in some specimens.

Genus *Linckia* Nardoa, 1834

Three species are recorded from the Indian seas. All the three species are collected during the Survey.

Key to the species of the Genus

1. Subambulacral spines in two series; furrow spines not separated by granules..... *L. guildingi* Gray, 1840
1'. Subambulacral spines in single series; furrow spines separated by verticle series of granules.....2
2. Arms normally five in number with single madreporite; arms fairly stout and blunt at the tip.....*L. laevigata* (Linnaeus, 1758)
2'. Arms often irregular in length with two madreporites; arms slender and more or less pointed at the tip.....*L. multifora* (Lamark, 1816)

Linckia guildingi Gray

Linckia guildingi Gray, 1840, p. 285: St. Vincents; H. L. Clark, 1921: Bermuda, Bahamas, Florida, Cuba, St. Kitts, Tobago, Brazil, Lower Guinea, Zazibar, Queensland Society Islands, Tahiti; Ely, 1942, p. 18: Hawaii; A. M. Clark & Davies, 1966, p. 598: Maldives; A. M. Clark & Rowe, 1971, pp. 36, 61: Islands of Western Indian Ocean, Raserere Islands East Africa & Madagascar, S. E Arabia, Persian Gulf, Maldiverea, Sri Lanka area Bay of Bengal, East Indies, North Australia. Philippines, China & South Japan, South Pacific Island, Hawaiian Islands (Distribution Table); James 1986, p. 579; Lakshadweep & Maldives, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material: Chetlat, one specimen R 210 mm; Amini, one specimen, R 120 mm; collected from lagoon, depth less than a metre.

Remarks: This is a very rare species in Lakshadweep. It probably lives among live corals.

Linckia laevigata (Linnaeus)

Asterias laevigata Linnaeus, 1758, p. 662.

Linckia laevigata Bell, 1902, p. 226: Lakshadweep: A. M. Clark & Rowe 1971, pp. 36, 62; Islands of Western Indian Ocean. Mascarare Islands East Africa & Madagascar, Lakshadweep, Sri Lanka area Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table); Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll; James, 1986, p. 579: Lakshadweep & Maldives, Gulf of Mannar and Palk Bay on the South East Coast of India; Sri Lanka, Andaman and Nicobar Islands (Distribution Table)

Material : Bitra, one specimen; Amini, one specimen, Agatti, one specimen; Kavaratti, three specimens; Minicoy, several specimens, all from collected the lagoon, less than one metre in depth.

Remarks : Both the blue and brown forms are collected. The arms are longer and slender in brown forms.

Linckia multifora (Lamack)
(Figs. 6-9)

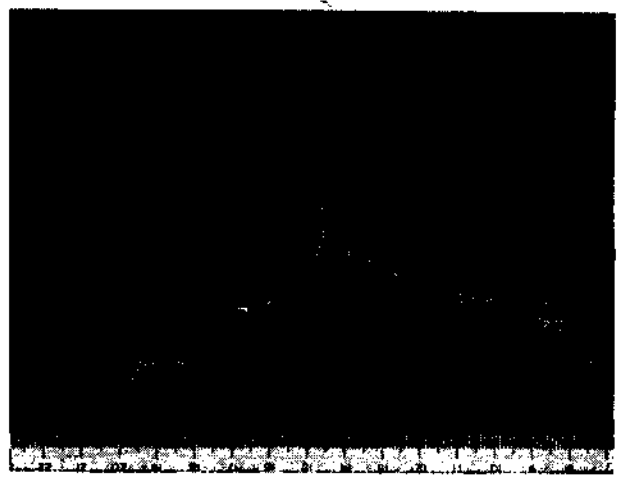

Fig. 6 *Linckia multifora* (Normal speciman)

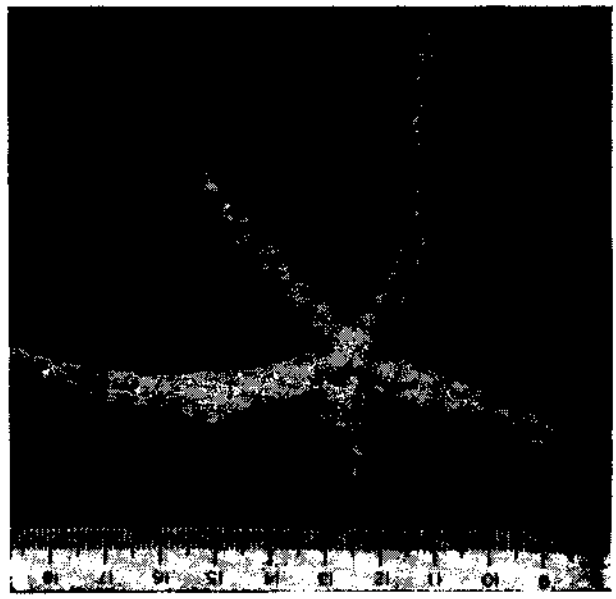

Fig. 7 *Linckia multifora* (with a bud)

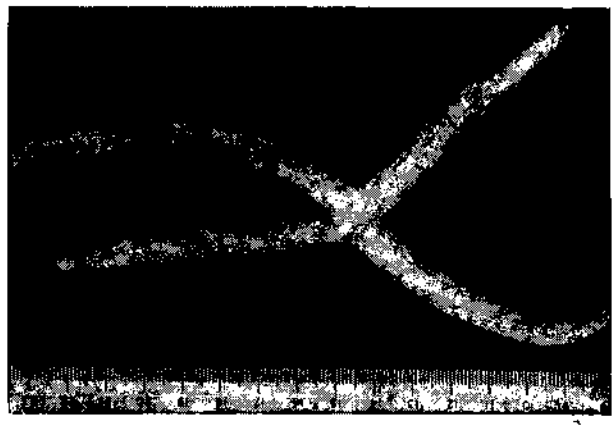

Fig. 8 *Linckia multifora* (With four arms)

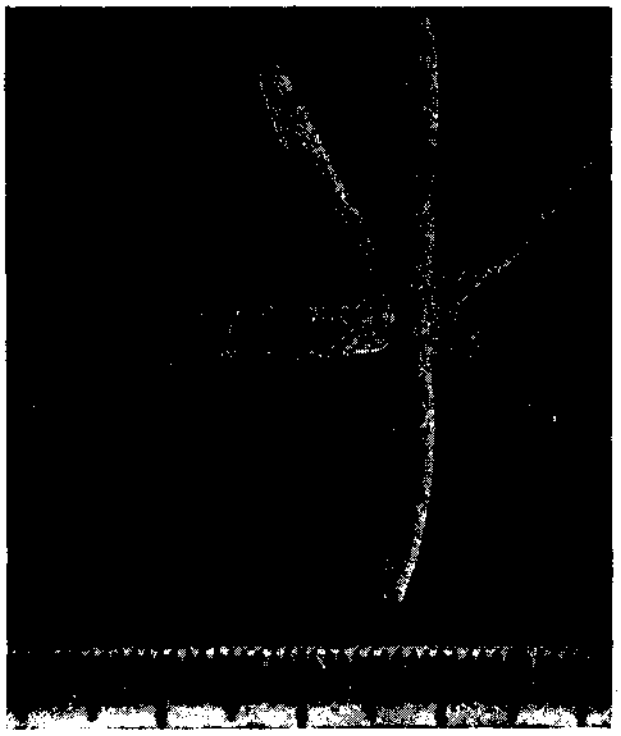

Fig. 9 *Linckia multifora* (With six arms)

Asterias multifora Lamarck, 1816, p. 565. Locality not known.

Linckia multiforis Bell, 1902, p. 226: Laksh-a dweep & Maldives.

Linckia multifora Ely, 1942, p. 19: Hawaii; A. M. Clark & Davies, 1966, p 598: Maldives; James, 1969, p. 53: Gulf of Mannar, Red sea, Lakshadweep, Borneo; A. M. Clark & Rowe, 1971, pp. 36, 62: Islands of the Western Indian Ocean, Mascarere Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Persian Gulf, West India & Pakistan Maldive area, Sri Lanka, East Indies, Philippines, China & S. Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll; James, 1986, p. 579: Lakshadweep & Maldives, Gulf of Mannar and Palk Bay along the South East coast of India, Sri Lanka (Distribution Table)

Material: Chetlat, two specimens: Bitra, one specimen; Kiltan, two specimens, Kadamat, several specimens; Amini, two specimens; Minicoy, several specimens, all specimens collected under coral stones.

Remarks: This is the most common starfish in the Lakshadweep. H. L. Clark (1921) has stated that the largest specimen known in the species has R 95 mm. The largest specimen in the present series has R 110 mm. Some commet orms have been collected. One form looks exactly like a cross. One specimen is of particular interest. The five arms are disimilar in size. On the smallest arm a bud has developed (Fig. 7) which has four arms. One of the arms is swollen due to the presence of a parasitic grastropod *Stilifer sp.*

Genus *Fromia* Gray, 1840

Only one species is known from the Laksha dweep. Now a second species is collected for the first time. Small forms living under coral stones with R rarely exceeding 40 mm.

Key to the species of the Genus

1. Abactinal plates markedly unequal; actinal plates with short blunt spinelets or enlarged granules.....*F. indicus* (Perrier, 1869)

1'. Abactinal plates though irregular, similar in size; abactinal granulation even; aboral side flat; carinal series of plates not distinct ....*F. milleporella* (Lamarck, 1816)

Formia indica (Perrier)

Scytaster indicus Perrier, 1869, p. 235: Locality not known.

Fromia indica Perrir, 1875, pp. 177-178; Koehler; 1910, p. 140; Hayashi, 1938, p. 59: Japan, James, 1969, p. 53: Andamans; A. M. Clark & Roaw, 1971, pp. 34, 62: Maldivearea, Sri Lanka, Bay of Bengal, East Indies, Philippines, China and Southern Japan; South Pacific Islands (Distribution Table), A. M. Clark & Davies, 1966, p. 602: Maldives; James, 1986, to 579; Lakshadweep & Maldive area, Sri Lanka, Andaman and Nicobar area (Distribution Table).

Material: Kavaratti, one specimen, under coral stones.

Remarks: This is very rare species in the Lakshadweep. Colour in the living condition is red.

Formia milleporella (Lamarck)

Asterias milleporella Lamarck, 1816, p. 564: Locality not known.

Formia milleporella H. L. Clark, 1921, p. 40, Torres Strait; A. M. Clark and Davies, 1966, p. 602: Maldives; A. M. Clark & Rowe, 1971, pp. 34, 63: Mascaerne Islands, East Africa & Madagascar, Maldive area, Sri Lanka, Bay of Bengal, East Indies, North

Australia, Philipines, China and Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 579: Lakshadweep and Maldive area, Sri Lanka (Distribution Table).

Material: Bitra, one specimen, collected from underside of coral stones.

Genus *Paraferdina* James, 1973

This new genus is reported from Minicoy in 1973. Since that time it has not been collected again.

Paraferdina laccadivensis James

Paraferdina laccadivensis James, 1973, pp. 556-559: Minicoy (Lakshadweep) James, 1986, 580: Lakshadweep & Maldive area (Distribution Table).

Material: Minicoy, one specimen, collected from the lagoon, depth less than one metre.

Remarks: James (1973) gave a detailed description of the species. It has not been collected again since its first discovery.

FAMILY: ASTEROPIDAE

This is a small Family with a few genera. In the Lakshadweep one genus is collected during the present survey.

Genus *Asteropsis* Muller & Troschel, 1840

This well marked genus is widely distributed in the Indo-Pacific region.

Asteropsis carinifera (Lamarck) (Fig. 10)

Asterias carinifera Lamarck, 1816, p. 556: Locality not known.

Asterope carinifera H. L. Clark, 1921, p. 33: Torres Strait.

Asteropsis carinifera James, 1969, p. 54: Solomon Islands of Western Indian Ocean, East Africa & Madagascar, Red Sea, S. E. Arabia, Sri Lanka area, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands; (Distribution Table); James, 1986, p. 580: Sri Lanka (Distribution Table).

Material: Chetlat, several specimens; Kiltan, several specimens, all collected from the reef flat.

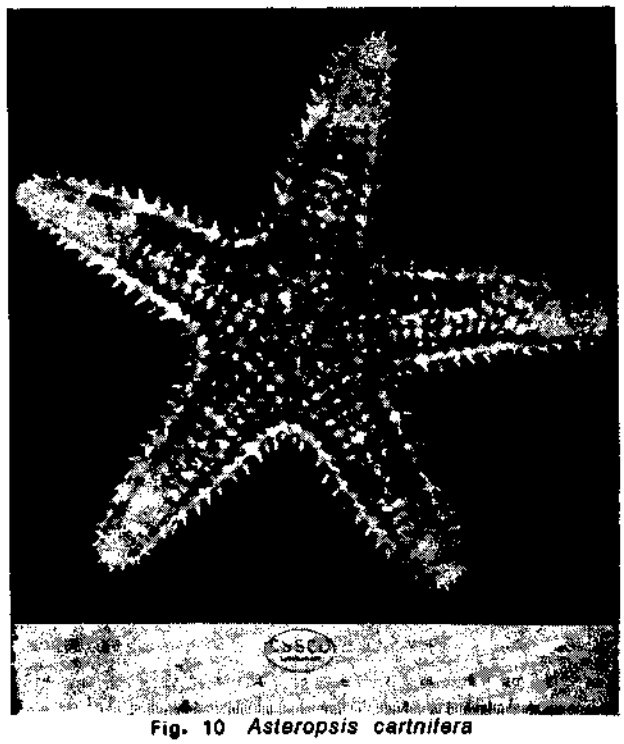

Fig. 10 *Asteropsis cartnifera*

Remarks: R of the specimens collected varied from 58-110 mm. Though this species is common at Chetlat and Kiltan it is surprising that this species is not recorded from the Lakshadweep and even from Maldives so far. It is recorded here for the first time from the Lakshadweep.

ORDER: SPINULOSA

Members belonging to two Families are known from the Lakshadweep. Species belonging to a third Family are collected for the first time during the survey.

Key to the Families of the Order

1. Arms 10-20 with numerous madreporites, aboral armament with numerous large, pointed spines mounted singly on stalk-like pedicles; size large ..... ACANTHASTERIADE

1'. Arms usually five or six, madreporite usually one though sometimes up to five present; size small to moderate 2

2. Arms short, body stellate or even sometimes pentagonal; aboral armament scale-like imbricating plates armed usually with fine spinelets or granules .....ASTERINIDAE

2'. Arms elongate, slender and cylindrical; aboral surface covered with thick skin; adambulacral spines few, usually three..... ECHINASTERIDAE

FAMILY : ACANTHASTERIDAE

This Family has only one genus *Viz., Acanthaster.*

Genus *Acanthaster* Gervasis, 1841

Only one species is known from the Lakshadweep.

Acanthaster planci (Linnaeus)
(Fig. 11)

Fig. 11 *Acanthaster planci*

Asterias planci Linnaeus, 1758, p. 832

Acanthaster planci Madsen, 1955, pp. 181-187: Mauritius, Haarlem Island, Kei Island: James, 1969, p. 54: Lakshadweep, Nicobar, Solomon Islands; A. M. Clark and Rowe, 1971, pp. 38, 71: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Western India & Pakistan, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands; (Distribution Table). James, 1986, p. 580; Lakshadweep & Maldives area, Sri Lanka, Andaman & Nicobar Islands. (Distribution Table).

Material : Kadamat, one specimen; Agatti, two specimens; Kavaratti. two specimens; Kalpeni, one specimen; Minicoy, three specimens, all specimens collected from live corals from a depth of 1-2 metres.

Remarks : Fortunately the concentrations of this species is negligible in Lakshadweep and therefore they do not form a threat to the coral reefs at present.

FAMILY : ASTERINIDAE

Members belonging to this family are small, secretive and are found clinging to the underside of rock fragments or concealed in crevices but some occur on sandy bottom. Many species are brightly coloured but in some the colouration is diversified and variable. Three genera are recorded for the first time from the Lakshadweep.

Key to the Genera of the Family

1. Arms carinate, relatively long R/r 2.0/1 to 4.0/1 ..... *Tegulaster* Livingstone, 1933

1'. Arms not carinate, short and triangular R/r 1.2/1 to 2.0/1 2

2. Abactinal plates of papular areas all of one kind not cresentic or notched for papulae ..... *Asterina* Nardoa, 1834

2'. Abactinal plates of papular areas of two kinds, the larger cresentic or notched for papulae ..... *Patirilla* Verrill, 1913

Genus *Tegulaster* Livingstone, 1933

Only one species is known under this genus from the Indian Seas. This genus is recorded for the first time from the Lakshadweep.

Tegulaster Ceylanicus (Doderlein)
(Fig. 12)

Fig. 12 *Tegulaster ceylanicus*

Disasterina ceylanica Doderlein, 1889, p. 825: Sri Lanka.

Tegulaster ceylanicus A.M. Clark of Rowe, 1971, p 67: Sri Lanka area (Distribution Table); James, 1986, P. 580: Lakshadweep & Maldive area, Sri Lanka Andaman & Nicobar area (Distribution Table).

Material: Agatti, one specimen; Kavaratti, one specimen, both collected under coral stones.

Remarks : This is a little known species. Colour in the living condition is rose-red. It is a first record to the Lakshadweep.

Genus *Asterina* Nardo, 1834

Only one species is recorded for the first time from the Lakshadweep.

Asterina burtoni Gray, 1840

Asterina burtoni Gray, 1840, P. 289: Red Sea; A. M. Clark & Davies, 1966, p 603: Maldives; A.M. Clark & Rowe 1971, pp. 38,68: Islands of Western Indian Ocean, Mauritius, East Africa & Madagascar, Red Sea, S. E. Arabia, Persian Gulf, Western India & Pakistan area, Maldive area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands. (Distribution Table)

Asterina cepheus Bell, 1902, p. 227: Maldives.

Material: Amini, one specimen collected under coral stones

Remarks: This is one of the most widely distributed starfishes. Its small size and its habit to attach to underside of boats accounts for its wide distribution.

Genus *Patiriella* Verrill, 1913

This genus is recorded for the first time from Lakshadweep. Only one species is collected.

Patiriella pseudoexigua Dartnall, 1971

Asterias exigua Lamarck, 1816, p. 554: Locality not known.

Asterina exigua Koehler, 1910, p. 129: Andaman & Nicobar Islands; H. L. Clark, 1921, p. 97: Torres Strait, South pacific Islands.

Patiriella exigua Fisher, 1919, p. 416: Philippines, East Indies: A. M. Clark & Rowe, 1971, pp. 38,67: East Africa & Madagacar, Bay of Bengal, East Indies, North Australia, Philippines. China & Southern Japan, South Pacific Islands (Distribution Table)

Patiriella pseudoexigua Dartnall, 1971, p. 43: Bay; James, 1986,p. 580: Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material: Agatti, two specimens, collected under coral stones.

Remarks: This small species easily escapes observation. It is a new record to the Lakshadweep.

Family ECHINASTERIDAE

Under this family the genus *Cistina* is collected for the first time from the Lakshadweep.

Genus *Cistina* Gray, 1840

This is a little known genus with one species.

Cistina columbiae Gray,1840
(Fig. 13 & 14)

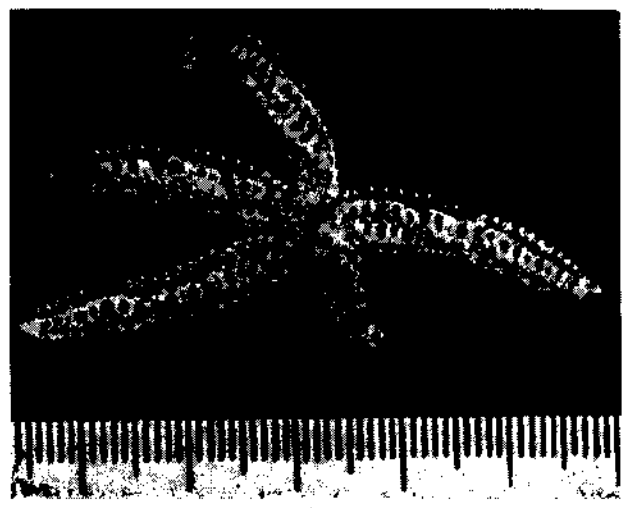

Fig. 13 *Cistina columbiae*

Cistina columbiae Gray,1840, p : Locality not known; A. M. Clark & Rowe, 1971, pp. 40, 72: Mascoure Islands, (Distribution Table).

Material : Chetlat, five specimens, under coral stones.

Remarks : The R of the specimens collected

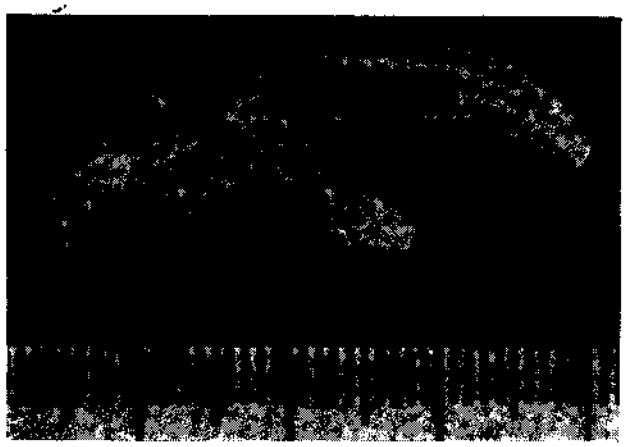

Fig. 14 *Cistina columbiae* (arms regenerating)

varied from 20-28 mm. The arms are dissimilar in size and in one specimen (Fig. 14) it is in process of regerneration. It can easily be mistaken for *L. multifora* in the field. On closer observation the spinelets are seen. The colour in the living condition is rose-pink in patches on the dorsal side. It is so far recorded only from the Mauritius. According to Miss. A. M. Clark (personal communication) MS records are available from Peros Banhos in the Chagos Archipelago, Guam and Solomon Islands and Jangoux has recently recorded it from New Caledonia. It is recorded here for the first time from the Lakshadweep.

CLASS: OPHIUROIDEA

The brittle stars are the smallest of the echinoderms and most active of the group. Majority of them live among coral reefsand under coral stones. Fourteen species are collected of which six are new records.

Species belonging to six families are collected. Species belonging to three families recorded for the first time.

Key to the Families of the Class

1. Dorsal arm plates rudimentary and often fragmented; disc liable to considerable distortion when preserved ..... OPHIOMYXIDAE

1'. Dorsal arm plates clearly visible, not rudimentary and not fragmented.....2

2. A pair of regular infradental papillae at the apex of each jaw below the lowest tooth, which is usually wide and square..... AMPHIURIDAE

2'. Apical papillae either multiple or single, rarely two.....3

3. Teeth broad and square-tipped with only a single papilla (or reduced tooth) if any, one or two distal oral papillae, usually well spaced from the apex of jaw; one fairly large rounded tentacle scale..... OPHIACTIDAE

3'. Teeth rounded or conical with one or many superficial papillae, if oral papillae present they form a continuous series up the side of the jaw; often more than one tentacle scale, or if only one then this may be elongated and pointed.....4

4. No oral papillae, each jaw more or less crowned with more or less compact cluster of apical tooth papillae ..OPHIOTRICHIDAE

4'. Oral papillae present on the sides of the jaws, apically either a cluster of tooth papillae or one or a few larger oral papillae 5

5. Both tooth papillae and oral papillae present, the former usually numerous..... OPHIOCOMIDAE

5'. Only oral papillae present, usually only one apical papilla below the teeth, atmost two three; disc scales naked .....OPHIURIDAE

Family OPHIOMYXIDAE

This is a small family with only one genus known from the Indian Seas. This genus is recorded for the first time from the Lakshadweep.

Genus *Ophiomyxa* Muller & Troschel. 1842

Though twenty species are known under this genus only one species is known from the the Indian Seas. This is recorded for the first time from the Lakshadweep.

Ophiomyxa australis Lutken, 1869

Ophiomyxa australis Lutken, 1869, p. 99: Locality not known: James, 1969, p. 54: Lakshadweep; A. M. Clark & Rowe, 1971, pp. 78, 92: Islands of Western Indian Ocean, Mascre Islands, East Africa & Madagascar, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines China & Southern Japan, South Pacific Islands; (Distribution Table), James, 1086, p. 581; Laksha-

dweep & Maldive area, Gulf of Mannar and Palk Bay along the S. E. coast of India, Sri Lanka, Andaman and Nicobar Islands, (Distribution Table).

Material: Minicoy, one specimen, collected under coral stones.

Remarks: This species is very rare in the Lakshadweep. The colour in the living condition is brick red on the dorsal side and pink on the ventral side. It was recorded for the first time from the Lakshadweep by the author in 1969.

Family AMPHIURIDAE

This is large cosmpolitan family. Nearly all members of the family are secretive and inactive, living buried in mud and sand or in the crannies of dead coral, shells or irregular rock fragments. Only one genus is collected from the Lakshadweep.

Genus *Amphipholis* Ljungman, 1866

Only one species is known from the Indian Seas.

Amphipholis squamata (Delle Chiaje, 1829)

Asterias squamata Delle Chiaje, 1829, p. 74: Locality not known.

Amphipholis squamata H. L. Clark, 1921, p. 106 : Torres Strait; Ely, 1942, p. 36. Hawaii, Thomas, 1962: Florida, James, 1969, p. 54: Gulf of Mannar, A. M. Clark, & Rowe, 1971, pp. 80, 99 Islands of Western Indian Ocean, East Africa & Madagascar, S. E. Arabia, Western India & Pakistan area, East Indies, Hawaiian Islands (Distribution Table); James, 1986, p. 581: Gulf of Mannar & Palk Bay along the South East coast of India, Andaman & Nicobar Islands (Distribution Table).

Material: Chetlat, two specimens, under coral stones.

Remarks: It has very wide distribution occurring in most of the Indo-Pacific region. Also reported from the Atlantic, St. Helena, Tobago and Bermuda. It is reported here for the first time from the Lakshadweep.

Family OPHIACTIDAE

It is a small family with a few genera. Only one genus is collected from the Lakshadweep.

Genus *Ophiactis* Lutken, 1856

Only two species are known from the Indian Seas. One species is collected from the Lakshadweep.

Ophiactis savignyi (Muller & Troschel, 1842)

Ophiolepis savignyi Muller & Troschel, 1842, p. 95: Egypt.

Ophiactis savignyi A. M. Clark & Davies, 1966, p. 599: Maldives; James, 1069, 55: Gulf of Mannar, Palk Bay, Lakshadweep; A. M. Clark & Rowe, 1971, pp. 82, 103: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Persian Gulf, Western India Pakistan, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines. China & Southern Japan, South Pacific Islands, Hawaiian Islands; (Distribution Table). Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll; James, 1986, p. 581: Lakshadweep & Maldive area, Gulf of Mannar & Palk Bay along the S.E. Coast of India; Sri Lanka, Andaman & Nicobar Area (Distribution Table).

Material: Minicoy, two specimens, collected from coral crevices.

Remarks: According to H. L. Clark (1946) this is the most common brittle star in the world, It is tropicopolitan in distribution.

Family OPHIOTRICHIDAE

This is a large family with several genera. Most of the species are associated with corals and sponges. Species belonging to two genera are collected.

Key to the genera of the family

Radial shields large; arms usually 9-20 times the disc diameter.....*Macrophiothrix* H.L. Clark, 1938

Radial shields small; arms four or five times the disc diameter.....*Ophiothrix* Muller & Troscel, 1840

Genus *Macrophiothrix* H.L. Clark, 1938

Only one species is collected under this genus. This is a new record to the Lakshadweep.

Macrophiothrix longipeda (Lamarck, 1816)

Ophiura longipeda Lamarck, 1816, p. 544: Mauritius.

Macrophiothrix longipeda H. L. Clark, 1938, p. 288: Australia; A. M. Clark & Davies, 1966, p. 648: Maldives; A. M. Clark, & Rowe, 1971, pp. 82. 114: Islands, of the Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Maldive area, Sri Lanka area, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, (Distribution Table)

Material : Chetlat, two specimens; Kiltan, two specimens; Kadmat, one specimen; Androth, one specimen, all collected under coral stones buried in sand.

Remarks : The length of the arms were 11.5 to 15 times the diameter of the disc. It is recorded here for the first time from the Lakshadweep.

Ophiothrix (Keystonea) nereidina (Lamarck 1840)

Ophiura nereidina Lamarck, 1840, p. 224: Australian Seas.

Ophiothrix nereidina Bell, 1902, p. 229: Lakshadweep, Maldives; Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll.

Ophiothrix (Keystonea) nereidina James, 1969, p. 55: Gulf of Mannar, Lakshadweep; A. M. Clark & Rowe, 1971, pp. 86, 107; Mascarene Islands, East Africa & Madagascar, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 582: Gulf of Mannar and Palk Bay along the S. E. Coast of India, Sri Lanka (Distribution Table).

Material : Bitra, one specimen, collected from from coral crevice.

Family OPHIOCOMIDAE

Members belonging to this Family are generally large with conspicuos colouration and active habits. Three genera are collected of which one is collected for the first time from Lakshadweep.

Key to the genera of the Family

1. Six armed fissiparous forms, size small; disc diameter rearly more than 5 mm, tentacle scale one.....*Ophiocomella* A. H. Clark, 1939

1'. Normally five arms, most specimens large, even upto 30 mm. in disc diameter; usually two tentacle scales.....2

2. Dorsal side of the disc with dense coat of rounded granules.....*Ophiocoma* Agassiz, 1836

2'. Disc armed with spines, sometimes in combination with granules.....
Ophiomastix Muller & Troschel 1842

Genus *Ophiocomella* A. H. Clark, 1939

Only one species is known under this genus from the Indian Seas. This is recorded for the first time from the Lakshadweep.

Ophiocomella sexradia (Duncan, 1887)

Ophiocnida sexradia Duncan, 1887, p. 92: Mergui Archipelago.

Ophiocomella sexradia James, 1969, p. 56: Palk Bay, Lakshadweep, Andaman, A. M. Clark & Rowe, 1971, pp. 86, 118: Islands of Western Indian Ocean, East Africa & Madagascar, Red Sea, Maldive area, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986, p. 582: Lakshadweep & Maldives, Gulf of Mannar & Palk Bay along the S. E. Coast of India Sri Lanka Andaman Nicobar Area.

Material : Chetlat, two specimens, Bitra, one specimen; Kiltan, two specimens.

Remarks : This species easily escapes observation in the field because of its small size and cryptic habits. It is often found associated with algae. It was recorded for the first time from Lakshadweep by the author in 1969.

Genus *Ophiocoma* Agassiz, 1836

This is a well marked and conspicuous genus with several species on the coral reefs of India. Five species are collected from the Lakshadweep of which one is a new record.

Key to the species of the genus

1. Interbrachial areas on the ventral side with a number of conspicuous circular scales ..... *O. anaglyptica* Ely, 1944

1'. Interbrachial areas on the ventral side with no enlarged circular scales.....2

2. Disc marked with beautiful pattern of radiating golden lines on a dark background .....*O. pica* Muller & Troschel, 1842

2'. Disc either uniformly dark or variegated or light green..... 3

3. Disc sparcely covered by granules.....4

3'. Disc densely covered by granules 5

4. Colour uniformly dark dorsally and ventrally .....*O. erinaceus* Muller & Troschel, 1842

4'. Colour variegated, sometimes dark brown dorsally but always lighter ventrally..... *O. scolopendrina* Lamarck, 1816

5. Disc pale in colour (brown or light yellow) often with a shade of light green..... *O. brevipes* Peters, 1851

5'. Colour of the disc either uniformly dark or variegated with reticulated pattern or spots .....*O. dentata* Muller & Troschel, 1842

Ophiocoma anaglyptica Ely, 1944

Ophiocoma anaglyptica Ely, 1944, 373: Canton Island; James, 1969, p. 56: Lakshadweep; A. M. Clark & Rowe, 1971, pp. 86, 118: South Pacific Islands (Distribution Table), James, 1986, p. 582: Lakshadweep and Maldive area (Distribution Table).

Material : Chetlat, eight specimens from reef flat.

Remarks : This species can easily be mistaken for *O. scolopendrina* in the field. It is mostly associated with live corals. It was listed from the Lakshadweep for the first time by the author in 1969.

Ophiocoma pica Muller & Troschel 1842

Ophiocoma pica Muller & Troschel, 1842, p. 101 : Locality not known; H. L. Clark, 1921, p. 127 : Torres Strait; James, 1969, p. 56 : Lakshadweep, Nicobar, Red Sea; A. M. Clark & Rowe, 1971, pp. 86, 118: Islands of Wester Indian Ocean, Mascarere Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldive area, Sri Lanka area, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands; (Distribution Table). James 1986, p. 58?: Lakshadweep & Maldive Area, Sri Lanka (Distribution Table).

Material : Chetlat, one specimen; Kadamat, one specimen; Kavaratti, two specimens, all collected from live coral branches.

Remarks : This species appears to live beyond the low tide mark. It appears to live among live corals. One of the most beautiful brittle stars in the living condition.

Ophiocoma erinaceus Muller & Troschel, 1842

Ophiocoma erinaceus Muller & Troschel, 1842; p. 98 : Red Sea; Bell, 1902, p. 228: Lakshadweep & Maldives; James, 1969, p. 56: Andamans, Lakshadweep, Mascare Islands, Red Sea; A. M. Clark & Rowe, 1971, pp. 86, 119: Islands of Western Indian Ocean, Mauritius, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldive Area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986, p. 582: Lakshadweep & Maldive Area, Gulf Mannar and Palk Bay along S. E. coast of India, Andaman and Nicobar Area. (Distribution Table); Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll.

Material: Chetlat, two specimens, Kiltan, one specimen; Kadamat, one specimen; Amini, two specimens; Androth, two specimens, all specimens, collected under coral stones.

Remarks: This species is usually found near the low water mark. It has very limited distribution in the intertidal region unlike *O. scolopendrina* which occurs from the supra-littoral zone to the infra littoral zone. This species does not exhibit autotomy to a marked degree like *O. scolopendrina*.

Ophiocoma scolopendrina (Lamarck)

Ophiura scopendrina Lamarck, 1840, p. 223: Mauritius.

Ophiocoma scolopendrina Muller & Troschel, 1842, p. 101 : Locality not known Bell, 1902, p. 228: Lakshadweep; James, 1969, p. 56: Andamans, Lakshadweep, Red Sea, Mauritius: A.M. Clark & Rowe, 1971, pp. 86, 119: Islands of the Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Persian Gulf, Maldive Area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands; Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll; James, 1986, p. 582 : Lakshadweep & Maldive Area, Gulf of Mannar & Palk Bay along the S.E. Coast of India, Sri Lanka, Andaman & Nicobar Islands (Distribution Table)

Material : Kiltan, several specimens; Kadamat, three specimens Amini, several specimens; Kalpeni, two specimens; Minicoy, several specimens.

Remarks : This is the most common species under the genus *Ophiocoma*: It occupies a very extended zone in the intertidal region from the supra-littoral region to the low water mark. It is some what gregareous.

Ophiocoma brevipes Peters
(Fig. 15)

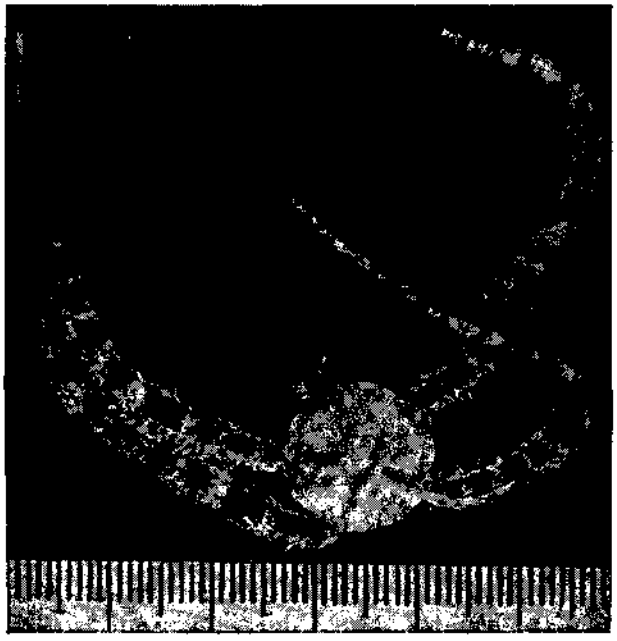

Fig. 15 *Ophiocoma brevipes*

Ophiocoma brevipes Peters, 1851, p. 465: Mozambique; Bell, 1902, p. 225; Maldives, Lakshadweep; James, 1969, p. 56; Andamans, Lakshadweep A. M. Clark & Rowe, 1971, pp. 86, 119 : Islands of the Western Indian Ocean, Mascarene Islands, East Africa & Madagacar, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawiian Islands (Distribution Table); Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll; James 1986, p. 582: Lakshadweep & Maldive area, Andaman Nicobar Islands. (Distribution Table).

Material : Chetlat, two specimens; Kadamat, one specimen; Minicoy, two specimens, all collected under coral stones.

Remarks: It is much rarer species than others. It can draw all its arms and fold them closely over the disc and hide in a small crevice. The lowermost spines of the proximal arm segments are flat and help in digging in sand. It can withstand long hours of exposure for it is found near the high water mark. There is not much autotomy in this species.

Ophiocoma dentata Muller & Troschel, 1842
(Fig. 16)

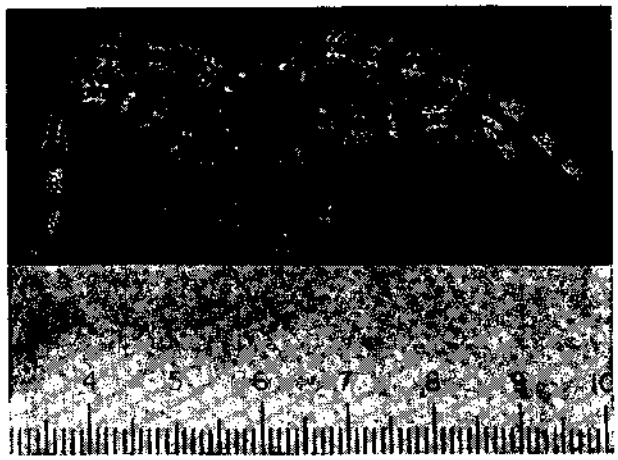

Fig. 16 *Ophiocoma dentata*

Ophiocoma dentata Muller & Troschel, 1842, p. 99: Locality not known; A. M. Clark & Rowe, 1971, pp. 86, 119: Islands of the Western Indian Ocean, Mascarene Islands, East Africa & Madagascar,

Maldive area, North Australia, Philippines, China & Southern Japan, South Pacific, Hawaiian Islands (Distribution Table); James, 1986, p. 582: Lakshadweep & Maldive Area, Andaman and Nicobar Area (Distribution Table).

Ophiocoma insularia Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll.

Ophiocoma brevipes var. *variegata* James, 1969, p. 56: Andamans & Lakshadweep.

Material: Chetlat, two specimens; Kiltan, several specimens; Kadamat, three specimens; Amini and Minicoy, several specimens, all specimens collected from underside of coral stones.

Remarks : This species is very common in Amini and Minicoy. Two colour forms, one with reticulated pattern on the disc and the other with black spots have been collected. Due to different colour patterns it was recorded under several names.

Genus *Ophiomastix* Muller & Troschel, 1842

One species is known from the Lakshadweep.

Ophiomastix annulosa (Lamark, 1840)
(Fig. 17)

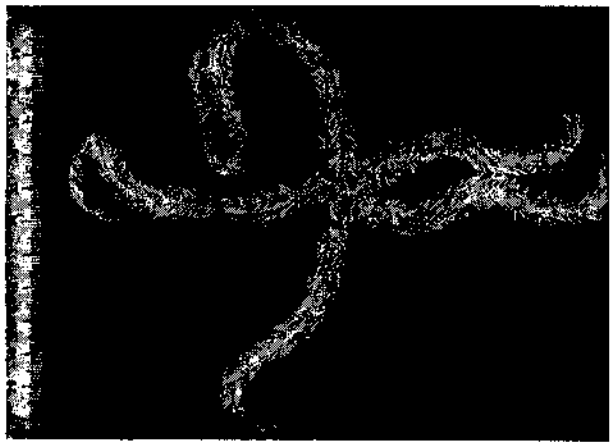

Fig. 17 *Ophiomastix annulosa* Dried specimen)

Ophiura annulosa Lamarck, 1840, p. 222: Locality not known.

Ophiomastix annulosa Muller & Troschel, 1842, p. 107: Japan; Bell, 1902, p. 229: Lakshadweep; James, 1969, p. 56: Andamans, Lakshadweep; Nagabhushanam & Rao, 1972, p. 289: Minicoy Atoll. A. M. Clark & Rowe, 1971, pp. 86, 120: Maldive area, Sri Lanka area, Bay Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table)

Material : Minicoy, one specimen, collected under coral stones.

Remarks : This species appears to be very rare in Lakshadweep.

Family OPHIURIDAE

This is a large Family with several genera. The disc is covered by scales or plates and the arm spines are small and apressed which are characterstic of the family. From the Lakshadweep only two genera are recorded.

Key to the genera of the Family

The scales on the dorsal and ventral side of the disc and the dorsal arm plates are surrounded by small scales..... *Ophioelegans* James, 1981

The scales on the dorsal and ventral side of the disc and the dorsal arm plates are not surrounded by small scales.....*Ophiolepis* Muller & Troschel, 1842

Genus *Ophioelegans* James, 1981

This genus is described by James (1981). It has only one species.

Ophioelegans cincta (Muller & Troschel, 1842)

Ophiolepis cincta Muller & Troschel, 1842, p. 90: Red Sea; A. M. Clark, & Davies, 1966, p. 603: Maldives; A. M. Clark & Rowe, 1971 pp. 90, 129: Islands of Western Indian Ocean, Mascarene Islands. East Africa & Madgascar, Red Sea, S. E. Arabia, Maldives, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table).

Ophioelegans cincta James, 1981, p. 15: Port Blair (South Andamans)

Material : Kavaratti, one specimen, collected under coral stones.

Remarks : This species is very rare and only one specimen could be collected. It is recorded

here for the first time from the Lakshadweep.

Ophiolepis superba H. L. Clark, 1938

Ophiolepis annulosa Muller & Troschel, 1842, p. 89: Locality not known.

Ophiolepis superba H. L. Clark, 1915, p. 89: Sri Lanka; A. M Clark & Rowe, 1971, pp. 90, 126: Islands of Western Indian Ocean, Mascarene Islands. East Africa & Madagascar, Red Sea, S. E. Arabia, Maldives Sri Lanka Area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands. (Distribution Table); James, 1986, p. 582: Lakshadweep & Maldives, Sri Lanka, Andaman & Nicobar Islands. (Distribution Table).

Material: Kavaratti, one specimen, collected under coral stones.

Remarks : This inert brittle star is very beautiful in the living condition. It is recorded for the first time from the Lakshadweep.

CLASS ECHINOIDEA

Sea urchins are large and conspicuous element of the coral reefs. They live in diverse habitats. Some of them bore into coral rocks while some live buried under sand. Some of them with long pointed spines and large pedicellariae are dangerous to handle in the field. The roe of some species of sea urchins are considered as delicacy and have good market in Japan. This class is divided into two Sub-classes.

Key to the Sub-Class of the Class

Test globular, or spherical; anus inside the apical system of plates.....REGULARIA

Test heart-shaped or flattened; anus out side the apical system of plates.....IRREGULARIA

SUB-CLASS: REGULARIA

Members of sea urchins belonging to this sub-class have a round profile with the peristome and periproct occupying central positions at oral and aboral poles respectively. Members belonging to four Orders have been collected and reportcd in this present work.

Key to the orders of the sub-class

1. Primary spines large, widely separated, contransting markedly with numerous, small secondary spines.....CIDAROIDEA

1'. Primary and secondary spines not markedly contransting in size 2

2 Epiphyses of the Aristotle's lantern fused across the top of each pyramid teeth keeled .....CAMARODONTA

2'. Epiphyses of the Aristotle's lantern not fused across the top of each pyramid. 3

3. Spines lack a cortex and are solid or provided with a narrow lumen;..... AULODONTA

3'. Spines are solid with or without cortex teeth unkeeled..... .....STIRODONTA

ORDER CIDAROIDEA

Only one Family is known under this Order

Family CIDARIDAE

Two genera are collected under this Family from the Lakshadweep.

Key to the genera of the family

Pores in adult specimens distinctly conjugate, collar of primary spines usually with red or purple spots or stripe ..... *Prionocidaris* A. Agassiz, 1863

Pores not conjugate or atleast sub-conjugate; collar of primary spines not spotted or stripped with red or purple: primary spines slender or coarse, usually not tapering; 'hairs' on the surface of the shaft anastomosing and forming a thick spongy coat .....*Eucidaris* Pomel; 1883

Genus *Priocidaris* A. Agassiz, 1863

Only one species is collected under this genus.

Prionocidaris verticillata (Lamarck, 1816) (Fig. 18)

Cidarites verticillata Lamarck; 1816, p. 56: Locality not known.

Prionocidaris verticillata A. M. Clark & Rowe, 1971, pp. 140, 151: Islands or Western Indian ocean, Mascarene Islands, East Africa & Madagascar, Maldive area,

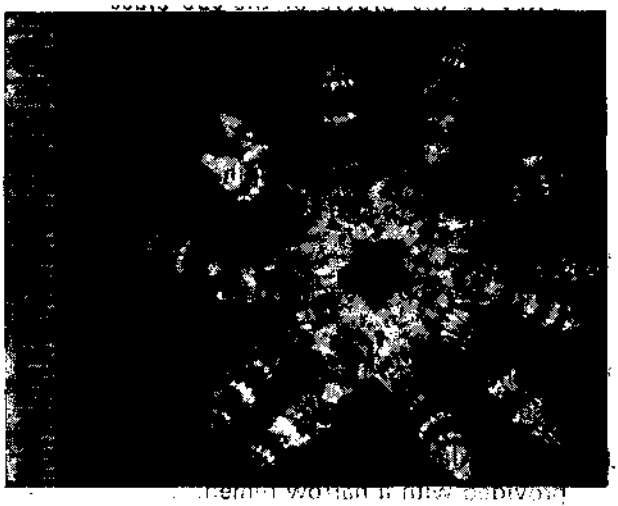

Fig. 18 *Prionocidaris verticellata*

Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, Hawaiian Islands (Distribution Table); James, 1986, p. 583 Laksha-dweep & Maldive Area, Andaman & Nicobar Islands (Distribution Table)

Material : Chetlat, several specimens; Kiltan, three specimens, collected from dead coral branches.

Remarks : A very beautiful sea urchin in living condition with symmetrical spines, with annulated primary spines. This species was found to live in the midst of dead coral branches. When the coral branches are broken the sea urchin is exposed.

Genus *Eucidaris* Pomel, 1883

Only one species is known under this genus from the Lakshadweep.

Eucidaris metularis (Lamarck, 1816)

Cidarites metularia Lamarck, 1816, p. 56 : East Indies.

Cidaris metularia Bell, 1902, x2p. 230: Maldives.

Eucidaris metularia A. M. Clark & Davies, 1966, p. 603: Maldives; A. M. Clark & Rowe, 1971, pp, 140, 150: Islands of the Western Indian Ocean, Mascarene Islands East Africa & Madagascar, Red Sea, Maldive area, Shri Lanka are Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Nagabhushanam & Rao, 1972, p. Minicoy Atoll; James, 1986, p. 582: Lakshadweep & Maldive Area, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Androth, one specimen collected under coralstones.

ORDER AULODONTA

Under this Order species belonging to one Family have been collected.

Family DIADEMATIDAE

Two genera are known from the Laksha-dweep.

Key to the genera of the Family

Primary ambulacral tubercles large in two regular series; ambulacral spines not peculiar; no spines on buccal plates..... *Diadema* Gray

Primary ambulacral tubercles very small; aboral ambulacral spines very slender, retrorsely barbed distally..... *Echinothrix* Peres, 1853

Genus *Diadema* Gray

Two species are collected under this genus. Both of them are new records to the Laksha-dweep.

Key to the species of the genus

Large tridentage pedicellariae mostly with narrow blades meeting at the tip; a red ring round the anus ..... *D. setosum* (Leske, 1778)

Tridentate pedicellariae leaf or spoon-shaped tapering slightly to a rounded distal end..... *D. savignyi* Michelin, 1845

Diadema setosum (Leske, 1778)

Echinometra setosa Leske, 1778, p. 36: East Indies.

Diadema setosum A. M. Clark & Rowe, 1971, pp. 140, 153: Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Sri Lanka area, Bay of Bengal, East Indies, North Australia, philippines China & Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 583: Sri Lanka, Andaman and Nicobar Islands (Distribution Table).

Material : Kiltan, four specimens, collected under coral stones.

Remarks : It is dangerous to handle this ssa urchin in live condition since the sharp spines enter into the hand. It is recorded for the first time from the Lakshadweep.

Diadema savignyi Michelin, 1845

Diadema savignyi Michelin, 1845, p. 15 : Mauritius; A. M. Clark & Rowe, 1971, pp. 140, 153: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, S.E. Arabia, Sri Lanka, East Indies, North Australia, Philippines China & Southern Japan, South Pacific Islands (Distribution Table); James, 1986 m p. 583: Sri Lanka, Andaman & Nicobar Area (Distribution Table).

Material: Chetlat, two specimens, collected under coral stones.

Remarks : This species is so far not recorded from the Maldives though the British Museum has specimens from Maldives. It is recorded here for the first time from the Lakshadweep.

Genus *Echinothrix* Peters, 1853

Two species are from the Lakshweep.

Key to the species of genus

Primary interabulacral spines distinctly verticillated, whorls close together; spines relatively brittle, inner cavity more than half diameter of spine; larger spines commonly banded ..... *E. calamaris* (Pallas, 1774)

Primary interambulacral spines distinctly striated, without whorls, relatively stout, inner cavity less than half diameter; unicolour ..... *E. diadema* (Linnaeus, 1758)

Echinothrix calamaris (Pallas, 1774)

Echinus calamaris Pallas, 1774, p. 31; East Indies

Echinothrix calamaris A. M. Clark & Rowe, 1971 pp, 140, 153: Islands of the Western Indian Ocean, Mascarene Islands, East Africa & East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Nagabushanam & Rao, 1972, p. 290: Minicoy Atoll.

Material: Chetlat, three specimens; Androth, one specimens; collected under coral stones on the reef.

Echinothrix diadema (Linnaeus, 1758)

Echinus diadema Linnaeus, 1758, p. 664: Locality not known

Echinothrix diadema Bell, 1902, p. 230: Maldives; James, 1969, p. 58: Lakshadweep; A. M. Clark & Rowe, 1971, pp. 140, 153: Islands of the Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S.E. Arabia, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines China & Southern Japan, South Pacific Islands, Hawaiian Islands, Hawaiian Islands (Distribution Table); Nagabhushanam & Rao, 1972, p. 290: Minicoy Atoll.

Material: Chetlat, two specimens; Kadmat, one specimen; Amini, two specimens; Kavaratti, two specimens; Minicoy, one specimen.

Remarks: This species is more common than the previous species.

ORDER STIRODONTA

Only specimens belonging to one family are known from the Lakshadweep.

Family STOMOPNEUSTIDAE

This family has only one genus. This has been collected from the Lakshadweep.

Genus *Stomopneustes* L. Agassiz, 1841

Only one species is known under this genus.

Stomopneustes variolaris (Lamarck, 1816)

Echinus variolaris Lamarck, 1816, p. 47: Locality not known.

Stomopneustes variolaris Koehler, 1927, p. 103: Mascarene Islands, Shri Lanka & Madagascar, S.E. Arabia, West India & Pakistan, Maldive, area; China & Southern Japan, South Pacific Islands (Distribution Table); Nagabhushnam & Rao, 1972 p. 290: Minicoy Atoll; James, 1986, p. 583: Lakshadweep & Maldive Area, Gulf of Mannar and Palk Bay on the

Indian side; Sri Lanka, Andaman & Nicobar Islands (Distribution Table),

Material: Chetlat, two specimens; Kiltan, two specimens collected undercoral stones.

Remarks: Since these were collected in the lagoon where the water is always calm, they were not found to bore into rock. In places like Visakhapatnam where there is heavy wave action this species burrows into rock for protection.

ORDER CAMRODONTA

Species belonging to three Families have been collected.

Key to the families of the order

1. Test sculptured by pits and depressions..... TEMNOPLEURIDAE

1'. Test not sculptured by pits and depressions..2

2. Gill cuts sharp and deep..... TOXOPNEUSTIDAE

2'. Gill cuts not sharp and deep..... ECHINOMETRIDAE

Family TOXOPNEUSTIDAE

Under this family two genera are collected from the Lakshadweep.

Key to the genera of the family

Globiferous pedicellariae very large and conspicuous.....*Toxopneustes* L. Agassiz, 1841

Globiferous pedicellariae small and inconspicuous.....Tripneusters L. Agassiz, 1841

Genus *Toxopneustes* L. Agassiz, 1841

Only one species is collected under this species.

Toxopneustes pileolus (Lamarck)
(Fig. 19)

Echinus pileolus Lamarck, 1816, p. 45: Mascarene Islands.

Toxopneustes pileolus A. M. Clark & Rowe, 1971, pp. 142, 156: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, S. E. Arabia, Sri Lanka area, Bay of Bengal, East indies, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 583: Gulf of Mannar & Palk Bay along the South East coast of India, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

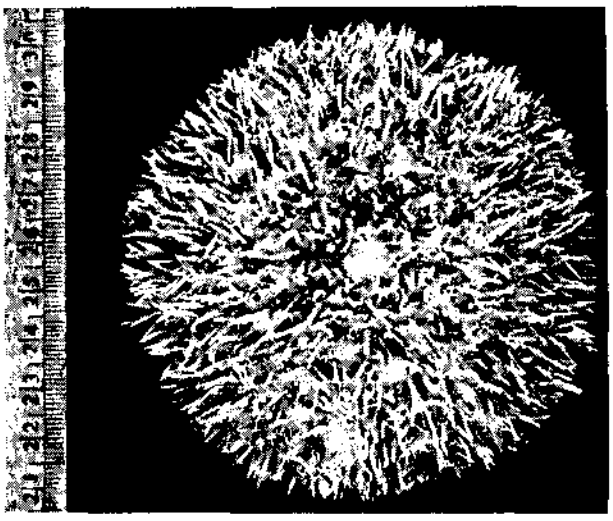

Fig. 19 *Trxopneustes pileolus*

Material: Kadamat, two specimens, on both occasions collected among live corals.

Remarks: In the living condition it has the habit of covering itself with bits of corals and pieces of algae. It is recorded here for the first time from the Lakshadweep.

Genus *Tripneustes* L. Agassiz, 1841

Only one species is collected under this genus.

Tripneustes gratilla (Linnaeus, 1758)
(Fig. 20)

Echinus gratilla Linnaeus, 1758, p. 664: Locality not known.

Tripneustes gratilla A. M. Clark & Davies, 1966, p. 399 : Maldives; James, 1969, p. 57: Gulf of Mannar, Nicobar, Mauritius, Red Sea; A. M. Clark & Rowe, 1971, pp. 142, 156: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madgascar, Red Sea, S. E. Arabia, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, (Distribution Table); Nagabhusahnam & Rao, 1972,

Fig. 20 *Tripneustes gratilla*

p. 290: Minicoy Atoll; James 1986, p. 583. Lakshadweep & Maldives, Gulf of Mannar & Palk Bay along S. E. Coast of India, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Chetlat, several specimens; Kiltan, several specimens; Kadamat, three specimens; Amini, several specimens; Kalpeni, two specimens, all specimens collected in the lagoons on algal beds.

Remarks : This species is common in the lagoon at Amini. The ripe gonads of this species are of export value and are considered as a delicay in Japan.

Family TEMNOPLEURIDAE

Only two genera are collected under this Family from the Lakshadweep.

Key to the Genera of the Family

Primary tubercles distinctly crenulated; coronal plates with small sutural pits or none..... *Salmacis* L. Agassiz, 1841

Primary tubercles not crenulated; interambulacral plates low and numerous; pore pairs distinctly biserial.....*Mespila* Agassix & Desor, 1846

Genus *Salmacis* L. Agasszi, 1841

Two species are known from the Lakshadweep. Only one species is collected during the survey.

Key to the Species of the Genus

Primary spines violet in colour; in the living condition covers itself with bits of shells, coral pieces etc .....*S. virgulata* L. Agassiz 1846

Primary spines banded with red and yellow colours; in the living condition does not cover with bits of shells and coral pieces ..... *S. bicolor* L. Agassiz, 1846

Salmacis virgulata L. Agassiz & Desor 1846

Salmacis virgulata L. Agassiz & Desor, 1846, p. 359: Sri Lanka; A. M. Clark & Rowe, 1971, pp. 140, 156: Sri Lanka, Bay of Bengal, East Indies, Philippines (Distribution Table); James, 1986, p. 583: Gulf of Mannar & Palk Bay on the Indian side; Sri Lanka.

Material : Androth, one specimen, collected on the reef flat.

Remarks : This species appears to be very rare. This is also not recorded from the Maldives. It is reported here for the first time from the Lakshadweep.

Genus *Mespila* Agassiz & Desor, 1846

Only one species is collected under this genus,

Mespila globulus (Linnaeus, 1758)

Echinus globulus Linnaeus, 1778, p. 664: Locality not known.

Mespila globulus A. M. Clark & Rowe, 1971, pp. 140, 155: Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table).

Material : Kavaratti, two specimens, collected under coral stones.

Remarks : This species is also not known from the Maldives. It is recorded here for the first time from the Lakshadweep.

Family ECHINOMETRIDAE

Under this Family three genera are collected from the Lakshadweep.

Key to the Genera of the Family

1. Only three pore-pairs to the arcs..... *Echinostrephus* A. Agassiz, 1863

1'. Four to many pore-pairs to the arcs.....2

2. Primary spines very strongly developed, long, thick and heavy..... *Heterocentrotus* Brandt, 1835

2' Primary spines not very strongly developed, not long, thick and heavy ..... *Echinometra* Gray, 1825

Genus *Echinostrephus* A. Agassiz, 1863

This little genus of curious rock-boring sea urchin is characterstic of the coral rock areas. Only one species is known.

Echinostrephus molaris (Blainville)
(Fig. 21)

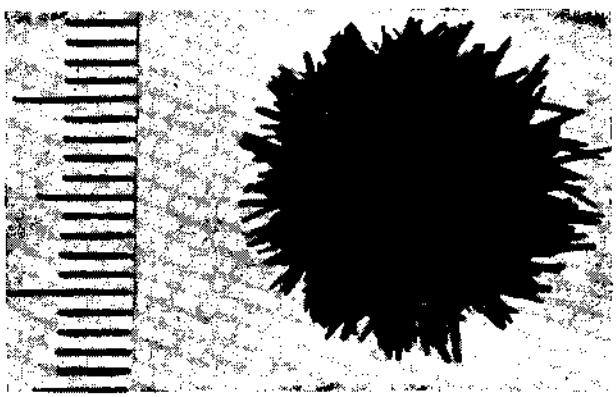

Fig. 21 *Echinostrephus molaris*

Echinus molaris Blainville, 1825, p. 88: Locality not known.

Echinostrephus molaris A. M. Clark, & Davies, 1966: Maldives: A. M. Clark & Rowe, 1971, pp. 142, 157: Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Western India & Pakistan, Maldive area; Sri Lanka area, Bay of Bengal, East Indies, North Australia, China & Southern Japan, South Pacific Islands; (Distribution Table): James' 1986, 1986, 583: Lakshadweep & Maldives Area, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Agatti, one specimen, collected from a coral stone.

Remarks : This is a rock borer and is recorded here for the first time from the Lakshadweep.

Genus *Heterocentrotus* Brandt, 1835

This extraordinary genus comprises the so called 'slate pencil' urchins. One species is known from the Lakshadweep.

Heterocentrotus mammillatus (Linnaeus, 1758)

Echinus mammillatus Linnaeus, 1758, p. 667: Locality not known.

Heterocentrotus mammillatus H. L. Clark, 1921, p. 151: Torres Strait; A. M. Clark & Davies, 1966, p. 603: Maldives; James, 1969, p. 58: Lakshadweep, Red Sea, Mascarne Islands, A. M. Clark & Rowe, 1971, pp. 142, 158: Mauritus, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldive area, Sri Lanka Area, East Indies, North Australia, Philippines China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table .

Material : Agatti, one specimen; Kavaratti, two specimens, collected from coral reef flat.

Remarks : It is one of the beautiful sea urchins in the living condition, The spines are used to write on slates.

SUBCLASS IRREGULARIA

Species belonging to this Subclass have the anal opening outside the apical system in posterior interambulacrum. Species belonging to all the four orders have been collected.

Key to the Orders of the Subclass

1. Ambulacra simple not forming petals aborally, test usually high..... HOLECTYPOIDA

1'. Ambulacra petaloid; test often flattened and broad 2

2. Dental apparatus strongly developed and present in adults; phyllodes absent..... CLYPEASTROIDA

2'. Dental apparatus present in young stages; phyllodes more or less developed.....3

3. Phyllodes and bourrelets well developed forming a floscelle.....CASSIDULOIDA

3'. Phyllodes usually little developed; bourrelets absent.....SPATANGOIDA

ORDER HOLECTYPOIDA

Forms regular with high test. Ambulacra simple. Apical system and peristone central. Periproct in close contact with the apical system. Spines simple and small. Pedicellariae of the usual four types.

There are two Suborders under this order of which members belonging to one Suborder have been recorded from the Indian Seas.

SUBORDER ECHINONEINA

Test often elongate. Peristome oblique. Gill slits and buccal plates absent. Primary tubercles do not form distinct verticle series except in young forms. Masticatory apparatus present in young stages only.

This Suborder has anly one Family *viz.*, Echinoneidae.

Family ECHINONEIDAE

Two genera are known under this Family of which one is known from the Indian Seas.

Genus *Echinoneus* Leske, 1778

Only one species is known from the Indian Seas.

Echinoneus cyclostomus Leske, 1778
(Fig. 22)

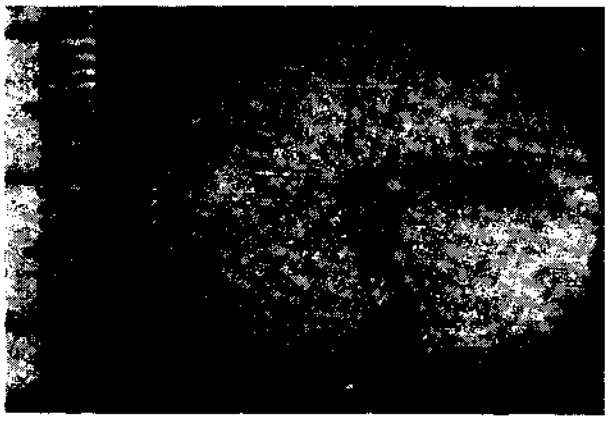

Fig. 22 *Echinoneus cyclostomus*

Echinoneus cyclostomus; Leske, 1778, p. 173: Locality not known; Bell, 1902, p. 232: Lakshadweep; A. M. Clark & Davies, p. 599: Maldives; A. M. Clark & Rowe, 1971, pp. 144, 158: Islands of Western Indian Ocean, Mascarene Islands East Africa & Madagascar, S. E. Arabia Maldive area, Sri Lanka Area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Nagahushanam & Rao, 1972, p. 290: Minicoy Atoll; James, 1986, p. 584: Lakshadweep & Maldives, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material: Chetlat, two tests; Kiltan, two tests.

Remarks: Only tests were collected. Live specimens were not seen on the reefs.

ORDER CLYPEASTROIDA

Species belonging to one Family is known from the Lakshadweep.

Family CLYPEASTERIDAE

Only one genus is collected from the Lakshadweep.

Genus *Clypeaster* Lamarck, 1801

Under this genus two species are recorded. The record of *Clypeaster humilis* by Nagabhushanam & Rao (1972) from Minicoy Atoll needs confirmation.

Key to the species of the Genus

Edge of the test markedly thickened; petaloid area somewhat thickened..... .....
C. reticulatus(Linnaeus, 1758)

Central part of the test raised and margin flat; petals more or less distinctly closed ... .
C. humilis (Leske, 1778)

Clypeaster reticulatus (Linnaeus, 1758)

Echinus reticulatus Linnaeus 1758, p. 663: Locality not known.

Rhephidoclypus reticulatus Koehler, 1922, p. 68: Maldives.

Clypeaster reticulatus A. M. Clark, & Rowe, 1971, pp. 144, 160: Islands of Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea S. E. Arabia, Persian Gulf, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986, p. 584: Lakshadweep &

Maldive area, Sri Lanka (Distribution Table).

Material : Chetlat, two tests; Kadamat, one test.

Remarks : No live specimens could be collected during the survey. In the Maldives it is recorded from more than 20 metres depth.

ORDER CASSIDULOIDA

In this Order species belonging to one Family are recorded.

Family ECHINOLAPADIDAE

Species belonging to one genus only are collected from the Lakshadweep.

Genus *Echinolampas* Gray, 1825

Two species are collected under this genus from the Lakshadweep.

Key to the species of the Genus

Peristome pentagonal; interproiferous zone of petals with crowded tubercles, often about eight in a single transverse series..... *E. ovata* (Leske, 1778)

Peristome oval; few tubercles between the pores .....*E. alexandri* de Loriol, 1876

Echinolampas ovata (Leske, 1778)
(Fig. 23)

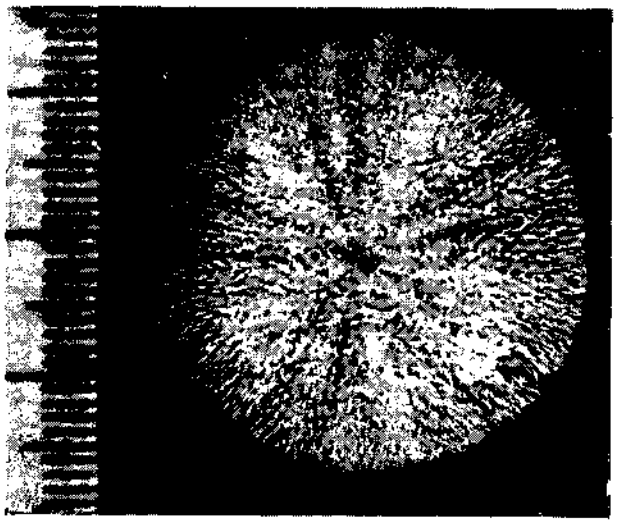

Fig. 23 *Echinolampas ovata*

Echinanthus ovatus Leske, 1778, p. 1919: Locality not known.

Echinolampas ovata A. M. Clark and Rowe, 1971, pp. 143, 163: Mascarene Islands, Red Sea, Sri Lanka area, Bay of Bengal, East Iddies, North Australia (Distribution Table); James, 1986, p. 584: Gulf of Mannar and Palk Bay on Indian side Sri Lanka.

Material : Chetlat, one specimen; Kiltan, one specimen; Amini, two specimens (one test); Androth, one test, all live specimens collected under corals stones.

Remarks : This species is collected for the first time from Lakshadweep.

Echinolampas alexandri de Loriol, 1876

Echinolampas alexandri de Loriol, 1876, p. 4: Mauritius; A. M. Clark and Rowe, 1971, pp 144, 163: Islands of the Western Indian Ocean, Mascarene Islands, S. E. Arabia; Sri Lanka area, Bay of Bengal, East Indies, South Pacific Islands (Distribution Table); James, 1986, p. 584: Gulf of Mannar and Palk Bay on the Indian side; Sri Lanka (Distribution Table).

Material : Kiltan, two specimens, Collected under coral stones.

Remarks : This species is recorded here for the first time from the Lakshadweep.

ORDER SPANTANGOIDA

Only one species belonging to the family Brissidae is collected during the survey. Nagabhushanam and Rao (1972) listed species belonging to two other families under this order from Minicoy Atoll.

Key to Families of the Order

1. Peristome crescentic or D-shaped; labrum well developed no subanal fasciole..... LOVENIIDAE

1'. Subanal fasciole present; no inner fasciole 2

2. Peripetalous fasciole absent..... SPATANGIDAE

2'. Peripetalous fasciole present. .BRISSIDAE

Family LOVENIIDAE

Under this Family two Genera are present. One species belonging to the Genus *Lovenia*

has been reported by Nagabhushanam & Raw (1972) from Minicoy Atoll.

Key to the Genera of the Family

No Peripetalous fasciole; sternum almost naked ..... *Lovenia* Agassiz & Desor, 1847

Peripetalous fasciole present and also inner and subanal ones; sternum well tuberculated..... *Breynia* Agassiz & Desor, 1847

Genus *Lovenia* Agassiz & Desor 1847

Under this genus only one species *viz.*, *L. elongata* (Gray, 1845) has been listed from Minicoy.

Family SPATANGIDAE

Under this Family genus *Maretia* has been recorded from Minicoy.

Genus *Maretia* Gray, 1855

Under this genus one species *viz.*, *M. planulata* (Lamarck) has been listed from Minicoy Atoll by Nagabhusahnam & Rao (1972).

Family BRISSIDAE

Under this Family two genera are collected from the Lakshadweep.

Key to the Genera of the Family

Distinct anal fasciole on each side of periproct; aubanal plastron not projecting like snout beyond periproctal area .....*Metalia* Gray,1855

No anal fasciole; subanal plastron not projecting like a snout.....*Brissus* Leske; 1778

Genus *Metalia* Gray' 1855

Under this Genus only one species *viz.* M. *spatangus* (Linnaeus, 1758) has been listed from Minicoy Atoll by Nagabhusahnam & Rao (1972).

Genus *Brissus* Leske, 1778

Under this Genus only test of one species has been collected during the survey

Brissus latecarinatus (Leske, 1778) (Fig. 24)

Spatangus latecarinatus Leske, 1778, p. 185: Locality not known.

Brissus latecarinatus A. M. Clark & Rowe, 1971, pp. 146, 165: Islands of the Western Indian Ocean, Mascarene Islans, East Africa & Madagascar; Maldive area, Sri Lanka area, East Indies, North Austrlia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986. p. 585: Lakshadweep & Maldive area, Sri Lanka (Distribution Table).

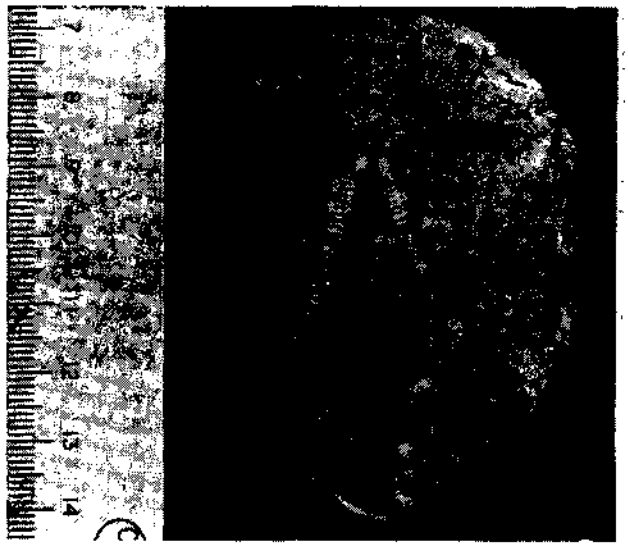

Fig. 24 *Brissus latecarinatus*

Material : Agatti, one specimen (test only).

Remarks : This species is recorded for the first time from Lakshadweep.

CLASS HOLOTHURIOIDEA

The holothurians are the least known group of the echinoderms because of the difficuities in preserving them and also due to the notable unattractiveness of the preserved specimens. In their habits they show less diversity than the more active brittle stars and the sea urchins. The majority of them are sluggish. The longest holothurian belonging to the order Apoda live more or less exposed on the sea bottom, particularly in the open areas near the coral reefs. Small forms live under rock fragments or among the dead corals often burying themselves deep in the sand and withdrawing out of sight when disturbed. The colours are mostly brown or grey of some shade. Some species are handsomely coloured with shades of red, yellow and violet colours. The tentalles are frequently in contract with the body colour. Some of them harbour commensals like crabs and Carapid fish.

The holothurians are the only group which have some economic value. An edible product known as *beche-de-mer* or *Trepang* is prepared out of the body wall of certain holothurians.

In this work 26 species are reported of which four species are new records to the Lakshadweep.

Species belonging to three Order have been collected.

Key to the Orders of the Class

1. Tentacles tree-shaped, much branched; anterior end with introvert ..... DENDROCHIROTIDA

1'. Tentacles peltata or digitate; no true introvert 2

2. Tentacles peltate; body cylindrical with podia ..... ASPIDOCHIROTIDA

2'. Body vermiform with rough or warty suface; tentacles pinnate; podia and respiratory trees absent ..... APODA

ORDER: ASPIDOCHIROTIDA

Species belonging to three Families have been collected from the Lakshadweep.

Key to the Families of the Order

1. Body cylindrical or vermiform; pedicels and papillae long (95-10 mm.) confined more or less to five ambulacral bands; calcareous ring ribbon-like with radials and interradials markedly dissimilar in size; body translucent LABIDODEMATIDAE

1'. Body cylindrical or rectangular; pedicels and papillae short not confined to ambulacral areas; calcareous ring not ribbon-like with radials and interradials of similar size; body not translucent 2

2. Gonads in single tuft to the left side of the the mesentery; spicules in various forms; S-shaped and C-shaped rods absent. ..... HOLOTHURIIDAE

2'. Gonads in two tufts, one on each side of the dorsal mesentery; S and C-shaped rods present..... STICHOPODIDAE

Family LABIDODEMATIDAE

This Family is described by James (1981) to accomodate the genus *Labidodemas* Seleka, 1867. So Far only one genus is known under this Family

Genus *Labidodemas* Selenka, 1867

One species is known from the Lakshadweep.

Lobidodemas rugosum (Ludwig, 1875)

Holothuria rugosa Ludwig, 1875, p. 110: South Pacific Islands; Pearson, 1913, p. p. 82: Maldives.

Labidodemas rugosum Rowe, 1969. p. 133; A.M. Clark & Rowe, 1971, pp. 176, 197: Maldive area, Bay of Bengal, East Indies, North Australia, Philippines, South Pacific Islands (Distribution Table) Mukhopadhyay & Samanta, 1983, pp. 308, 312: Kavaratti (Lakshadweep); James, 1986, p. 585: Lakshadweep & Maldives area, Andaman and Nicobar area (Distribution Table).

Material: Chetlat, two specimens; Kadamat, two specimens, collected under coral stones.

Remarks: At Andaman this species is found complety buried inside sand under big stones. It is a rare species in Lakshadweep.

Family HOLOTHURIIDAE

Under this Family three Genera are collected during the survey.

Key to the Genera of the Family

1. Spicules: tables, buttons, rod resetts, perforated plates; if branched rods present only in combination with others and never on their own . ....*Holothuria* Linnaeus, 1764

1'. Spicules: very numerous branched rods usually dichotomously lobed 2

2. Anus guarded by five enlarged clacified papillae or anal teeth ...*Actinopyga* Bronn, 1860

2'. Arms not guarded by five enlarged calcified papillae though five groups of similar papillae may be present ..... *Bohadschia* Jaeger, 1833

Genus *Holothuria* Linnaeus, 1764

Over one hundered species are known under this genus. Several attempts were made to reduce the unwieldy mass of species included under the genus into more manageble groups by earlier workers like Pearson (1914), Panning (1929-35) and Deichmann (1958). For one reason or other the earlier studies remained inconclusive. Rowe (1969) revised the Family Holothuriidae and proposed a new classification which is followed in this paper.

Under this genus 17 subgenera have been recognised by Rowe (1969). Of these species belonging to eight subgenera have been collected. The subgenus *Cystipus* is recorded for the first time from the Lakshadweep. The following key is adopted from Rowe (1969).

Key to the subgenera the Genus

1. Spicules: tables always present in combination with rods or rosettes, never with buttons 2

1'. Spicules: tables always present in combination with buttons, no rosettes or rods. .3

2. Spicules: tables usually with reduced disc and moderately high or high spire ending in a few spines forming maltase cross when viewd from above ....*H. (Holodemia)* Pearson, 1914

2'. Spicules: tables in combination with rods in the body wall, tables with reduced disc and spire, either rounded at the tip or terminate in a few spines which form a single or double maltase cross when viewed from above, no rosettes. .... *H. (Semperothuria)* Deichmann, 1958

3. Spicules : table variously developed never modified into hollow fenestrated spheres; buttons smooth, regularly or irregularly developed, often twisted. 4

3'. Spicules: tables always strongly developed sometimes modified into hollow fenestrated spheres; buttons always knobbed or rugose or modified to form hollow fenestrated ellipsoids 7

4. Spicules: tables usually well developed the rim of the disc not spinose; buttons not twisted, sometimes flat and thin with or without an apparent median longitudina ridge, outlines regular or irregular... 5

4'. Spicules: tables more or less well developed disc usually spinose; buttons irregular or twisted, never flattened, lacking any appearance of a median longitudinal ridge. 6

5. Spicules: tables well developed, disc smooth and round usually with ten or more peripheral holes, spines of moderate height ending in a several small spines; buttons oval thin, flat, very rarely with a few knobs an apparent median longitudinal ridge present, three to six pairs of relatively small holes, buttons regular or irregular in outline .....*H. (Platyperona)* Rowe, 1969

5'. Spicules: tables fairly stout, disc smooth squarish in outline, usually with eight regular pheripheral holes spire of moderate height ending in a cluster of small spines; buttons not thin or flat and lacking any appearance of longitudinal ridge usually with three pairs of comparitively large holes and regular in outline .... *H. (Thymioscycia)* Pearson, 1914

6. Spicules: tables not strongly developed, rim of disc usually spinose, spire low, ending usually in a ring of spines or cluster of spines, tables occasionally degenerate or incomplete; buttons irregular though not twisted, usually with three pairs of holes or else incomplete forming small lobed rosette-like bars ..... *H. (Mertensiothuria)* Deichmann, 1958

6'. Spicules; tables always well developed rim of disc spinose and turned up to give a' cup and saucer' aspect to the table in laterial view, spire low to moderate in height, usually terminating in a ring or cluster of small sipnes; pseudobuttons abundant, smooth, usually irregular and often reduced to a single row of three or four holes, occasionally buttons quite regular with three pairs of holes ... . *H. (Lessonothuria)* Deichmann, 1958

7. Spicules: tables with disc usually knobbed spire low, bearing many short spines which are sometimes so numerous and closely crowded that they may almost either obscure the disc or become connected to the knobs

of the margin of the disc thus forming a fenestrated sphere; buttons usually simple with large regularly or irregularly arranged knobs, generally three to four or more pairs of relatively small holes which may become somewhat obscured by the size of the large knobs . . *H. (Cystipus)* Haacke, 1880

7'. Spicules: tables stout, well developed spire moderate or high, never modified into hollow fenestrated ellipsoids; tables well developed with smooth disc, spire of moderate height or high terminating in several small spines; buttons hollow fenestrated ellipsoids though a few simple knobbed buttons may be present .... *H. (Microthele)* Brandt, 1835

Subgenus *Halodeima* Pearson, 1914

One species is known from the Lakshadweep.

Holothuria (Halodeima) atra Jaeger, 1833

Holothuria atra Jaeger, 1833, p. 22: East Indies.

Holothuria (Halodeima) atra Rowe, 1969, p. 137: Amboina; A. M. Clark & Rowe, 1971, pp. 176; Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea S. E. Arabia, Persian Gulf, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan South Pacific Islands Hawaiian Islands (Distribution Table); Mukhopadhyay & Samanta, 1983, pp. 302, 311: Lakshadweep & Maldive area, Gulf of Mannar & Palk Bay on the Indian side, Sri Lanka, Andaman & Nicobar Islands (Distribution Table),

Material : Chetlat, several specimens, Kiltan, several specimens; Kadamat, five specimens; Amini, three specimens; Agatti, several specimans, Kavaratti, two specimens, all specimens collected from the lagoon.

Remarks: This is the most common holothurian in Lakshadweep. This species is always fully exposed on sandy bottoms and is never encountered under stones.

Subgenus *Semperothuria* Deichmann, 1958

Only one species is collected under this subgenus.

Holothuria (Semperothuria) cinerascens (Brandt, 1835)

(Fig. 25)

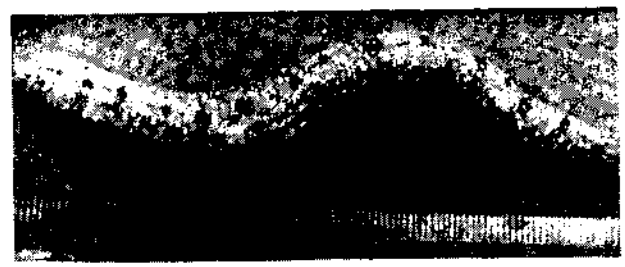

Fig. 25 *Holothuria (Semperothuria) cinerascens*

Stichopus (Gymnochirota) cinerascens Brandt, 1835, p. 51: China & Southern Japan.

Holothuria cinerascens Pearson, 1913, p. 64: Maldives, Seychelles, Sri Lanka; James, 1969, p. 61: Gulf of Mannar, Arabian Sea, Lakshadweep.

Holothuria (Semperothuria) cinerascens Rowe, 1969, p. 135: A. M. Clark & Rowe, 1971, p. 178: Islands of Western Indian Ocean Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldives, Sri Lanka area, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Mukhopadhyay & Samanta, 1983, pp. 302, 311: Lakshadweep; James, 1986, p. 583: Lakshadweep & Maldive area, Sri Lanka (Distribution Table).

Material : Chetlat, two specimens; Bitra, two specimens; Kiltan, Several specimens; Kadamat, three specimens; Amini, several specimens Androth, one specimen; Kavaratti, three specimens; Minicoy, several specimens, all specimens collected under coral stones.

Remarks: This is a common holothurian in Lakshadweep. They were found to attach to the rock firmly. It is provided with profuse cuvierian tubles which are discharged on disturbance to the animal.

Subgenus *Platyperona* Rowe, 1969

Only one species is known from the Lakshadweep. This was reported for the first time from the Lakshadweep by the author in 1969.

Holothuria (Platyperona) difficilis (Semper)

Holothuria difficilis Semper, 1868, p. 92: Samoa.

Microthele difficilis A. M. Clark and Davies, 1966, p. 600: Madives. James, 1969, p. 61: Lakshadweep, Red Sea.

Holothuria (Playperona) difficilis Rowe, 1969, p. 145.; A. M. Clark & Rowe, 1971, p. Islands of Western Indian Ocean, Mascarene Islands, Red Sea, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia; Philippines, China & Southern Japan, South Pacific Islands Hawaiian Islands (Distribution Table); Mukhopadhyay & Samanta, 1983, pp. 302, 311: Lakshadweep; James, 1986, p. 585: Lakshadweep & Maldive area, Sri Lanka, Andaman & Nicobar Islands, (Distribution Table).

Material: Chetlat, several specimens; Kiltan, several specimens; Amini, several specimens; all collected under coral stones.

Remarks: The colour in the living condition is light brown with dark brown blotches. The posterior end is tapering. The ventral side is thickly distributed by pedicels which are yellowish-brown in colour.

Subgenus *Thymiosycia* Pearson, 1914

Three species are collected from the Lakshadweep during the survey.

Key to the species of the subgenus

1. Spicules: buttons with small holes burrowing form with often red spots . . .. *H. (Thymioscyia) arenicola* Semper, 1868

1'. Spicules: buttons with large holes 2

2. Spicules : tables stout with a cluster of short spines at the top fugitive form skin Sanday to touch ..... *H. (Thymioscyia) impatiens* (Forskal, 1775)

2'. Spicules: tables not stout and with a few spines at the top skin smooth and soft; fugitive form..... *H. (Thymioscyia) hilla* Lesson, 1830

Holothuria arenicola Semper, 1868, p. 81: Philippines.

Holothuria (Thymioscyia) arenicola Rowe, 1969, p. 147: A. M. Clark & Rowe, 1971, p. 178: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, Maldives, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986, p. 585: Lakshadweep & Maldive area, Andaman and Nicobar area (Distribution Table).

Material : Chetlat, four specimens; Kadamat, two specimens; Amini, one specimen; Androth, one specimen, all found buried in sand.

Remarks: At Chetlat when the tide recedes small holes were seen through which water was gushing out. These are caused by this species. It is almost impossible to take out the species. The moment we dig they will go deeper into sand and below there are big stones which make digging difficult. It is recorded here for the first time from Lakshadweep.

Holothuria (Thymioscyia) impatiens (Forskal)

Fistularia impatiens Forskal, 1775, p. 121: Red Sea.

Holothuria impatiens Selenka, 1867, p. 340: Suez; A. M. Clark & Davies, p. 599: Maldives; James, 1969, p. 61: Andamans, Lakshadweep, Red Sea. Nagabhushanam & Rao, 1972, p. 290: Minicoy Atoll;

Holothuria (Thymiosycia) impatiens Rowe; 1969, p. 146; A. M. Clark & Rowe, 1971, p. 178: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia Persian Gulf, Maldives, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Isiands, Hawaiian Islands

(Distribution Table) Mukhopadhyay & Samanta, 1983, pp. 307, 311: Lakshadweep & Maldive area, Sri Lanka, Andaman and Nicobar area;

Material : Chetlat, two specimens; Kiltan, two; Kadamat, one specimen; Amini, two specimens; Agatti, one specimen; Kalpeni, two specimens; Kalpeni, two specimens; Minicoy, three specimens, all collected under coral stones.

Remarks : It is very common holothurian in Lakshadweep. It is a fugitive form found under stones. Two or three specimens are found under the same rock. On disturbing thick Cuvierian tubles are released. It was reported for the first time from the Lakshadweep by the author in 1969. It is distributed in the Atlantic also

Holothuria (*Thymioscscia*) *hilla* Lesson

Holothuria hilla Lesson, 1830, p. 266: South Pacific Islands: A. M. Clark & Rowe, 1967, pp. 126-128.

Holothuria monocaria Koehler & Vaney, 1908, p. 11: Lakshadweep; Mergui Archpelago, Andamans, Persian Gulf; A. M. Clark & Davies, 1966, p. 603: Maldives; Nagabhusahnam

Holothuria (*Thymiosycia*) *hilla* Rowe, 147; A. M. Clark & Rowe, 1971, p. 178: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascas, Red Sea, S.E. Arabia, Persian Gulf; Maldives, Sri Lanka, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, & Rao, 1972, p. 290: Minicoy Atoll: (Distribution Table) Mukhopadhay & Samata, 1983, pp. 307, 311: Lakshedweep; James, 1986, p. 585: Lakshadweep & Maldives area, Sri Lanka, Andaman and Nicobar Islands, (Distribution Table).

Matirial: Chetlat, several specimens; Bitra, two specimens; Kiltan, several specimens; Kadamat, three specimens; Amini, two specimens; Minicoy, two specimens, all collected under coral stones.

Remarks : It is one of the most common holothurians in Lakshadweep. It is a fugitive species found under coral stones.

Subgenus *Mertensiothuria* Deichmann, 1958

Three species are known from the Indian Seas of which two have been collected from the Lakshadweep.

Key to the species of the subgenus

1. Spicules in the inner layer resembling narrow rosettes .....*H. (Mertensiothuria) pervicax* Selenka, 1867

1'. Buttons delicate, mostly with large holes, often narrow.....*H (Mertensiothuria) leucospilota* (Brandt, 1835)

Holothuria (*Mertensiothuria*) *pervicax* (Selanka, 1867)

Holothuria pervicax Selanka, 1867, p. 327: Zanzibar; A. M. Clark & Davies, 1966, p. 600: Maldives; James, 1969, p. 61: Lakshadweep.

Holothuria (*Mertensiothuria*) *pervicax* Rowe, 1969, p. 149; A. M. Clark & Rowe, 1971, p. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldives, Sri Lanka area, East Indies, North Australa, Philippines, South Pacific Islands Hawaiian Islands (Distribution Table); Mukhopadhyay & Samanta, 1983, p. 311: Lakshadweep; James, 1986, p. 585: Lakshadweep & Maldive area, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Chetlat, one specimen; Minicoy, two specimen; all collected under coral stones.

Remarks : This is a rare species in Lakshadweep. It is a reported for the first time from Lakshadweep by James (1969) James (1986) also reported for the first time from Andaman and Nicobar area. In fact this is the first record to the whole of Bay of Bengal.

Holothuria (*Mertensiothuria*) *leucospilota* (Brandt, 1851)

Stichopus (*Gymnochirota leucospilota* Brandt, 1835, p. 51: South Pacific Islands.

Holothutia vagubunda Koehler & Faney, 1908, p. 17: Andaman Islands, Gulf of Persia, Great Cocas Island, Lakshadweep.

Holothuria leucospilota A M. Clark & Davies, 1966, p. 603: Maldives; James, 1969, p. 62; Gulf of Mannar, Arabian Sea, Andamans, Lakshadpeep, Red Sea.

Holothuria (*Mertensiothuria*) *leucospilota* Rowe, 1969, p. 148; A. M. Clark & Rowe, 1971, pp. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa, & Madagascar, Red Sea, S. E. Arabia, Persian Gulf, Western India & Pakistan, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); James, 1986, p. 585: Lakshadweep & Maldives, Gulf of Mannar & Palk Bay along S. E. coast of India, Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Chetlat, several specimen; Kiltan, several specimens; Kadamat, four specimens; Amini, several specimens; Androth, two specimens; Kavaratti, three specimens; Minicoy, five specimens, all collected in the lagoon.

Remarks : This species has a peculiar habit of tucking its posterior end under a big rock. The anterior end keeps on moving with ventrally directed tentacles. In some places as many as 5 or 6 were found to be distributed per square metre.

Subgenus *Lessonouthuria* Deichmann, 1958

Only one species is known under this subgenus from the Lakshadweep.

Holothuria (*Lessonothuria*) *pardalis* Selenka, 1867

Holothuria pardalis Selenka, 1867, p. 336: Sandwich Islands, Zanzibar. A. M. Clark, Davies, 1966, p. 600: Maldives; James, 1969, p. Gulf of Mannar, Andamans, Lakshadweep, Gulf of Kutch: Nagabhushanam & Rao 1972, p. 291: Minicoy Atoll.

Holothuria (*Lessonothuria*) *pardalis* Rowe, 1969, p. 150; A. M. Clark & Rowe, 1971, p. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, S. E. Arabia; Western India & Pakistan, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands; Mukhopadhyay & Samanta, 1983, p. 311: Lakshadweep

Material : Chetlat, three specimens; Bitra, two specimens; Kiltan, four specimen; Minicoy, two specimens, all collected under coral stones.

Remarks : It is one of the most common holothurians of the Lakshadweep. It is not an active holothurian but the tentacles are well extended during movements. It is a burrowing form.

Subgenus *Cystipus* Haacke, 1880

Only one species is collected under this genus from the Lakshadweep.

Holothuria (*Cystipus*) *rigida* (Selenka)

Stichopus rigidus Selenka (Partime) 1867, p. 317: Zanzibar, Hawaii.

Holothuria rigida Semper, 1868, p. 79: Philippines.

Holothuria (*Cystipus*) *rigida* Rowe, 1969, p. 155; A. M. Clark & Rowe, 1971, p. 176: Mascarene Islands, East Africa and Madagascar, Red Sea, Maldive area, East Indies, North Australia, Philippines, South Pacific Islands (Distribution Table); James, 1986, p. 585: Lakshadweep & Maldive area, Andaman and Nicobar area.

Material : Kiltan, two specimens, found buried under sand.

Remarks : This is a rare species in Lakshadweep. It is a fussorial form. In small specimens sand sticks to the body as a coating. It is an inactive holothurian showing very little movement. It is recorded here for the first time from the Lakshadweep.

Subgenus *Microthele* Brandt, 1835

Only one species is collected under this subgenus from the Lakshadweep.

Holothuria (*Microthele*) *nobilis* (Selenka) (Fig. 26)

Mulleria nobilis Selenka, 1867, p. 313: Zanzibar, Sandwich Islands.

Fig. 26 *Holothuria (Microthele) nobilis*

Microthele nobilis A. M. Clark & Davies, 1966, p. 600: Maldives: James; 1969, p. 61: Lakshadweep, Red Sea; Nagabhusahnam & Rao, 1972, p, 291 : Minicoy Atoll.

Holothuria (Microthele) nobilis Rowe, 1969, p. 162; A. M. Clark & Rowe, 1971, p. 178: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, Maldive area, Sri Lanka area, East Indies, North Australia, Philippines China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table) Mukhopadhyay & Samanta, 1983, p. 311: Lakshadweep; James, 1986, p. 585: Lakshadweep & Maldive area, Sri Lanka, Andaman and Nicobar Islands (Distribution Table)

Material : Chetlat, several specimens; Kiltan, several specimens; Kadamat, three specimens; Amini, several specimens; Kavaratti, two specimens, all specimens collected from the lagoon, depth less than a metre.

Remarks: This is the most valuable holothurian for *beche-de-mer*. It was found common at Amini and Chetlat. There is very good scope to exploit this species in Lakshadweep.

Genus *Actinopyga* Bronn, 1861

Three species are collected from the Lakshadweep.

Key to the species of the Genus

1. Tentacles 25 or more; colour chocolate brown above and lighter below..... *A. mauritiana* (Quoy & Gainard, 1833)

1'. Tentacles 20 or fewer; colour either brown or black..... 2

2. Large rods, often branched at the ends, sometimes with lateral branches; colour uniformly brown throuhout..... *A. echnites* (Jaeger, 1833)

2'. Large rods absent; rosettes small often incomplete; black or dark brown..... *A. miliaris* (Quoy & Gaimard, 1833)

Actinopyga mauritiana (Quoy & Gaimard, 1833)

Holothuria mauritiana Quoy & Gaimard, 1833, p. 138: Mauritius.

Actinopyga mauritiana Koehler & Vaney, 1908, p. 22: Galle, Lakshdweep, Coco Island, Andaman Island; A. M. Clark & Davies, 1966, p. 603: Maldives; James, 1969, 61: Andamans, Nicobar, Lakshadweep, Red Sea; A. M. Clark & Rowe, 1971, p. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Red Sea, Western India and Pakistan, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, (Distribution Table); Nagahushanam & Rao, 1972, p. 290: Minicoy Atoll; Mukhopadhyay & Samanta, 1983, pp. 300, 311: Lakshadweep; James, p. 585: Lakshadweep & Maldive area, Sri Lanka, Andaman Nicobar Islands (Distribution Table).

Material : Chetlat, several specimens; Kiltan, several specimens; Kadamat, four specimens; Amini, several specimens; Agatti, two specimens; Androth, two specimens; Kavaratti, three specimens; Kalpeni, one specimen; Minicoy three specimens, all specimens collected on the reef flat near the low water mark.

Remarks : This is one of the most common holothurians in the Lakshadweep. This species can be used for *beche-de-mer* preparation. Often on lifting the specimen small pieces of corals, and such other objects are found attached to the ventral side.

Actinopyga echinites (Jaegery, 1833)

Mullerie echinites Jaeger, 1833, p. 17: East Indies.

Actinopyga echinites Pearson, 1914, p. 183: Indian Ocean; Rowe, 1969, p. 131; A. M. Clark & Rowe, 1971, p. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, S. E. Arabia, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan; South Pacific Islands (Distribution Table); James, 1986, p. 585: Sri Lanka, Andaman & Nicobar Islands (Distribution Table).

Material : Amini, two specimens, under coral stones.

Remarks : This species grows to a large size and is used in the preparation of *beche-de-mer*. It is very rare and is recorded for the first time from the Lakshadweep. It is also not known from the Maldives.

Actinopyga miliaris (Quoy & Gaimard, 1833)

Holothuria miliaris Quoy and Gaimard, 1833, p. 137: East Indies.

Actinopyga miliaris James, 1969, p. 61: Lakshadweep; Rowe, 1969, p. 131; A. M. Clark & Rowe, 1971, p. 176: Islands of Western Indian Ocean, Mascarene Islands, East Africa & Madagascar, Red Sea, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China and Southern Japan, South Pacific Islands (Distribution Table); Nagabhusahnam & Rao, 1972, p. 290: Minicoy Atoll; Mukhopadhyay and Samanta, 1983, p. 311: Lakshadweep.

Material : Minicoy, two specimens, collected under coral stones.

Remarks : This a rare holothurian in Lakshadweep. Good quality *beche-de-mer* can be prepared from this species. It was recorded for the first time from Lakshadweep by James (1969).

Genus *Bohadschia* Jaeger, 1833

Two species are collected under this genus from the Lakshadweep during the survey. One of them is recorded here for the first time.

Key to the species of the genus

Colour in life pale or yellow brown above and white below.....*Bohadschia marmorata* (Jaeger, 1833)

Colour brown or purplish brown with eye-like spots all over the body.....*Bohadschia argus* Jaeger, 1833

Bohadschia marmorata Jaeger, 1833 (Fig. 27)

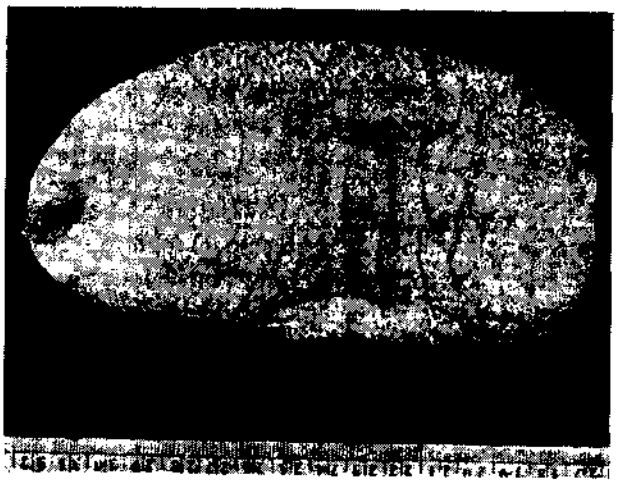

Fig. 27 *Bohadschia marmorata*

Bohadschia marmorata Jaeger, 1833, p. 18: East Indies; A. M. Clark & Rowe, 1971, p. 176: Mascarene Islands, East Africa & Madagascar; Red Sea, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table); Nagabhushanam and Rao, 1983, p. 301: Lakshadweep. James; 1986 p. 585: Lakshadweep and Maldive area, Gulf of Mannar and Palk Bay on the Indian side, Sri Lanka, Andaman and Nicobar Islands (Distribution Table).

Holothuria marmorata James, 1969, p. 62: Andamans, Lakshadweep; Nagabhushanam & Rao, 1972, p. 290: Minicoy Atoll.

Material : Chetlat, several specimens; Bitra, two specimens; Kiltan, several specimes; Kalpeni, two specimens, all specimens collected from lagoon, depth less than a metre.

Remarks : This species recorded for the first time from the Lakshadweep by James (1969).

Bohadschia argus Jaeger, 1833

Bohadschia argus Jaeger, 1833, p. 19: East Indies; Rowe, 1969, p. 130; A. M. Clark

and Rowe, 1971, p. 176: Islands of Western Indian Ocean, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands (Distribution Table); James, 1986, p. 58: Sri Lanka, Andaman and Nicobar Islands (Distribution Table).

Material: Chetlat, several specimens; Kiltan, several specimens; Kadamat, two specimens; Amini, several specimens; Agatti, two specimens; Kavaratti, three specimens; all specimens collected from the lagoon,depth less than one metre.

Remarks: Though this is a very common species surprisingly it has not so far been reported from the Lakshadweep. It is reported here for the first time from the Lakshadweep. It is also not reported from the Maldives so far.

Family STICHOPODIDAE

Under this Family two genera are collected from the Lakshadweep.

Key to the genera of the Family

Spicules in the form of tables, branched rods, S or C-shaped rods.....*Stichopus* Brandt, 1835

Spicules reduced, grains or dichotomously branched rods.....*Thelenota* Brandt, 1835

Genus *Stichopus* Brandt, 1835

Two species are collected from the Lakshadweep.

Key to the species of the genus

Colour dark green; C-shaped spicules not large ..... *S. chloronotus* Brandt, 1835

Colour yellowish-brown with small brown dots ..... *S. variegatus* Semper, 1868

Stichopus chloronotus Brandt, 1835

Stichopus chloronotus Brandt, 1835, p. 50: Japan; A. M. Clark & Davies 1966, p. 600: Maldives; James, 1969, p. 61: Lakshadweed, Nicobar; A. M. Clark & Rowe 1971, p. 178: Islands of the Western Indian Ocean, Mascarene Islands, East Africa and Madagascar, Maldive area, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Islands, Hawaiian Islands (Distribution Table); Nagabhushanam & Rao, 1983, p. 312: Lakshadweep. James, 1986, p. 586: Lakshadweep & Maldive area, Sri Lanka, Andaman and Nicobar Islands (Distribution Table).

Material: Chetlat, two Specimens, Kiltan, several specimens; Kadamat, one specimen; Amini, two specimens; Agatti, one specimen; Kavaratti, two specimens; Kalpeni two specimens, all specimens collected from lagoon, depth less than a metre.

Remarks : It is extremely abundant in the lagoon of Kiltan Island during January, 1987. It lies out in the open without making any attempt to conceal its body under corals.

Stichopus variegtuas Semper, 1868

Stichopus variegatus Semper, 1868, p. 73: Philippines; A. M. Clark & Rowe, 1971, p. 178: Mascarene Islands, East Africa and Madagascar, Red Sea, S. E. Arabia, Persian Gulf, Maldive area Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines; China & Southern Japan, South Pacific Islands (Distributbution Table); Nagabhushanam & Rao, 1983, p. 312: Lakshadweep; James, 1986, p. 586: Lakshadweep & Maldive area, Gulf of Mannar and Palk Bay on the Indian side, Sri Lanka, Andaman & Nicobar Islands (Distribution Table)

Material: Chetlat, two specimens; Kiltan, two specimens; Kadamat, one specimen collected under coral stones.

Genus *Thelenota* Brandt, 1835

This genus grows to a massive size of 600 mm. in length. One species is collected during the survey.

Thelenota ananas (Jaeger, 1833)
(Fig. 28)

Trepang ananas 1833, p 24: East Indies

Thelenota ananas A. M. Clark and Davies, 1966, p. 603: Maldives; James, 1969, p. 60: Lakshadweep; A. M. Clark and Rowe, 1971, p. 178: Maldives, East Indies, North Australia, China & Southern Japan, South Pacific Islands (Distribut-

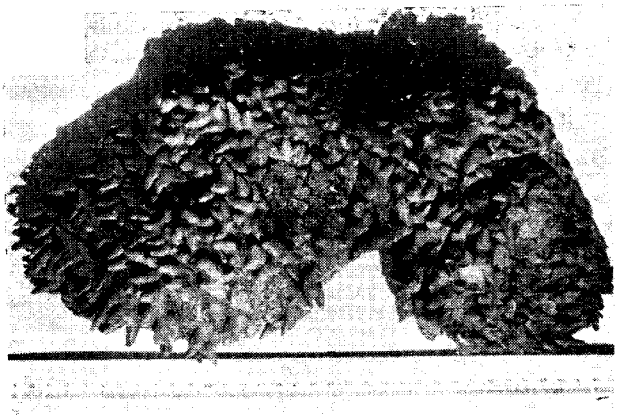

Fig. 28 *Thelenota ananas*

ion Table); Nagabhushanam & Rao, 1972, p. 291: Lakshadweep; Mukhopadyay & Samanta, 1983, pp. 309, 311; Lakshadweeep; James, 1986, p. 586: Lakshadweep & Maldive Islands (Distribution Table).

Material : Chetlat, three specimens; Kavaratti, one specimen; Minicoy, three specimens, all specimens collected from the lagoons, depth less than a metre.

Remarks: This is one of the quality holothurians for the preparation of *beche-de-mer*. It was recorded for the first time from the Lakshadweep by James (1969).

ORDER DENDROCHIROTIDA

Species belonging to one Family have been collected during the survey.

Family PHYLLOPHORIDAE

Two genera are collected under this Family from the Lakshadweep. One of them is a new record to the Lakshadweep.

Key to the genera of the Family

Radials with shorter posterior prolongations, interradial single piece Spicules: large perforated plates, perforations almost of completely obliterated; calcareous ring with rather short posterior bifurcate prolongations on the radial plates which are formed of several small pieces..... *Afrocucumis* Deichmann, 1944

Radials with longer posterior prolongations, interrdials with eight pieces; Spicules; tables with four pillared spire, which is low, usually terminating in a ring of short spines, perforated plates also present ... ...*Phyrella* Heading & panning, 1954.

Genus *Afrocucumis* Deichmann, 1944

Only one species is collected under this genus.

Afrocucumis africana (Semper, 1868)

Cucumaria africama Semper, 1863, p. 58: Philippines.

Afrocucumis africana James, 1969, p. 60 Andamans, Lakshadweep; A. M. Clark, 1971, p. 182: Islands of Western Indian Ocean, Mascarene Isladns, East Africa & Madagascar, Maldive area, Bay of Bengal, East Indies, North Australia, China & Southern Japan, South Pacific Islands (Distribution Table); Mukhopadyay & Samanta, 1983, p. 312: Lakshadweep; James, 1986, p. 586: Lakshweep and Maldive area, Andarnan and Nicobar Islands (Distribution Table).

Material : Chetlat, five specimens; Minicoy, six specimens, collected from the crevices of coral stones.

Genus *Phyrella* Heding & Panning, 1954

This genus is reported for the first time from the Lakshadweep. Only one species is collected from the Lakshadweep.

Phyrella fragilis (Oshima, 1912)

Phyllophorus fragilis Oshima, 1912, p. 81: Japan.

Phyrella fragilis A. M Clark & Rowe, 1971, p. 184 : East Indies, China & Southern Japan; James, 1983, pp. 37,38 : Port Blair (Andamans); James, 1986, p. 585 : Andaman & Nicobar Islands (Distribution Table)

Material : Chetlat, two specimens; Amini, one specimen; Agatti, one specimen; Androth, two specimens, all specimens buried in sand under coral stones.

Remarks : It is recorded here for the first time from the Lakshadweep. James (1983) listed it for the first time from Andamans. Due to its burrowing habits it is not reported from many places in the Indo-Pacific region.

ORDER : APODA

Three species belonging to one Family under this Order have been collected during the survey.

Family SYNAPTIDAE

Three genera are collected during the survey. One of them is a new record to the Lakshaweep.

Key to the Genera of the Family

1. Size very large, anchor plates subrectangular with numerous holes..... *Synapta* Eschscholtz, 1827

1'. Size not very large, anchor plates oval with seven large holes.....2

2. Calcareous ring with conspicuous anterior projections; anchor plates abruptly contracted posteriorly..... *Ophiodesma* Fisher, 1907

2'. Calcareous ring without noticeable anterior projections; anchor plates not abruptly contracted at posterior end, but with large smooth hole on either side ..... *Euapta* Ostergren, 1898

Genus *Synapta* Eschschol tz, 1829

Only one species is known under this genus from the Indian Seas. This has been collected from the Lakshadweep.

Synapta maculata (Chamisso & Eysenhardt,1821)
Holothuria maculata Chamisso & Esenhardt, 1821, p. 352 : South Pacific Islands.

Synapta maculata James, 1969, p. 62: Andamans, Lakshadweep; A.M. Clark & Davies 1966, p. 603: Maldives; A M. Clark & Rowe, 1971, p. 186 : Islands of Western Indian Ocean, Mascarene Island, East Africa & Madagascar, Red Sea, S. E. Arabia, Maldive, area, Sri Lanka area, Bay of enal, East Indies, North Australia, Philippines, China & Southern Japan, South Pacific Island (Distribution Table); Nagabhushanam & Rao, 1972, p. 291 : Minicoy Atoll; Mukhopadhyay & Samanta, 1983, pp. 310, 312: Lakshadweep; James, 1986, p. 587: Lakshadweep & Maldives area, Sri Lanka, Andaman & Nicobar Islnd (Distribution Table).

Material : Chetlat, several specimens; Kiltan, two specimens; Kadamat, two specimens; Amini, one specimen; Agatti, one specimen; Kalpeni, two specimens; Minicoy, several specimens.; all collected from the reef flat.

Remarks: This species is common in Lakshadweep. It shovels sand into the mouth with its relatively large pinnate tentacles. The tentacles are seen to be in active moment during feeding. It crawls along by holding on to solid objects by its anchors.

Genus *Ophiodesma* Fisher, 1907

Under this genus one species is recorded for the first time from the Lakshadweep.

Ophiodesma grisea (Sempsry, 1868)

Synapta grisea Semper, 1868, p. 11: Philippines.

Ophiodesma grisea A.M. Clark & Rowe, 1971, p. 186 : East Africa, & Madagascar, Red Sea, S.E. Arabia, Sri Lanka area, Bay of Bengal, East Indies, North Australia, Philippines, Hawaiian Islands (Distribution Table); James, 1985, p. 586: Sri Lanka, Andaman & Nicobar Island (Distribution Table).

Material: Kavaratti, one specimen, collected on the reef flat.

Remarks : It is recorded here for the first time from the Lakshadweep.

Genus *Euapta* Ostergren, 1898

Under this genus only one species is known from the Indian Seas. It was recorded for the first time from Lakshadweep by James (1969).

Euapta godeffroyi (Semper, 1868)

Synapta godeffroyi Semper, 1868, p. 231 : Nevigator Island.

Euapta godeffroyi A.M. Clark & Davies, 1966, p. 600 : Maldives; James, 1969, p. 62 : Lakshadweep; A.M. Clark & Rowe, 1971, p. 184 : Moscarene Isludy, East Africa & Madagascar, Red Sea, Maldives area, East Indies, North Australia, Philippines, South Pacific Islands, Hawaiian Islands (Distribution Table); Mukhopadhyay & Samanta, 1983, p. 312 : Lakshadweep; James, 1986, p. 587 : Lakshadweep & Maldive area (Distribution Table).

Material: Amini, one specimen; Kalpeni, one specimen; Minicoy, one specimen.

Remarks: This is a rare species in the Lakshadweep. It was recorded for the first time from the Lakshadweep by James (1969).

All the echinoderms collected during the survey from the various Islands are listed in Table I.

ZOOGEOGRAPHY

A study of the zoogeography of echinoderms is interesting for the reasons that their movements are limited, their bathymetrical range is narrow, their larval life is brief and that they are entirely marine in habit. The composition and origin of the Australian echinoderms has been dealt with at length by H.L. Clark (1921, 1946). A.M. Clark (1976, 1980, 1984) wrote on the zoogeography of echinoderms of the coral reefs and echinoderms from Hong Kong and the Seychelles respectively. Although echinoderms are known to have a wide range of distribution out of a total of 1029 shallow-water echinoderms considered by A.M. Clark and Rowe (1971) from the Indo-West Pacific region only 57 (5.5%) extend their range of distribution from the Islands of the Western Indian Ocean to the Hawaiian Islands. Only eight species are known throughout the tropic in Atlantic and Pacific Oceans. Recently James (1986) wrote a paper on the zoogeography of shallow-water echinoderms of the Indian Seas. He has clearly shown that the faunal composition of echinoderms of Sri Lanka and India along the Gulf of Mannar and Palk Bay are somewhat different and he has given reasons for this difference in distribution. He has also recorded fifty species for the first time from the South East Coast of India,Lakshadweep and the Andaman and Nicobar Islands.

In this paper a total of 255 species of echinoderms known from the shallow-waters upto a depth of 20 metres from the Lakshadweep-Maldive area (129 species), Sri Lanka (178 species) and the Andaman and Nicobar Islands (111 species) are considered for discussion here. Seventy eight species are collected from the various Islands of the Lakshadweep (Table 1.) Of these 30 species are recorded for the first time from the Lakshadweep. Of the 78 species collected from the Lakshadweep 38 species are collected only from the Lakshadweep. Some species like *Mithrodia clavigera*, *Cistina columbiae* and *Ophiocoma anaglyptica* are cavernicolous and are likely to be taken at other places in the Indian region when intensive collections are made. *Linckia multifora*, *Dactylosaster cylindricus*, *Ophiocoma dentata*, *Bohadschia argus*, *Holothuria Mertensiothuria*) *leucospilota* and *Stichopus chloronotus* are very common in the Lakshadweep. It is surprising that the large starfish *Asteropsis carinifera* which was common at Kiltan and Chetlat is so far not recorded from the Lakshadweep and even from the Maldives. *Linckia multifora* and *D. cylindricus* which are common at Lakshadweep are not distributed in the Andaman and Nicobar Islands. Of the 255 species only 49 species are common to the three regions showing that only 19.2% of the species are distributed in the three widely separated regions of Lakshadweep-Maldive area, Sri Lanka and Andaman and Nicobar Islands. Sixty seven species are collected from Sri Lanka alone. This maximum number partly reflects due to the intensive collections made at Sri Lanka since 1882, and also due to the 'area effect' refered by Price (1982). Sri Lankan coast is far more extensive that the coast line of small Islands in the Lakshadweep and the Andaman and Nicobar Islands. Therefore a corresponding increase in species diversity is apparent. As many as 15 publications are available on the echinoderms of Sri Lanka. Twenty five species are reported only from the Andaman and Nicobar Islands. James (1986) listed 111 species of which 27 species are new records to the Andaman and Nicobar Islands. Comparison of the species distributed in different regions show interesting relationships. There seem to be greater affinity between the echinoderms of Sri Lanka and Lakshadweep since 39 (15.2%) species are common to both the regions whereas only 21 (8.2%) species are common between Sri Lanka and Andaman and Nicobar Islands and only 16 (6.2%) species are common to the Lakshadweep to the Andaman and Nicobar Islands. James (1986) has stated that the echinoderms of Lakshadweep are oceanic and those of Andaman and Nicobar Islands are continental. Since both the Lakshadweep and Sri Lanka are Oceanic Islands there is greater similarity of fauna between them.

Echinoderms common to the Lakshadweep and Sri Lanka, Sri Lanka and Andaman and Nicobar Islands and Lakshadweep and Andaman and Nicobar Islands are listed in Table 2. Echinoderms reported from Sri Lanka alone and echinoderms common to Lakshadweep, Sri Lanka and Nicobar Islands are given in Table 3. Echinoderms reported from the Lakshadweep and Andaman and Nicobar Islands alone are presented in Table 4. Finally the number of echinoderms with their percentage from various regions and their combinations are given in Table 5.

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TABLE 1. *List of Echinoderms Collected from the Lakshadweep*
(NR: New Record; C; Common; R: Rare; New genus & species T: test only)

	Chetlat	Bitra	Kiltan	Kadmat	Amini	Agatti	Androth	Kavaratti	Kalpeni	Minicoy	Remarks
ASTEROIDAE											
OREASTERIDEA											
Culcita novaeguineae	+	—	+	+	—	+	—	+	—	+	NR
C. schemideliana	—	—	—	+	+	—	—	+	—	—	
Halityle regularis	—	—	+	—	—	—	—	—	—	—	NR
Pentaceraster regulus	—	+	—	—	—	—	—	—	—	—	NR
OPHIDIASTERIDAE											
Linckia laevigata	—	+	—	—	+	+	—	+	—	+	C
L. guildingi	+	—	—	—	+	+	—	—	—	—	R
L. multifora	+	+	+	+	+	+	—	+	+	+	C
Dactylosaster cylindricus	+	—	+	+	+	—	—	+	—	+	C
Leiaster leachi	—	+	—	—	—	—	—	—	—	+	NR
Paraferdina laccadivensis	—	—	—	—	—	—	—	—	—	+	N. gen. et. sp.
Fromia indica	—	—	—	—	—	—	—	+	—	—	R
F. milleporella	—	+	—	—	—	—	—	—	—	—	R
ASTEROPIDAE											
Asteropsis carinifera	+	—	+	—	—	—	—	—	—	—	NR
ASTERINIDAE											
Asterina burtoni	—	—	—	—	+	—	—	—	—	—	R
Patirella exigua	—	—	—	—	—	+	—	—	—	—	NR
Tegulaster ceylanica	—	—	—	—	—	+	—	+	—	—	NR
ACANTHASTERIDAE											
Acanthaster planci	—	—	—	+	—	+	—	+	+	+	R

Table 1 contd.

ECHINASTERIDAE											
Cistina columbiae	+	—	—	—	—	—	—	—	—	—	NR
OPHIUROIDEA											
OPHIOMYXIDAE											
Ophiomyxa australis	—	—	—	—	—	—	—	—	—	+	NR
AMPHIURIDAE											
Amphipholis squamata	+	—	—	—	—	—	—	—	—	—	NR
OPHIACTIDAE											
Ophiactis savignyi	—	—	—	—	—	—	—	—	—	+	
OPHIOTRICHIDAE											
Macrophiothrix longipeda	+	—	+	+	—	—	+	—	—	—	
Ophiothrix (Keystonea) nereidina	—	+	—	—	—	—	—	—	—	—	NR
OPHIOCOMIDAE											
Ophiocomella sexradia	+	+	+	—	—	—	—	—	—	—	NR
Ophiocoma scolopendrina	—	—	+	+	+	—	—	—	+	+	
O. dentata	+	—	+	+	+	—	—	—	—	+	C
O. brevipes	+	—	—	+	—	—	—	—	—	+	R
O. anaglyptica	+	—	—	—	—	—	—	—	—	—	NR
Ophiomastix annulosa	—	—	—	—	—	—	—	—	—	+	
Ophiocoma erinaceus	+	—	+	+	+	—	+	+	+	—	
O. pica	+	—	—	+	—	—	—	+	—	—	
OPHIURIDAE											
Ophioclegans cincta	—	—	—	—	—	—	+	—	—	—	NR
Ophiolepis superba	—	—	—	—	—	—	—	+	—	—	NR
ECHINOIDEA											
CIDARIDAE											
Eucidaris metularia	—	—	—	—	—	—	+	—	·	—	
Prionocidaris verticellata	+	—	+		—	—	—	—	—	—	
DIADEMATIDAE											
Diadema setosum	—	—	+	—	—	—	—	—	—	—	NR
D. savignyi	+	—	—	—	—	—	—	—	—	—	NR
Echinothrix calamaris	+	—	—	—	—	—	+	—	—	—	
E. diadema	+	—	—	+	+	—	—	+	+	+	
STOMOPNEUSTIDAE											
Stomopneustes variolaris	+	—	+	—	—	—	—	—	—	+	

Table 1 contd.

TEMNOPLEURIDAE											
Mespila globulus	—	—	—	—	—	—	—	+	—	—	NR
Salmacis virgulata	—	—	—	—	—	—	+	—	—	—	NR
TOXOPNEUSTIDAE											
Toxopneustes pileolus	—	—	—	+	—	—	+	—	—	—	NR
Tripneustes gratilla	+	—	+	+	+	—	—	—	+	—	
ECHINOMETRIDAE											
Echinometra mathaei	+	—	+	+	+	—	+	+	—	+	
Echinostrephus molaris	—	—	—	—	—	+	—	—	—	—	NR
Heterocentrotus mammillatus	—	—	—	—	—	+	—	+	—	—	
ECHINONEIDAE											
Echinoneus cyclostomus	+	—	—	—	—	—	—	—	—	—	T
CLYPEASTERIDAE											
Clypeaster reticulatus	+	—	—	+	—	—	—	—	—	—	T
ECHINOLAMPADIDAE											
Echinolampas alexandri	—	—	+	—	—	—	—	—	—	—	NR
E. ovata	+	—	—	+	+	—	+	—	—	—	NR
BRISSIDAE											
Brissus latecarinatus	—	—	—	—	—	+	—	—	—	—	T
HOLOTHURIOIDEA											
HOLOTHURIIDAE											
Actinopyga mauritiana	+	—	+	+	+	+	+	+	+	+	C
A. echinites	—	—	—	—	+	—	—	—	—	—	R
A. miliaris	—	—	—	—	—	—	—	—	—	+	R
Bohadschia argus	+	—	+	+	+	+	—	+	—	—	C
B. marmorata	+	+	+	—	—	—	—	—	+	—	
Labidodemas rugosum	+	—	—	+	—	—	—	—	—	—	R
Holothuria (Cysuipus) rigida	—	—	+	—	—	—	—	—	—	—	NR
H. (Halodeima) atra	+	—	+	+	+	+	—	+	—	—	C
H. (Lessonothuria) pardalis	+	+	+	+	—	+	—	—	—	+	C
H. (Mertensiothuria) leuscospilota	+	—	+	+	+	—	+	—	—	+	C
H. (M.) pervicax	+	—	—	—	—	—	—	—	—	+	R
H. (Microthele) nobilis	+	—	+	+	+	+	—	+	—	—	C
H. (Playperona) difficilis	+	—	+	—	+	—	—	—	—	+	C
H. (Semperothuria) cinerascens	+	+	+	+	+	—	—	+	—	+	

Table 1 contd.

H. (Thymiosycia) arenicola	+	—	—	+	+	—	—	—	—	—	C
H. (T) hilla	+	+	+	+	+	—	—	—	—	+	C
H. (T.) impatiens	+	—	+	+	+	+	—	—	—	+	C
STICHOPODIDAE											
Stichopus chloronhtus	+	—	+	+	+	+	—	+	+	—	C
S. variegatus	+	—	+	+	+	—	—	—	—	—	
Thelenota ananas	+	—	—	—	—	—	—	—	—	+	R
PHYLLOPHORIDAE											
Afrocucumis africana	+	—	—	—	—	—	—	—	—	+	R
phyrella fragilii	+	—	—	—	+	+	+	—	—	—	NR
SYNAPTIDAE											
Euapta godeffroyi	—	—	—	—	+	—	—	—	+	+	R
Ophioesma grisea	—	—	—	—	—	—	—	+	—	—	NR
Synapta maculata	+	—	+	+	+	+	—	—	+	+	C
Total number of species	44	12	30	31	30	25	5	20	7	29	

TABLE 2 *Distribution of Echinoderms in Lakhsadweep, Sri Lanka and Andaman and Nicobar Islands*

Echinoderms common to Lakshadweep & Sri Lanka	Echinoderms common to Sri Lanka and Andaman and Nicobar Islands	Echinoderms common to Lakshadweep and Andaman and Nicobar Islands
Capillaster multiradiatus	*Luidia savignyi*	*Comoster gracilis*
Comanthina schlegeli	*Astropecten zebra*	*Astropecten monaeanthus*
Heterometra reynaudi	*Protoreaster nodosus*	*Culcita novaeguineae*
Comatella maculta	*Protoreaster lincki*	*Archaster typicus*
Lamprometra palmata	*Nardoa lemonnieri*	*Ophiocoma brevipes*
Stephanometra indica	*Metrodira subulata*	*Ophiocoma dentata*
Decametra taprobanes	*Asterina sarasini*	*Ophionereis porrecta*
Oligometra serripinna	*Euretaster bribrosus*	*Prionocidaris verticellatus*
Astropectenindicus	*Echinaster purpureus*	*Echinothrix calamaris*
Siraster tuberculatus	*Ophiomaza cacaotica*	*Afrocueumis africana*
Dactylosaster cylindricus	*Ophiopteoon elegans*	*Labidodemas rugosum*
Fromia milleporella	*Ophiaracnella gorgonia*	*Patinapta oopeax*
Leiaster leachi	*Ophioplocus imbricatus*	*Holothuria (Cystipus) rigida*
Linckia multifora	*Colobocentrus atratus*	*Holothuria (Metriatyla) albiventer*
Asteropsis carinifera	*Actinopyga lacanora*	*Phyrella fragilis*
Astroboa clavata	*Polycheira rufescens*	*Holothuria (Thymiosycia) arenicola*
Gymnolophus obscura	*Bohadschia argus*	

Table 2 contd.

Macrophiothrix langipeda	*Bohadschia vitiensis*
Ophiothrix purpurea	*Holothuria (Selenkothuria) erinaceus*
Ophiocoma pica	*Holothuria (Metriatyla) scabra*
Ophionereis dubia	*Acaudina molpadioides*
Ophiaracnella septemspinosa	
Asthenosoma varium	
Salmacis bicolor	
Salmacis virgulata	
Temnopleurus toreumaticus	
Temnotrema siamense	
Clypeaster rarispinus	
Clypeaster reticulatus	
Echinolampas alexandri	
Echinolampas ovata	
Martie planulata	
Pseudomaretia alta	
Lovenia elongata	
Actinopyga serratidens	
Bahadschia tenuissima	
Holothuria (Platyperona) difficilis	
Holothuria (Semperothuria) cinerascens	
Leptopentacta javanicas	

TABLE 3

Distribution of echinoderms in Lakshadweep, Sri Lanka and Andaman and Nicobar Islands

Echinoderms reported from Sri Lanka alone	Echinoderms reported from Lakshadweep, Sri Lanka and Andaman and Nicobar Islands
Comaster parvicirrus	*Luidia maculata*
Comanthus samoanus	*Astropecten polyacanthus*
Comatella stilligera	*Culcita schmideliana*
Amphimetra molleri	*Fromia indica*
Heterometra amboinae	*Linckia guildingi*
Himerometra robustipinna	*Linckia laevigata*
Stemphanometra spicata	*Asterina burtoni*
Cenometra herdmani	*Patiriella pseudoexigua*
Troptometra carinata	*Tegulaster ceylanica*
Luidia hardwicki	*Acanthaster planci*
Luidia hardmani	*Ophiomyxa autralia*
Astropecten andersoni	*Amphipholis squamata*
Astropecten bengalensis	*Ophiactis savignyi*
Astropecten eurycanthus	*Ophiocoma erinaceus*

Table 3 contd.

Astropecten hemprichi
Astropecten sarasini
Anthenea pentagonula
Goniodiscaster scaber
Goniodiscaster vallei
Stellaster equestris
Pentaceraster affinis
Poraster superbus
Gomophia aegyptica
Disasterina spinosa
Amphiura (Fellaria) octacantha
Amphiura (Amphiura) lutkeni
Amphiodia microplax
Macrophiothrix variablis
Ophiocnemis marmorata
Ophiothrix exigua
Ophiothrix (Keystonea) nereidina
Ophiaracna incrassata
Phyllacanthus imperialis
Prionocidaris baculosa
Microcyphus ceylanicus
Salmaciella dussumieri
Clypeaster fervens
Pseudoboletia maculata
Gymnechinus robillardi
Clypeaster humilis
Fibularia volva
Peronella oblonga
Echinodiscus auritus
Echinodiscus bisperforatus
Metalia latissima
Rhynobrissus pyramidalis
Holothuria (Selenkothuria) moebi
Holothuria (Semperothuria) imitans
Holothuria (Theelothuria) kurti
Holothuria (Theelothuria) spinifera
Stichopus naso
Havelockia versicolor
Polycheira stulhmanni
Pentacta armatus
Pentacta quadrangularis
Pseudocolochirus violaceus
Labidoplax dubia
Staurothyone rosacea
Synaptula striata
Stolus buccalis
Stolus conjugens
Ophiocoma scolopendrina
Ophiocomella sexradia
Ophiomastix annulosa
Ophioelegans cincta
Ophiolepis superba
Ophiura kinbergi
Eucidaris metularia
Prionocidarais baculosa
Astropyga radiata
Diadema savignyi
Diadema setosum
Echinothrix diadema
Stomopneustes variolaris
Toxopneustes pileolus
Tripneustes gratilla
Echinometra mathaei
Echinostrephus molaris
Echinoneus cyclostomus
Laganum depressum
Actinopyga echinites
Actidopyga mauritiana
Actinopyga miliaris
Bohadschia marmorata
Holothuria (Lessonothuria) pardalis
Holothuria (Halodeima) edulis
Holothuria (Holodeima) atra
Holothuria (Mertensiathuria) leucospilo
Holothuria (Microteele) nobilis
Holothuria (Thymiosycia) hilla
Holothuria (Thymiosycia) impatiens
Stichopus chloronotus
Stichopus variegatus
Ophiodesma grisea
Synapta maculata

Table 3 contd.

Thyone papuensis
Trachythyone imbricata
Trachythyone typica
Ohshimella ehrenbergi
Phyllophorus (Phyllothuria) cbuenis
Phyllopeorus (Urodemelta) brocki

Table 4 Distribution of Echinoderms in Lakshadweep, Sri Lanka and Andaman and Nicobar Islands

Echinoderms reported from Lakshadweep alone	Echinoderms reported from Andaman and Nicobar Islands alone
Heterometra flora	*Ceratonardoa carinata*
Heterometra sol	*Fromia armata*
Decametra mollis	*Nareoa frianti*
Dorometra mauritiana	*Neoferdina offerti*
Archaster loriolis	*Tamaria dubiosa*
Halityle regularis	*Chaetaster vestitus*
Formia nodosa	*Ophiocentrus verticillatus*
Paraferdina laccadivensis	*Amphioplus (Amphioplus) intermedius*
Mithrodia clavigera	*Amphioplus (Lymanella) andrae*
Cistina columbiae	*Ophiactis modesta*
Ophiocentrus dilatatus	*Macrophiothrix speciosa*
Ophiopteron elegans	*Ophiarthrum pictum*
Ophiothela danae	*Ophiaranella infernalis*
Ophiothix foveolata	*Ophiolepis nodosa*
Ophiothrix trilineata	*Archnoides placenta*
Ophiothrix (Keystocea) propinqua	*Breynia vredenburgi*
Ophiocoma anaglyptica	*Moira stygia*
Ophiomastix variablis	*Metalia sternalis*
Ophiopeza spinosa	*Holothuri (Acanthotrapeza) pyxis*
Chaetodiadema granulatum	*Holotnuria (Mertensiothuria) fuscocinerea*
Parasalenia gratiosa	*Trachytnyone alcocki*
Mespila globulus	*Protankyra pseudodigitata*
Parasalenia poehli	
Heterocentrotus mammillatus	
Echinocsamus crispus	
Fibularia ovulum	
Peronella lesueuri	
Echinolampas alexandri	
Brissus latecarinatus	
Bohadschia graeffei	
Labtdodemas semperianum	
Holothuria (Metriatyla) martensi	
Holothuria (Stauropora) discrepans	
Holothuria (Thymiosycia) aphanes	
Thelenota ananas	
Euapta godeffroyi	
Syanptula recta	

TABLE 5. *Number of echinoderms known from various regions of India*

	Lakshadweep, Sri Lanka Andaman & Nicobar	Lakshadweep only	Sri Lanka only	Andaman & Nicobar only	Lakshadweep & Sri Lanka	Sri Lanka & Andaman Nicobar	Laksha-dweep & Andaman & Nicobar
Crinodis	—	4	9	—	8	—	1
Asteroids	10	6	15	6	7	9	3
Ophiuroids	10	10	8	9	7	4	3
Echinoids	13	10	14	4	12	1	2
Holothuroids	11	8	21	6	5	7	7
Total	49 (19.6%)	38 (14.9%)	67 (26.2%)	25 (9.8%)	39 (15.2%)	21 (8.2%)	16 (6.2%)

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12. BECHE-DE-MER RESOURCES OF LAKSHADWEEP

D. B. James

Information on the *beche-de-mer* resources of Lakshadweep is limited. Earlier no suveys were conducted to estimate the resources of holothurians used in the preparation of *beche-de-mer*. In fact very little information is available even on the holothurians of the Lakshadweep Koehler and Vaney (1905, 1908, 1910) reported 18 species from deep sea, eight species from shallow-water and one species from deep sea around the Lakshadweep. Of the eight shallow-water species reported only *Actinopyga mauritiana* is of commercial importance. James (1969) catalogued 15 species of holothurians from the Lakshadweep of which only four species *viz.*, *Thelenota ananas*, *Holothuria* (*Microthele*) *nobilis*, *Actinopyga miliaris* and *A. mauritiana* are used for *beche-de-mer* preparation. James (1973, 1986) pointed out that the Lakshadweep is very important for the exploitation of holothurians for *beche-de-mer*. Daniel and Haldar (1974) listed 23 species of holothurians from the Lakshadweep including deep sea forms. Mukhopadhyay and Samanta (1983) reported 12 species of holothurians from the Islands of Androth, Kalpeni and Minicoy. Of these, three species *viz.*, *Actinopyga mauritiana*, *Bohadschia marmorata* and *Thelenota ananas* are used in the preparation of *beche-de-mer* Recently James (1983) stated that detailed survey needs to be conducted in the Lakshadweep especially for the commercially important species of holothurians.

RESOURCES

So far there is no quantitative estimation of the resources of the holothurians from the Lakshadweep. The holothurians chiefly live in the lagoon and some species live only on coral reefs. According to Mannadiar (1977) the lagoon area in the Lakshadweep is about 420

sq. km. Species of holothurians like *Holothuria (Microthele) nobilis, Bohadschia argus, B. marmorata* and *Thelenota ananas* occur in the lagoon. Other species of holothurians like *Actinopyga mauritiana, A. miliaris* and *A. echinites* are found to live on the reefs. In the case of the species found in the lagoons actual numbers are counted in unit areas and later raised to the total area of the lagoon of each Island. When holothurians are distributed all over the lagoon from the shore to the reef their numbers are enumerated at different transects and then the total number is estimated for the whole lagoon. For species living on the reefs number of species are counted in unit areas and then raised to the whole area of the reef.

Although 35 species of holothurians are known from Maldive and Lakshadweep area, during the present survey only 25 species of holothurians are collected. Of these only seven species *viz. Holothuria (Microthele) nobilis, Thelenota ananas, Actinopyga miliaris, A. echinites, Bohadschia argus* and *B. marmorata* are used in the preparation of *beche-de-mer.* Of the seven only four species *viz., Holothuria (Microthele) nobilis, Actinopyga mauritiana, Bohadschia argus* and *B. marmorata* occur in appreciable quantities in some of the Islands which lend themselves for commercial exploitation.

Bohadschia argus (Fig. 1) is the most abundant species in the Lakshadweep. This is popularly known as Tiger or Leopard fish. Its size ranges from 300-500 mm and width ranges from 100-120 mm, with body wall 6-12 mm in thickness. Live weight of the animal varies

Fig. 1 *Bohadschia argus*

from 1-2 kg. It is common on coral sand and at depths from 2-6m. Body is cylindrical with very smooth surface. Cuvierian tubules are extruded through the body in large quantities. Colour is black with distinctive eye-like spots all over the surface which are conspicuously encircled with light colour. Because of the abundant supply of Cuvierian tubules it is not considered to have high value for *beche-de-mer* since handling of the live specimen is difficult in the field. In Kilakarai on the mainland when they collect *Bohadschia marmorata* which is also having abundant supply of Cuvierian tubules, they make a slit in the field itself and throw out the Cuvierian tubules and viscera in the sea and bring only the body wall of the animal. The same method can be adopted for this species in Lakshadweep. It a very common species and is collected during the survey from Chetlat, Kiltan, Kadmat, Amini, Agatti and Kavaratti. It should be available in other Islands also. The resource is maximum at Kadmat and it is estimated at 1177 tonnes. At Kiltan 368 tonnes and at Chetlat 160 tonnes were estimated. At Amini the resource was poor and the estimate came to only 11.9 tonnes.

Holothuria (Microthele) nobilis (Fig. 2) is by far the best holothurian suited for *beche-de-mer* preparation. This species is popularly known as Test fish or Mammy fish. It commands highest price in the *beche-de-mer* market. This species occurs in two colour forms, the white and black. The white form is said to be more valuable. The white form is usually found in

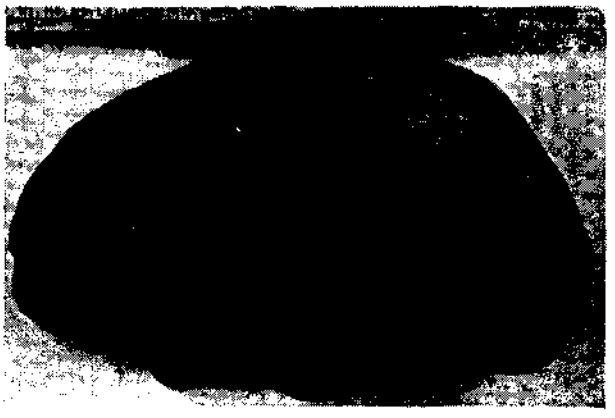

Fig. 2 *Holothuria (Microthele) nobilis*

more than 3 m depth of water. It occurs upto a depth of 30 m. It is most abundant on clean sand among the reefs. Young white forms live among algae. The black form is found in shallow waters from the reef to about a depth of 3 m. During the present survey the specimens were collected only from the shallow waters and therefore only black forms alone were encountered.

It growes to a length of 300-400 mm and the width varies from 100-150 mm, with body wall 10-12 mm in thickness In the living condition the body is like a loaf. The most distinguishing external feature is the presence of six to eight lateral teat-like projections which are evident only when seen under water in the living condition. Live weight varies from 2-3 kg. Colour in the live condition is dark brown or black on the top and white beneath or yellowish white mottled with black or brown on white background. During the survey this species has been collected from Chetlat, Kiltan, Kadmat, Amini, Agatti and Kavaratti. Based on the survey 1882 tonnes were estimated at Kavaratti, 209 tonnes at Chetlat, 172 tonnes at Kiltan and at Amini. 165 tonnes

Next in abundance is *Bohadschia marmorata* (Fig. 3.) It is popularly known as brown sand fish. It grows to a length of 400 mm. The body wall is 10-15 mm in thickness. Body is cylindrical in shape with tubefeet distributed all over the body with the ventral side slightly flattened.

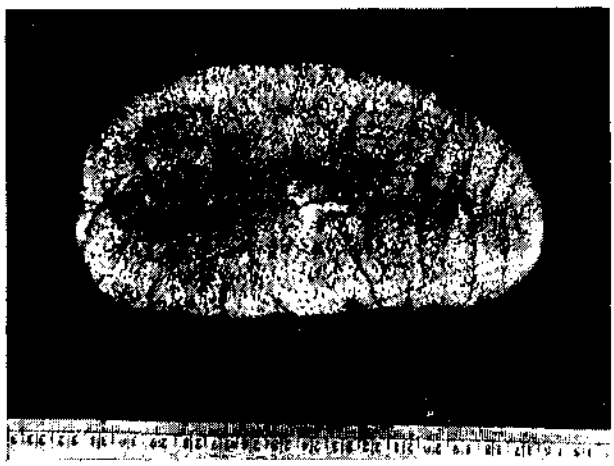

Fig. 3 *Bohadschia marmorata*

It lies freely on the surface of sand in the lagoon. A coating of sand is found on the body. Copious Cuvierian tubues are extruded from the body when the animal is distributed. Therefore the method adopted for *B. argus* should be adopted for handling the animal during processing. Colour is golden brown with small brown dots. It is found on coarse sand and commonly occurs in depths of 2-6 m. During January, '87 it was found to be common at Kiltan in the lagoon. In Kiltan 103 tonnes and at Chetlat 33 tonnes estimated.

Actinopyga mauritiana (Fig. 4) is a valuable species for *beche-de-mer*. It is popularly known as surf red fish. It grows to a length of 400 mm and width is 80-100 mm. Weight in live condition varies from 0.5 to 1 kg. The shape of the body is almost cylindrical with the ventral side flat with three rows of tubefeet. Body wall is 6 mm in thickness. Colour in the live condition is brick red on the dorsal side and white on the ventral side. In smaller forms the dorsal side has white patches on the sides. It

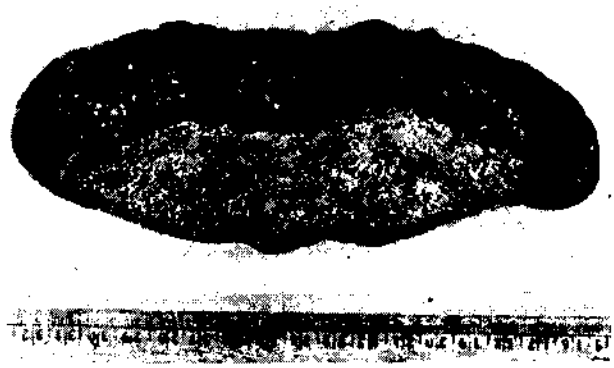

Fig. 4 *Actinopyga mauritiana*

is found to occur where the surf breaks on the outerside of the reef. The tubefeet are firmly attached to the rocks to prevent the animal being carried away by the waves. This species is never encountered in the lagoon and is found at the low water mark. It is one of the most common species in the Lakshadweep and is collected from all the Islands surveyed except at Bitra. At Cheltat it is estimated 201 tonnes and Kadmat 130 tonnes. In Kiltan 23 tonnes and at Amini 10 tonnes were estimated. Eploring beyond the outer reef for this species will be profitable.

Thelenota ananas(Fig. 5) is popularly known as prickly red fish. It is a very valuble species for *beche-de-mer*. It is a massive form and the length ranges from 400- to 700 mm The width

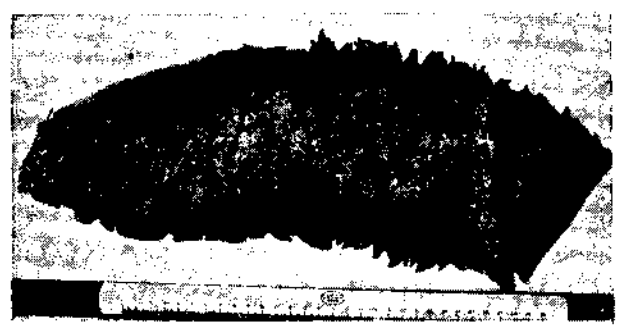

Fig. 5 *Thelenota ananas*

of this species varies from 150 to 200 mm. Live weight varies from 3 to 6 kg. Shape is very distinct and characterstic with numerous pointed teats in groups of two or three all over the body on the dorsal side. There are numerous large tubefeet on the flat ventral side. The colour reported is reddish orange on the dorsal side but at Chetlat the two specimens collected were brown in colour. The lengths of the two specimens collected were 550 and 600 mm and their weights were 2.5 and 2.7 kg respectively. It occurs in the lagoon and it is distributed at a depth of 2-30 m on clean bottoms often beside large coral heads. Formerly one of the most valuable species for *beche-de-mer* but there is only limited demand for it now. Due to high water content it shrinks more than other species during processing. During the present survey it is collected from Chetlat, Kavaratti and Minicoy Islands. It is not possible to give estimates for this species since it was collected only on a few occasions.

Actinopyga echinites (Fig. 6) is also another valuble species for *beche-de-mer.* It is popularly known as deep water red fish. Length ranges from 200-300 mm and width ranges from 80 to 100 mm. Body wall is about 10 mm in thickness. Live weight ranges from 0.5 to 1 kg. The body

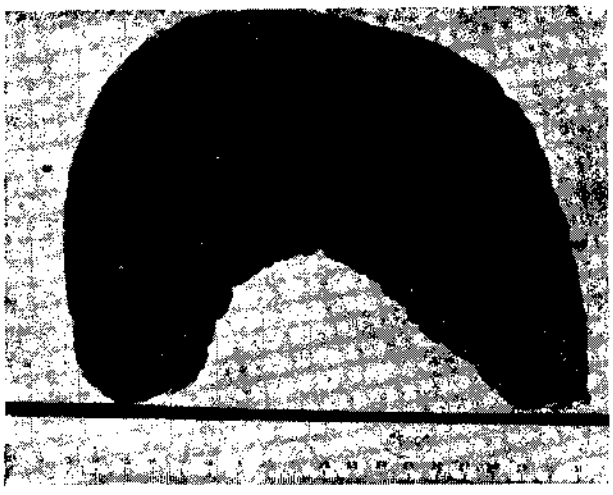

Fig. 6 *Actinopyga echinites*

is sub-cylindrical with the ventral side flat. It is wider in the middle and slightly tapers at both the ends and has a slightly wrinckled surface. Often sand settles on the dorsal side of the body. It is found to be distributed from 3 to 30 m depth and is found to live among live corals. During the survey it is collected only from Amini Islands. Deep water collection was not made during the survey and this accounts for the collection of a stray specimen on the reef at Amini Island.

Another important species for *beche-de-mer* is *Actinopyga miliaris* (Fig 7). This is popularly known as black fish. Its length ranges from 200 to 300 mm and width from 80 to 120 mm. Thickness of the body wall is about 8 mm. Live weight of the animal varies from 0.5 to 2 kg. The body is cylindrical with three rows of tubefeet arranged on the ventral side sometimes dark

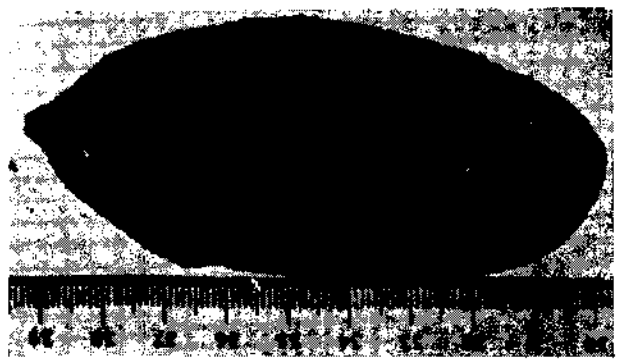

Fig. 7 *Actinopyga miliaris*

brown. It is found mainly in less than two meters depth. It also lives on the reef flats among live corals and among algal beds. During the survey it is collected only from the Minicoy Island. Prices of *beche-de-mer* in the market rank second or third to teat fish.

HISTORY OF BECHE-DE-MER INDUSTRY

The history of the *beche-de-mer* trade in the Lakshadweep is not well documented. Mannandiar (1977) stated that the *bache-de-mer* was once largely produced in Lakshadweep. According to him Sir. W. Robinson who visited the South Canara Islands in 1844-1845 reported that during the fishing season, a good many of the Islanders are employed by the Moplah merchants in the preparation of *beche-de-mer*. This product was in good demand for the Chinese market at Bombay. But slowly the industry began to decline and by the time Mr. W. G. Underwood visited Malabar Islands in 1881-83 the trade has almost died out. They used to be sent to Mangalore and thence shipped to China. The local people do not use it in any form. When the external demand declined, the people neglected the industry and quite naturally became extinct. When Hornell (1917) visited the Kiltan Island in 1908 he saw small quantities

of *beche-de-mer* being processed from three species. Judging from the local names he has given they are *Holothuria (Microthele) nobilis, Bohadschia argus* and *Actinopyga mauritiana,* which are even abundant today. He also noted that the methods of curing were different from those practised in Palk Bay. They resembled the methods adopted in Australia and Polynesia. Obiviously these methods were introduced by the Chinese. Ayyangar (1922) who made a survey of the fauna and fishing industries of the Lakshadweep noted that the *beche-de-mer* industry which was a success for sometime in Androth had to be abandoned due to an epidemic of cholera and this was attributed to the insanitary condition in which the curer kept his yard at that time. He stated that at Kiltan except for the statement that it was once practised no traces of the industry were found. The failure is attributed to poor prices for the manufactured product.

The present author when he visited Amini, Kadmat, Kiltan and Chetlat during January-February,'87 collected the following information on the *beche-de-mer* industry of Lakshadweep. About 65-70 years back one person who is still alive at Chetlat used to process *Holothuria (Microthele) nobilis.* He used to cut the holothurian into four bits and boil the bits and dry them. He did this for four years. He started the processing when somebody from mainland suggested. When everybody ridiculed him for processing *Koka* (local name for sea cucumber) he finally gave up. In a day he used to process 5-10 specimens. He was paid Rs. 3.00 per kilo those days. In an year he could process about 20-30 kg. At Kiltan there is a place even today known as *Koka Pulikkayar* which means a place to boil holothurians. Copper vessel used for boiling at Chetlat is still available (Fig. 8). The main reason why the *beche-de-mer* industry has not established itself in Lakshadweep is due to the fact that it is difficult to export the material directly to China or even to the main export markets in Singapore and Hong Kong those days. So they used to cater only to the needs of the Chinese population in Bombay and this also died out when the demand for the product slowly dwindled with the disappearence of the Chinese population.

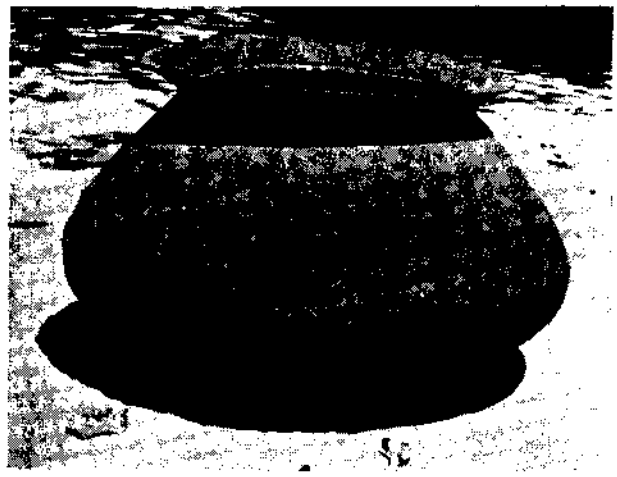

Fig. 8 Vessel used for boiling holothurians at Chetlat

The Lakshadweep Administration made some laudable attempts to revive the industry in recent years. In 1967 one Inspector of Fisheries and a Fisherman belonging to the Fisheries Department were sent to Rameswaram for one month to learn the processing of holothurians. They returned and processed different species of holothurians in the same manner as they adopt for *Holothuria (Metriatyla) scabra* at Rameswaram. They found the holothurian *Holothuria (Microthele) nobilis* suitable for processing and the processed samples were handed over to the Fisheries Department. After that nothing is known. Immediately after this one person from Madras came to Androth and processed nearly seven tonnes of *Holothuria (Microthele nobilis)* by paying a royalty of Rs. 1.00 per kilo to the Administration. He purchased the holothurians by paying five or ten paise per specimen. He processed the material at Androth and Kavaratti. Details regarding the method he adopted for processing could not be collected. Fisheries Department rightly restricted the collection of material below the length of 150 mm. We have to appreciate the foresight showed by the Department to conserve the resource. After two years the same person wanted to once again visit Lakshadweep but the Administration did not give permission.

FUTURE PROSPECTS

The present survey has indicated good resources of holothurians used for processing. In the whole of the Indian region only at Lakshadweep the best quality holothuran *Holothuria*

(*Microthele*) *nobilis* from which first grade *beche-de-mer* can be prepared is available in appreciable quantities. As stated earlier the holothurians are mostly concentrated in the lagoon while some of the economically important species live on the reef. On a very modest estimate the resource of *Holothuria* (*Microthele*) *nobilis* and *Bohadschia argus* will be between 3000 to 5000 tonnes when we take the whole Lakshadweep into consideration. Immediately processing can be taken up in the case of *Holothuria* (*Microthele*) *nobilis* since the processing is very simple and does not involve much labour. Also since this is first grade holothurian for *beche-de-mer* the returns will be high.

Since this species has not been processed earlier in the proper manner the processing is described here in brief. The holothurians are introduced into boiling water one by one after the viscera is thrown out and the inside water is squeezed out. During boiling the flame has to be kept high. Only a few specimens should be boiled at a time to provide individual attention to the specimens. The teat fish tend to float as air is sealed inside with water which builds up pressure with rising temperature. After some time the body wall breaks if proper care is not taken. Bloated specimens are taken out, punctured at the mid dorsal region and put back for the completion of the cooking process. The material is stirred frequently using spatula ended pole. The material has to be boiled for 30-45 minutes. Since it does not become very rubber-like, during boiling the bouncing test for sand fish does not apply here. After boiling the teat fish are removed using ring-net end pole. The material is cooled by placing in raised platform or wooden planks or on top of logs. Each teat fish is cut on the mid-dorsal side leaving a little uncut portions near mouth and cloaca. If there are unremoved visceral portions, the same should be washed out by using lukewarm water. The product should be again boiled for another 15-20 minutes. The product shrinks and the body wall becomes hard. During boiling the material has to be stirred frequently. The material is removed after boiling with a ring net ended pole. Then wooden splinters of 30-50 mm long are placed between the cut edges of the dorsal wall to expose the interior. The material has to be dried in the sun on drying platforms. During the rainy weather the material can be smoke dried. However smoke dried material is not much favoured by the buyers.

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13. SPONGE FAUNA OF LAKSHADWEEP

P. A. Thomas

INTRODUCTION

The present collection of sponges from Lakshadweep is of great significance since this group had been left out while Gardiner (1903-1906) dealt with the fauna and geography of the Maldive and Laccadive archipelagoes. Since then several works dealing with the sponge fauna of the Indian seas have appeared, but unfortunatly, few of these relating to the sponge fauna of Lakshawdeep. In this context the special interest taken by Dr. S. Jones, the then Director of the Central Marine Fisheries Research Institute in the 1960's in studying and documentting the fauna of Lakshadweep is worth mentioning. Besides obtaining data on the various fisheries of the island by the scientists posted at Minicoy, other scientists/research scholars, who were deputed to Minicoy from time to time also collected voluminous data and material from the different islands of this archipelago, to be later worked out by those interested. Sponges, thus collected, formed the part of a Ph. D. thesis (11 species including one new species) submitted by the present author in 1968 to the Kerala University. The subsequent collections of sponges from Minicoy were worked out and published serially (Thomas' 1973; 1979, 1980 and 1980a). The above works have helped to know mainly about the sponge fauna of Minicoy island and these accounted for a total of 41 species of Demospongiae falling under 23 families and 32 genera, while the sponge fauna of other islands still remained unexplored.

STRUCTURE AND COMPOSTION OF THE MAJOR TAXA OF SPONGES IN LAKSHADWEEP

The present review is based on sponges collected from various islands of the Lakshadweep Archipelago and hence species already recorded from Minicoy have also been included for the comprehensiveness of the account. A detailed systematic account of the sponges collected during the present survey will be published elsewhere.

It is customary to classify the extant sponges under 4 Classes—Demospongiae or silicious sponges, Calcispongiae or calcareous sponges, Hyalospongiae or hexactinellid sponges and Sclerospongiae. Of the above 95% of the recent sponges as the members of this class are better adapted to meet any vtcissitudes of nature, and hence collection of porifera made from any ocean will contain more of Demospongean members. From Lakshadweep only species belonging to this class have been recorded so far, But, this does not necessarily mean that the members of Calcispongiae are not represented in this area; careful examination might reveal the presence of a few calcareous species. However, the chances of encountering species of Hyalospongiae and Sclerospongiae are practically nil since hyalospongean species are, by nature, deep-water forms and Sclerospongiae form a highly specialised group with regard to their habitat preferance.

ORDERS OF THE CLASS DEMOSPONGIAE SOLLAS AND THEIR COMPOSTION IN LAKSHADWEEP

Species of this class are adapted for a life in both marine and freshwater realms and the skeleton is made of hydrated silica with or without an admixture of spongin. Some may also incorporate arenaceous objects (sand grains, spicules of other sponges etc.) into their body for maintaining sufficient rigidity. In a few families a specialised skelton of any sort may even be wanting. Species of this class dominate in shallow water areas throughout the world.

This class is divided into 8 orders based on general structure and spicular compostion. As in the other classes of the Phylum Porifera, here also there is considerable difference in the number of species falling under each order. The species of the order Poecilosclerida Topsent usually dominate in any collection of Porifera. The relative numerical abundance

(percentage) of species falling under each order from 5 Islands (Kavaratti, Suheli, Kalpeni, Androth and Minicoy) is given in Table 1. The corresponding figures for the other regions such as the Gulf of Mannar, Palk Bay and the Seychelles Bank are also included in the table for comparison.

least impressive numerically with 4 species, which forms about 4.4% of the total number of species. The above composition is based on the pooled data, when the number of species in each island is considered, the pattern may change considerably except in the case of the order Hadromerida. An order-wise appraisal of

Table : *Order-wise composition of species* (%)

Orders	K*	S	KA	A	M	P	SE	G
1. Keratosida	14.3	12.9	22.2	16.6	12.7	13.2	10.6	8.0
2. Haplosclerida	17.8	3.2	16.7	9.6	7.3	13.2	9.6	14.2
3. Poecilosclerida	17.8	16.1	16.7	11.1	21.8	19.7	26.0	26.9
4. Halichondrida	—	—	5.5	—	9.1	7.7	7.7	11.3
5. Hadromerida	35.7	38.7	30.6	61.1	29.1	23.1	20.2	15.6
6. Epipolasida	—	12.9	2.8	—	7.3	7.7	11.5	6.2
7. Choristida	7.2	3.2	—	—	9.1	11.0	10.6	10.9
8. Carnosida	7.2	12.9	5.5	5.6	3.6	4.4	3.8	6.9

* K=Kavaratti; S=Suheli; KA=Kalpeni; A=Androth; M=Minicoy;
P=Pooled data for all islands; SE=Seychelles Bank;
G=Gulf of Mannar and Palk Bay; — = not represented

As has been mentioned earlier, species of the Order Poecilosclerida dominate in any collection (see the percentage composition of species from the various orders in areas like Seychelles Bank, Gulf of Mannar and Palk Bay), but in the present collection from Lakshadweep, both Island-wise and in pooled data for all the 5 islands, the members of the Order Hadromerida dominate (21 species). This deviation from the normal distribution is due to the abundance of species belonging to the families Clionidae and Spirastrellidae that are well known for their boring habit. The abundance of calcium carbonate, in the form of coral skeleton, affords a condition quite congenial for the growth and proliferation of boring sponges belonging to the aforesaid two families.

Next, in order of abundance in the Lakshadweep region, comes Poecilosclerida which accounts for 18 species (19.7 %). Species belonging to the orders Keratosida and Haplosclerida are equally abundant with 12 species (13.2%) each. The order Choristida has 10 species (11.0%) while the orders Halichondrida and Epipolasida have 7 species (7.7%) each. Of all the orders represented Carnosida is the

the sponge fauna of the Lakshadweep may be made as follows:

1. Order Keratosida Grant

This is a polyphyletic group with utmost variation in shape, size and colour. Mineral skeleton, as a rule, is absent and its place is taken by spongin fibres which may be reticulate or dendritic in arrangement. Fibres may contain arenaceous objects in varying degrees; spicules made of spongin may be rarely noted in some. Some genera may completely be devoid of any skeleton.

Three families, Spongiidae Gray, Dysideidae Gray, Aplysillidae Vosmaer are represented in Lakshadweep, accounting for a total of 12 species referable to 10 genera. Species of the first family have elastic spongin fibres and hence they are, at least some species, used as 'bath sponge'. The most common and widely distributed 'bath sponge' on the mainland of India (*Spongia officinalis* Lin.) is represented by its variety *ceylynensis* Dendy in Lakshadweep and was collected, at least in stray numbers, from almost all the islands surveyed. Specimens collected f rom the lagoon had an encrusting

growth form while those washed ashore on the open side of the island (mainly Kavaratti and Kiltan) were of irregular, tuberous morphology. The fibres, in all these cases, were rather robust and with poor resilience, indicating poor commercial possibilities.

Species falling under this family may be divided into two subfamilies based on the nature of skeleton. Fibres represented in the first subfamily (Spongiinae de Laubenfels) may or may not be trellised or fascicular. Similarly, a sand cortex also may or may not be present. Genera like *Spongia* Lin., *Hippiospongia* de Laubenfels, *Heteronema* Keller, *Hyattella* Lendenfeld and *Pyllospongia* Ehlers fall under this subfamily. The second subfamily, Verongiinae de Laubenfels, may be divided into two subdivisions based on the nature of the fibres whether trellised and fascicular or not. The genus *Fasciospongia* Burlon, comes under the former subdivision while the genus *Thorectopsamma* Burton, under the latter. Generally, the species falling under this subfamily have very tough fibres with poor resiliency and hence are of no commercial value.

The second family, Dysideidae Gray, is represented at Lakshadweep by two genera, *Dysidea* Johnston and *Dendrilla* Lendenfeld, the former with two, and the latter with a single species. Species of *Dysidea* incorporate sand grains etc., into their skeleton and hence are quite friable on drying. The fibres of *Dendrilla* never incorporate sand grains, and are laminated and pithed. These fibres often run in a feebly dendritic fashion. The species represented is *D. cactus* Selenka. and the specimens, when macerated, ooze out a secretion of the same colour.

The third family, Aplysillidae Vosamer, is quite different from the aforementioned two families in that the fibres are distinctly dendritic and, besides, there may be diactinal or triactinal spicules made of a substance very close to spongin in chemical composition. The only genus represented is *Psammaplysilla* Keller, which has no spongin spicules at all. *P. purpurea* (Carter) could be collected from 7 of the islands surveyed. Though a branching body form is very well noted in advanced stages, such specimens were not present in any of the islands surveyed, and all of them were encrusting indicating the early stage in the life cycle.

This order ranks second numerically in both Kalpeni and Androth.

2. Order Haplosclerida Topsent

The skeleton, in this order, is very simple. It is reticulate with rectangular to triangular meshes and the fibres may be uni or multispicular with spongin covering the spicules in degrees. Spicules are represented by diactinal (oxeas or strongyles) megascleres and sigmoid or toxoid microscleres. Spongin may be seen cementing the spicules at their corners or just covering the spicules (as in Haliclonidae de Laubenfels) or thickly (as in Callyspongiidad de Laubenfels), forming stout fibres. In Adociidae de Laubenfels the microscleres seen may be sigmas (genus *Sigmadocia* de Laubenfels) or sigmas and toxas (genus *Orina* Gray) in addition to the characteristic megascleres of the family. Genus *Damirina* Burton, also of the family Adociidae, has dermal tornotes over an isodictyal reticulation of spined (often verticillately) acanthostrongyles. During the present survey a new species of this genus (*D. laccadivensis*) could be collected. This has irregularly spined acanthostrongyles instead of the normal verticillate type. Specimens of the new species were collected from two islands, Kalpeni (D-2) and Minicoy (J-3). The substratum beneath the specimen, in both cases, presented a highly disintegrated look and it could not be confirmed weather the sponge is intruding into cavities made by other boring sponges or not. The most common and widely distributed species of the family is *Sigmadocia fibulata* (Schmidt). This sponge grows in association with the alga *Ceratodictyon spongiosum* (Zanard) and hence drefer to colonise well-lighted areas of the lagoon. This species could be collected from 5 islands of this archipelago.

The fourth family Desmacidonidae Gray, has reticulate or plumoreticulate skeleton with diactinal megascleres. Microscleres are represented by chelas and sigmas mostly, the former often with some curious modifications. Genus *Iotrochota* Ridley has both monacts and diacts as megascleres. Genus *Cornulum* Carter is represented by a single specis, *C. vesiculatum* (Dendy) from Kalpeni (I-3). This species was

first reported from the Gulf of Mannar by Dendy (1905). The body is vase or bladder shaped with fistules arising from the upper parts. Usually these fistules project from the bottom as the main body remains buried in the sand. Spicules consist of strongyles and oxeas for megascleres and isochelas for microscleres.

The total number of species falling under the present order from Lakshadweep is 13 and may be classified under 8 genera and 4 families.

3. Order Poecilosclerida Topsent

This is structurally the most diverse order of the class Demospongiae and is very well known for the different categories of spicules it contains. Megascleres are represented by both monacts and diacts and are with curious modifications of some sort or the other. Spiny spicules are rather common. Spicules may show considerable regional differentiation. Spongin may be noted in varying degree and in some cases spicules may even get aggregated into a reticulation of a very complicated nature Microscleres represented may be of different types, sigmas, chelas, toxas, raphides and so on. But there are some genera in which the microscleres may totally be absent.

The body form, in this order, may vary considerably; some may be encrusting throughout their life, but others may be ramose, bushy, massive or foliate. Species falling under this order may be beautifully coloured. Some species which cannot tolerate direct sunlight may prefer to grow attched to the under surface of hard objects away from siltfall.

A very large fraction of all the described genera of the Phylum Porifera fall under this order, but this order has only second position in Lakshadweep in the order of numerical abundance, the first being the order Hadromerida Topsent. It is still not known whether the abundance of calcium carbonate in the form of coral produces a favaurable condition for the growth of boring sponges of the order Hadromerida or the sea bottom covered with coral sand inhibits the growth of species of order Poecilosclerida. However, this is an exceptional condition noted in the species composition of individual islands as well as in the pooled data for all islands surveyed at present.

de Laubenfels (1936) suggested 4 artificial 'Divisions' for this order based on the nature of principal and auxiliary spicules, whether diactinal or monactinal. In the first Division, Phorbasiformes, the principal and at least some of the auxiliary spicules are diactinal while auxiliaries are monactinal; in the third, Myxilliformes, the principal ones are monactinal and auxiliaries, diactinal and finally, in the fourth, Microcioniformes, both principal and auxiliary spicules are monactinal. Judging from the above grouping, families such as Phorbasidae de Laubenfels, and Agelasidae Verrill fall under the first Division, family Plocamiidae Topsent under the second; families Myxillidae Hentschel, Tedaniidae Ridley and Dendy and Raspailiidae Hentschel under the third; and families Microcionidae Hentschel, Ophlitaspongiidae de Laubenfels and Amphilectidae de Laubenfels under the fourth Division.

Only two genera of the family Phorbasidae, viz, *Echinodictyum* Ridley and *Damiriana* de Laubenfels, are represented at Lakshadweep. The spiculation in the former genus consists of oxeas in fibres accompanied by partly projecting styles; the fibres are echinated by acanthostyles and no microscleres are represented. The only species represented is *E. longistylum* Thomas. Genus *Damiriana* has dermal tylotes and endosmal oxeas; microscleres are represented by arcuate chelas and sigmas. *D. schmidti* (Ridley) is a widely distributed Indo-Pacific species which, in the reef environment, retains the encrusting habit throughout life. This species has been collected from four of the islands surveyed. The next family of the present Division is Agelasidae. The members of this family have neither principal spicules or auxiliaries in the strict sense and those represented may be put under the category 'echinating,. Spongin fibres are developed and form a fine reticulum. The inclusion of this family under this Division is open to criticism and a better position for this would be the fourth Division. Since reduction of spicules is so characteristic here, de Laubenfels (1936) concluded that the family is polyphyletic and a still

further reduction of spicules will lead to the absence of spicules at all, as seen in the case of spongiidae Gray. Bergquist and Hartman (1969) concluded that a better place for this family would be among Axinellida since they noted some similarities in free amino acid patterns and sterol composition of these two groups. Genus *Agelas* D & M, the representative of this monogeneric family, has unique echinating spicules in which the spines are arranged in nodal whorls. Two well-known species (*A. mauritiana* (Carter) and *A. ceylonensis* Dendy) and an unidentified species (*Agelas* sp. Thomas, 1980) have been hitherto known from Minicoy. However, no species of this genus could be collected during the present survey. Of the aforementioned two species the first one is a widely distributed Indo-Pasific species while the second enjoys distribution only in the Indian Ocean.

Only one family (Plocamiidae Topsent) of the second Division is represented at Lakshadweep and a s pecies (*Plocamilla mannarensis* (Carter) has been recorded by Burton and Rao (1932). This is a widely distributed Indian Ocean species and the specimens grow to a bushy structure with a short peduncle bearing several dichotomously dividing branches of 3 to 5 mm diameter.

The third Division, Myxilliformes, is represented at Lakshadweep by three families, Myxillidae Hentschel. Tedaniidae Ridley and Dendy and Raspailiidae Hentschel. Two Myxillid sponges, *Myxilla arenaria* Dendy and *Myxilla* sp. have been recorded so far, the first one from Kalpeni and the other from Minicoy (Thomas, 1980). The former species exhibits the habit of incorporating sand grains etc., into the body. Two genera of the family Tedaniidae, which are found rather well distributed in the Lakshadweep, are *Tedania* Gray and *Acanthacarnus* Levi. The first genus has diactinal auxiliaries and monactinal principal spicules together with characteristic 'onychaetas' of the genus. A widely distributed cosmopolitan species, *Tedania anhelans* (Lieberkuhn), has been collected from 7 islands of this archipelago. It appears from the collection that specimens here do not grow to a massive size unlike in the inshore areas of the mainland. Genus *Acanthacarnus* Levi, a close relative of the genus *Acarnus* Gray, differs from the latter in the presence of acanthostyles added to its spiculation. Principal spicules, in this case, are monactinal (styles) and the auxiliaries, diactinal (tylotes). In addition to these there are both acanthostyles and claydotylotes (or 'rose-stem') as echinating spicules. Microscleres are represented by isochelas and toxas. *A. souriei* Levi, a species common to the Atlantic Ocean, Mediterranean Sea and some parts of the Indian Ocean, is widely distributed in Lakshadweep. Family Raspailiidae Hentschel is represented by a single species, *Rhabderemia prolifera* Annandale. Annandale (1915), in the original description, mentioned that this species may utilise the cavities made by boring sponges, but during the present survey it was noted that no other boring sponge was present in galleries occupied by this species. The characteristic spicules are hockey stick-like rhabdostyles, microstyles, microstyles and twisted sigmas. This species could be collected from 5 islands in this archipelago.

Under the fourth Division, Microcioniformes, families such as Microcionidae Hentschel, Oplitaspongiidae de Laubenfels and Amphilectidae de Laubenfels are represented at Lakshadweep. Species falling under the first family retain the encrusting habit throughout their life time and are beautifully coloured. *M. acertoobtusa* Carter is devoid of any acanthostyle which is quite characteristic of the genus and the isochelas, at least some, have a twisted appearance. Two other species, *M. rhopalophora* (Hentschel , is quite peculiar in the respect that there are two types of acanthostyles. Genera falling under the family Ophlitaspongiidae from Lakshadweep are *Ophlitaspongia* Bowerbank, *Clathria* Schmidt, *Mycale* Gray and *Zygomycale* Topsent. The principal spicules, in all these cases, are monactinal (styles or subtylostyles) and auxiliaries, subtyoystyles, sometimes of different sets. In the first genus microscleres are represented by toxas and arcuate isochelas. In the case of the genus *Clathria* the subtylostyles may be basally spined, and may be of different sets; the acanthostyles that echinate the fibres are of common occurrence. Microscleres are representened by palmate isochelas, but in some cases they may be totally wanting. Genus *Mycale* has anisochelas, sigmas, toxas and raphides; there may be different sets in each

category. Genus *Zygomycale* is peculiar in the respect that it has isochelas added to the typical spiculation of the above genus. Species falling under the abova-mentioned genera are *Ophlitaspongia rimosa* (Ridley), *Clathria reinwardti* Vosmaer, *Mycale grandis* Gray and *Zygomycale parishii* (Bowerbank). Except for *O. rimosa*, all the others are known only from Minicoy.

The family Amphilectidae de Laubenfels is represented by a single species: *Biemna fortis* (Topsent), which has styles, sigmas (two sets) and raphides (often in groups). Specimens usually grow buried in sand with finger-like projections arising from the upper parts.

The total number of species falling under this order from Lakshadweep is 18 and may be classified into 9 families and 4 genera.

4. Order Halichondrida Vosmaer

Spicules encountered in this order may be monacts or diacts or a combination of both. Microscleres, as a rule, are rare. This order is represented at Lakshadweep by three families, Halichondridae Gray. Axinellidae Ridley and Dendy and Hymeniacidonidae de Laubenfels. The first family has exceedingly simple spiculation consisting of only oxeas. A rspecial dermal skelton is sometimes present and composed of tangentially placed oxeas over extensive subdermal spaces. *Halichondria panicea* Johnston, a typical cosmopolitan species of the family, could be collected from Androth. Another genus which may be considered under the present family is *Ciocalypta* Bowerbank. This has styles instead of oxeas and the dermal skeleton is composed of small styles. The subdermal spaces are quite extensive. Thomas (1973) recorded *C. Polymastia* (Lendenfeld) from Minicoy extending its distribution westward to the Indian Ocean (previously known from New Zealand and Australia).

Species of the family Axinellidae may be differentiated from those of the other families of the order in that the axial and extra-axial specialisations are well pronounced in this case Megascleres are represented by monacts and diacts and microscleres, if at all present, may be raphides and microxeas Those species without spiny microxeas are grouped under the subfamily Axinellinae de Laubenfels, while those with spiny microxeas under the subfamily Higginsiinae Higgin, Genera like *Bubaris* Gray and *Phycopsis* Carter fall under the former and *Myrmekioderma* Ehlers under the latter sufamilies. Genus *Bubaris* has both styles and/or subtylostyles erect on the substratum and sinuous strongyles that may be arranged in the form of mat over the substratum or in an axial column, depending on the form of growth. From Minicoy a specimen of *Bubaris* was reported as *Bubaris* sp. (Thomas, 1980a). Genus *Phycopsis* has only oxeas, and two specimens (of different species) could be collected. (Sp. 1 from Agatti and Sp. 2 from Minicoy) during the present survey. Specific identification, in both these cases, was not possible due to the small and inadequate nature of the material. The subfamily Higginfiinae is represented by the genus *Myrmekioderma* and the species already reported from Minicoy is *M. granulata* (Esper). This has a well developed cortex reinforced with small acanthoxeas. The main skeleton, in this case, is composed of smooth oxeas together with raphides.

Species falling under the family Hymeniacidonidae have fleshy ectosome; but the endosome is quite comparable to that of any typical exinellid species. Spicules are represented by smooth oxeas, styles and crooked strongyles. Only one species, *Acanthella cavernosa* Dendy, is known from Lakshadweep (Minicoy)

The order is represented at Lakshadweep by three families, 6 genera and 7 species.

5. Order Hadromerida Topsent

Demospongiae with radiate and corticate architecture; megascleres are represented by monacts (tylostyles or subtylostyles), smaller megascleres assume a brush-like arrangement at the surface giving a pronounced fur-like appearance to the surface. Microscleres may be of different types or totally absent; when present, they are of astrose type.

Of the four families represented at Lakshadweep, two families, viz., Spirastrellidae Hentschel and Clionidae Gray are unique in the respect that almost all the species falling under them exhibit the habit of boring into calcium carbonate material such as shell, coral calcareous algae etc., causing considerable

damage or even death to these calcium secreting animals. These species, hence, play an important role in the bioerosion of the reef system. Details on the bioerosion generated by the various species of sponges are furnished elsewhere in this Bulletin and hence such details are deleted from the present account. The only genus from the family Spirastrellidae represented in the present collection that does not bore into calcareous matter is *Timea* Gray. The spiculation consists of tylostyles, mostly erect on the substratum, and euasters of one or more sets. These asters are seen densely packed inside the sponge. Two species, *T. stellizeriens* (Carter) and *T. stellata* (Bowerbank), are represented at Lakshadweep. The other two families of this order, viz., Suberitidae Schmidt and Placospongiidae Gray are rather poorly represented. The former family possessess tylostyles/subtylostyles or rarely styles; and the radial arrangement of the skeleton is distinct only towards the outer part of the specimen. Species falling under four genera have been collected; they are, *Suberites* Nardo, Laxosuberites Topsent, *Pseudosuberites* Topsent and *Aaptos* Gray. Tylostyles form the main spicules in the former three genera, while in the last, spicules are represented by strongyloxeas and styles. The family Placospongiidae is represented at Lakshadweep by the genus *Placospongia* Gray. Spicules, in this case, are tylostyles for megascleres and sterrospires, spirasters, spherasters and spherules for microscleres. The sterrospires are densely packed in the cortical region to form a thick crust which is subdivided into polygonal areas by pore-bearing grooves. The only species represented at Lakshadweep is *Placospongia carinata* (Bowerbank), which is known only from Minicoy.

The total number of species falling under the present order is 21 and these may be classified under 11 genera and 4 families.

6. Order Epipolasida Sollas

Architecture radiate and with well developed cortex. Microscleres, if present, astrose type and Megascleres may be monactinal or diactinal. Spongin, as a rule, absent. Two families, Jaspidae de Laubenfels and Tethyidae Gray are known to occur at Lakshadweep. Genera falling under the former family are *Prostylyssa* Topsent, *Jaspis* Gray and *Zaplethea* de Laubenfels. In the genus *Prostylyssa* the megascleres may be monacts or diacts, and the microscleres are represented by microstyles. The only species represented is *P. foetida* (Dendy) which is widely distributed in the Indo-Pacific. Spiculation in tha genus *Jaspis* consists of oxeas as megascleres and euasters and microxeas as microscleres. *Jaspis penetrans* (Carter) is a boring species commonly distributed in tha reef environment in Lakshadweep. Genus *Zaplethea* resembles the above genus in spiculation, but the microxeas represented here are biangulated. A subspecies of *Zaplethea digonoxea* (ssp. *diastra* Vacelet and Vasseur), the only subspecies in the Indo-Pacific, has been collected from Suheli. Family Tethyidae is well defined family with strongyloxeas arranged in radial bundles. The cortex is well marked and is densely packed with spherasters. Other microscleres represented include euasters of one or more types. *T. robusta* Bowerbank, *T. japonica* Sollas and *T. diploderma* Schmidt are the species represented at Lakshadweep. Another genus of the same family, *Tethytimea* de Laubenfels, differs from the above genus in the possession of tylostyles in the place of strongyloxeas; microscleres resemble those of the genus *Tethya*. *T. repens* (Schmidt) is known only from Minicoy.

The total number of species included under this order from Lakshadweep is 7 and these are referable to 4 genera and two families.

7. Order Choristida Sollas

Radial architecture is well pronounced in this order; a well defined cortex may or may not be present. Long shafted triaenes (tetractines) form the most dominant type of spicules followed by oxeas. Microscleres represented are of different types; euasters, streptasters, sigmaspires, microxeas and so on.

Four families, Ancorinidae Gray, Geodiidae Gray, Craniellidae de Laubenfels and Kaliapsidae de Laubenfels, of this order are represented at Lakshadweep. The first family (Ancorinidae) may be divided into two subfamilies based on the nature of the microscleres. The first subfamily (Ancorininae) includes species having streptasters, with or without euasters; while the second subfamily

(Stellettinae) includes only those with euasters. Genus *Ecionemia* Bowerbank, with its two species, *E. acervus* Bowerbank and *E. thielei* Thomas, fall under the first subfamily and genera such as *Aurora* Sollas and *Stelletta* Schmidt, under the latter. Genus *Aurora* is represented by *A. globostellata* (Carter) and *A. rowi* Dendy. Spicules are represented by oxeas and triaenes for megascleres and spherasters, oxyasters, and raphides for microscleres. Both these are widespread Indian Ocean species and are collected from Suheli and Amini respectively. Genus *Stelletta* has microscleres of two types; and is represented by a single species *S. tethyopsis* Carter. This species has dichtriaenes and is here reported outside its type locality, the Gulf of Mannar. Family Geodiidae is unique in the possession of a tough crust of sterrasters in the cortical region. The only representative of the family in Lakshadweep is *Geodia lindgreni* (Lendenfeld). Family Craniellidae has, along with the typical spiculation of the order, peculiar and minutely roughened sigmaspires as microscleres. Two genera of this family are known to occur in this archipelago; they are *Cinachyra* Sollas and *Paratetilla* Dendy, and are collected from Kavaratti and Minicoy respectively. The former genus has the typical spiculation of the family while the latter is characterised by the presence of short-shafted orthotriaenes at the junction of the ectosome and endosome. *Paratetilla bacca* (Selenka) is a well distributed Indo-Pacific species. Finally, the family Kaliapsidae, a family created by de Laubenfels (1936) for a group of genera that possess lithistid spicules, is represented at Lakshadweep by two genera *Theonella* Gray and *Lophacanthus* Hentschel. Spiculation in the former genus consists of ectosomal triaenes over endosomal desmas. Microscleres are represented by microstrongyles that are minutely roughened. Burton (1928) described *Theonella cupola* from Laccadives, but this species has not been obtained during the present survey. Genus *Lophacanthus* has lophotriaenes, desmas and rhabdostyles; but is devoid of any microscleres. *L. rhabdophorus* Hentschel is a widely distributed Indo-Australian species and has been reported from Minicoy.

The total number of species falling under this order from Lakshadweep is 10 and these are referable to 8 genera and 4 families.

8 Order Carnosida Carter

Corticate and radiate architecture is not well marked, unlike in the previous order. Long-shafted triaenes are rarely met with in this order, instead the tetraxon spicules represented here are with short, often stumpy, rays These spicules are called 'calthrops'.

Two families of this order, viz., Halinidae de Laubenfels and Chondrillidae Gray only are known from the present survey. The family Halinidae exemplifies to the fullest extent the characters of its order and has only calthrops and diactinal spicules for megacleres. The microscleres in this case are of astrose type. Based on the structure of microscleres this family may be divided into subfamilies; Halininae de Laubenfels having streptasters and Corticiinae Vosmaer, with euasters. Under the former subfamily two genera, *Halina* Bowerbank, the type of the family and *Dercitopsis* Dendy are recorded. *Halina* Bowerbank has peculiar calthrops provided with dichomodifications and the streptasters represented are straight. *Halina plicata* (Schmidt) is a boring species and is fairly well distributed in almost all the islands surveyed. The other genus, *Dercitopsis*, has calthrops, triods and oxeas, the last one often centrotylote in nature. The only species collected is *D. Minor* Dendy, from Suheli. The only genus falling to the subfamily Corticiinae from Lakshadweep is *Samus* Gray. It has lumpy amphitriaenes and lumpy sigmoid spicules. The species represented is *Samus anonyma* Gray which is circum equatorial in distribution. It is a coral boring species and has been collected from 6 of the islands surveyed. The spicules of this species are often found intermingled with those of the genus *Cliona*, and no spacimen could be located *in situ* to record its general morphology.

family Chondrillidae has only asters as spicules. There may be one or two categories of these spicules and no megasclere is represented. The typical genus, *Chondrilla* Schmidt, is represented at Lakshadweep by a single species *C. sacciformis* Carter. This species could be obtained only from Suheli

The total number of species falling under this order from Lakshadweep is 4. These species may be classified under 2 families and 4 genera. The maximum number of species (4) has been collected from Suheli.

ISLAND-WISE DISTRIBUTION OF SPECIES

The various species collected from the different islands of Lakshadweep are systematically enlisted in Table 2. The maximum number of species (58) was obtained from Minicoy.

Table 2. *Island-wise distribution of sponge species*

Sr. No:	Species/Classification	Distribution									
		Kavaratti	Suheli	Kalpeni	Androth	Minicoy	Kadmat	Amini	Kiltan	Kalpitti	Agatti
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Class Demospongiae Sollas											
	Order Keratosida Grant										
	Family Spongiidae Gray										
1.	*Spongia officinalis* Lin. ssp. *ceylonensis* Dendy	X	X	X	X	X	—	X	X	X	X
2.	*Hippiospongia* sp.	—	—	—	—	—	—	—	X	—	—
3.	*Heteronema erecta* Keller	—	—	X	—	—	—	—	—	—	—
4.	*Hyattella cribriformis* (Hyatt)	X	—	—	—	X	—	X	—	X	—
5.	*Phyllospongia foliascens* (Pallas)	—	X	—	—	X	—	—	X	—	—
6.	*P. dendyi* Lendenfeld	—	—	—	—	X	—	—	—	—	—
7.	*Thorectopsamma* sp.	—	—	X	—	—	—	—	—	—	—
8.	*Fasciospongia cavernosa* (Schmidt)	—	—	X	X	—	X	X	—	—	—
	Family Dysideidae Gray										
9.	*Dysidea fragilis* (Montagu)	—	—	X	—	X	—	—	X	—	—
10.	*D. herbacea* (Keller)	—	—	X	—	X	—	—	X	—	—
11.	*Dendrilla cactus* (Selenka)	X	X	X	—	—	—	—	—	—	—
	Family Aplysillidae Vosmaer										
12.	*Psammaplysilla purpurea* (Carter)	X	X	X	X	X	X	X	—	—	—
	Order Haplosclerida Topsent										
	Family Haliclonidae de Laubenfels										
13.	*Haliclona oculata* (Lin.)	—	—	X	—	—	—	—	—	—	—
14.	*H. tenuiramosa* Burton	—	—	X	—	—	—	—	—	—	—
15.	*H. exigua* (Kirkpatrick)	X	—	—	—	—	—	—	—	—	—
	Family Desmacidonidae Gray										
16.	*Iotrochota baculifera* Ridley	X	—	X	—	—	—	—	—	—	—
17.	*Gelliodes fibulatus* Ridley	X	—	—	—	—	—	—	—	—	—
18.	*Cornulum vesiculatum* (Dendy)	—	—	X	—	—	—	—	—	—	—
	Family Adociidae de Laubenfels										
19.	*Sigmadocia fibulata* (Schmidt)	X	X	X	—	X	—	—	—	X	—
20.	*S. pumila* (Lendenfeld)	—	—	—	—	X	—	—	—	—	—
21.	*Orina sagittaria* (Sollas)	X	—	—	—	—	—	—	—	—	—
22.	*Damirina laccadivensis* n. sp.	—	—	X	—	X	—	—	—	—	—
	Family Callyspongiidae de Laubenfels										
23.	*Callyspongia diffusa* (Ridley)	—	—	—	—	X	—	—	—	—	—
24.	*C. fibrosa* (Ridley and Dendy)	—	—	—	X	X	—	X	—	—	—
	Order Poecilosclerida Topsent										
	Family Phorabasidae de Laubenfels										
25.	*Echinodictyum longistylum* Thomas	—	—	—	—	X	—	—	—	—	—

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
26.	*Damiriana schmidti* (Ridley)	X	X	X	—	X	—	—	—	—	—
	Family Agelasidae Verrill										
27.	*Agelas mauritiana* (Carter)	—	—	—	—	X	—	—	—	—	—
28.	*A. ceylonica* Dendy	—	—	—	—	X	—	—	—	—	—
29.	*Agelas* sp.	—	—	—	—	X	—	—	—	—	—
	Family Plocamiidae Topsent										
30.	*Plocamilla mannarensis* (Carter)	—	—	—	—	X?	—	—	—	—	—
	Family Myxillidae Hentschel										
31.	*Myxilla arenaria* Dendy	—	—	X	—	—	—	—	—	—	—
32.	*Myxilla* sp.	—	—	—	—	X	—	—	—	—	—
	Family Tedaniidae Ridley and Dendy										
33.	(*Tedania anhelans* Lieberakuhn)	X	X	X	X	X	X	X	—	—	—
34.	*Acanthacarnus souriei* Levi	X	—	X	—	—	—	—	—	—	—
	Family Raspailiidae Hentschel										
35.	*Rhabderemia prolifera* Annandale	X	X	X	X	X	—	—	—	—	—
36.	*Microciona aceratoobtusa* Carter	X	X	—	—	—	—	—	—	—	—
37.	*M. rhopalophora* (Hentschel)	—	X	—	—	—	—	—	—	—	—
	Family Ophlitaspongiidae de Laubenfels										
38.	*Ophlitaspongia rimosa* (Ridley)	—	—	—	—	—	—	—	—	—	X
39.	*Clathria reinwardti* Vosmaer	—	—	—	—	X	—	—	—	—	—
40.	*Mycale grandis* Gray	—	—	—	—	X	—	—	—	—	—
41.	*Zygomycale parishii* (Bowerbank)	—	—	—	—	X	—	—	—	—	—
	Family Amphilectidae de Laubenfels										
42.	*Biemna fortis* (Topsent)	—	—	—	—	X	—	—	—	—	—
	Order Halichondrida Vosmaer										
	Family Halichondridae Gray										
43.	*Halicondria Panicea* Johnstom	—	—	X	—	—	—	—	—	—	—
44.	*Ciocalypta Polymastia* (Lendenfeld)	—	—	—	—	X	—	—	—	—	—
	Family Axinellidae Ridley & Dendy										
45.	*Buberis* sp.	—	—	—	—	X	—	—	—	—	—
46.	*Myrmekioderma granulata* (Esper)	—	—	—	—	X	—	—	—	—	—
47.	*Phycopsis* sp. 1	—	—	—	—	—	—	—	—	—	X
48.	*Phycopsis* sp. 2	—	—	—	—	X	—	—	—	—	—
	Family Hpmeniacidonidae de Laubenfels										
49.	*Acanthella cavernosa* Dendy	—	—	—	—	X	—	—	—	—	—
	Order Hadromerida Topsent										
	Family Spirastrellidae Hentschel										
50.	*Spirastrella coccinea* (D & M)	X	—	—	X	X	—	—	—	—	—
51.	*S. cuspidifera* (Lamarck)	—	X	—	—	X	—	—	—	—	—
52.	*S. inconstans* (Dendy)	X	X	X	X	X	X	X	X	—	X
53.	S. *aurivilli* Lindgreu	—	X	X	X	—	—	X	—	—	—
54.	*Timea stellivarians* (Carter)	—	—	—	—	X	—	—	—	—	—
55.	*T. stellata* (Bowerbank)	—	—	—	—	—	—	X	—	—	—
	Family Suberitidae Schmidt										
56.	*Suberites csrnoses* (Johnston)	—	—	—	—	X	—	—	—	—	—
57.	*Laxosuberites crucistus* (Dendy)	—	X	—	—	X	—	—	—	—	—
58.	*Pseudosuberites* sp.	—	—	X	—	X	—	—	—	—	—

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
59.	*Aaptos aaptos* (Schmidt)	—	—	—	—	X	—	—	—	—	—
	Family Placospongiidae Gray										
60.	*P acospongia carinata* (Bowerbank)	—	—	—	—	X	—	—	—	—	—
	Family Clionidae Gray										
61.	*Amorphinopsis excavans* Carter	X	X	X	X	X	X	—	—	—	—
62.	*Aka minuta* Thomas	X	X	X	X	X	—	—	—	—	—
63.	*A. laccadivensis* n. sp.,	—	—	—	—	X	—	—	—	—	—
64.	*Cliona celata* Grant	X	X	X	X	X	—	X	—	—	X
65.	*C. vastifica* Hancock	X	X	X	—	—	—	—	—	—	—
66.	*C. viridis* (Schmidt)	X	—	X	—	—	—	—	—	—	—
67.	*C. carpenteri* Hancock	X	X	X	X	X	X	—	—	—	—
68.	*C. ensifera* Sollas	X	X	X	X	X	X	—	—	—	—
69.	*C. murconata* Sollas	—	X	—	X	X	—	—	—	—	—
70.	*Thoosa armata* Topsent										
	Order Epipolasida Sollas										
	Family Jaspidae de Laubenfels										
71.	*Prostylyssa foetida* (Dendy)	—	—	—	—	X	—	—	—	—	—
72.	*Jaspis penetrans* (Carter)	—	X	X	—	—	—	—	—	—	—
73.	*Zapleihea digonoxea* ssp. *diastra* (V & V)	—	X	—	—	—	—	—	—	—	—
	Family Tethyidae Gray										
74.	*Tethya robusta* Bawerbank	—	X	—	—	X	X	—	—	—	—
75.	*T. japonica* Sollas	—	—	—	—	X	X	—	—	—	—
76.	*T. diploderma* Schmidt	—	X	—	—	—	—	—	—	—	—
77.	*Tethytimea repens* (Schmidt)	—	—	—	—	X	—	—	—	—	—
	Order Carnosida Sollas										
	Family Ancorinidae Gray										
78.	*Ecionema acervus*	—	—	—	—	—	—	—	—	—	—
79.	E. *thielei* Thomas	—	—	—	—	X	X	—	—	—	—
80.	*Aurora rowi* Dendy	—	—	—	—	—	—	X	—	—	—
81.	*A. globostellata* (Carter)	—	X	—	—	—	—	—	—	—	—
82.	*Stelletta tethyopsis* Carter	X	—	—	—	—	—	—	—	—	—
	Family Geodiidae Gray										
83.	*Geodia lindgreni* (Lendenfeld)	—	—	—	—	X	—	—	—	—	—
	Family Craniellidae de Laubenfels										
84.	*Cynachyra cavernosa* (Lamarck)	X	—	—	—	—	—	—	—	—	—
85.	*Paratetilla bacca* (Selenka)	—	—	—	—	X	—	—	—	—	—
	Family Kaliapsidae de Laubenfels										
86.	*Theonella cupola*	—	-	—	—	X ?	—	—	—	—	—
87.	*Lophacanthus rhabdophorus* Hentschel	—	—	—	—	X	—	—	—	—	—
	Order Carnosida Carter										
	Family Halinidae de Laubenfels										
88.	*Halina plicata* (Schmidt)	X	X	X	—	X	X	X	—	—	—
89.	*Dercitopsis minor* Dendy	—	X	—	—	—	—	—	—	—	—
90.	*Samus anonyma Gray*	X	X	X	X	X	X	—	—	—	—
	Family Chondrillidae Gray										
91.	*Choudrilla sacciformis* Carter	—	X	—	—	—	—	—	—	—	—
	Total	28	31	35	18	58	13	12	6	3	5

X = Present; — = Absent; ? = Doubtful

ZOOGEOGRAPHY OF THE SPONGE FAUNA OF LAKSHADWEEP

Four the purpose of assessing the inter-relationship of the sponge fauna of Lakshadweep, the distribution of the various species represented was tabulated under 7 widely separated zoogeographical regions such as the Atlantic Ocean, Mediterranean Sea, Red Sea, Australian regions (same as the Indo-Australian region given in 'Challenger' Report), Pacific Ocean, Arctic and Antarctic. The present analysis indicates that the sponge fauna of Lakshadweep is very closely related to that of Australian region and 51 species (or 62.6%) are common to both these areas. Next to this the Lakshadweep fauna has more similarity with that of the Pacific Ocean and this is evident from the number (40 or 43.9%) of common species. The next zoogeographical area with which the present fauna has more in common is the Red Sea where 33 species (or 36.3%) are found to occur. The Atlantic sponge fauna has 25 species (27.5%), Mediteranean fauna has 16 species (17.6%), Arctic has 4 species (4.4%) and Antarctic has 3 species (3.3%) in common with the Lakshadweep sponge fauna.

Burton (1930) advocating the theory of water currents in relation to sponge abundance and distribution in the oceans opined that indian Ocean forms a closed system since it is bounded at its north and west by continents and south by an impassable boundary of cold waters of the west wind drift. The water currents prevailing in this closed system flow mainly from east to west and this may be the prime reason for the spreading of Australian and Pacific fauna into the Indian Ocean. Whenever any species is introduced into this system its further migration is governed by equatorial and monsoon currents which prevail to a greater extent along the continental shelf in different areas.

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14. SEAWEED AND SEAGRASS RESOURCES

N. Kaliaperumal, P. Kaladharan and S. Kalimuthu

INTRODUCTION

All macroscopic algae occurring in the marine habitat and coastal brackish waters are known as seaweeds. They from one of the important marine living resources and belong to four major classes namely Chlorophyceae (green algae), Phaeophyceae (brown algae), Rhodoyhyceae (red algae) and Cyanophyceae (blue-green algae). Seaweeds are the only source for the production of phytochemicals namely agar-agar, carrageenan and algin, which are extensively used in various industries such as food, confectionary, textiles, pharmaceuticals, dairy and paper industry mostly as gelling, stabilising and thickening agents. Seaweeds are also used as human food animal feed and manure in several countries.

At present there are about 30 agar and 28 algin industries situated in Tamil Nadu, Gajarat, Maharashtra, Karnataka, Kerala, Andhra Pradesh and Orissa. They get the raw material mainly from the natural beds occurring in Tamil Nadu coast. Since 1970 many seaweed industries are coming up in India and the raw meterial from natural seaweed beds are insufficient to meet the requirements of these industries. Hence surveys of seaweed resources have been carried out from time to time in different regions of the mainland, Lakshadweep and Andaman-Nicobar islands to locate the seaweed growing areas and to assess the standing crop of seaweeds, like in Chilka Lake (Mitra, 1946); Andhra Pradesh (Anon, 1984); Tamil Nadu (Chacko and Malu Pillai, 1958; Thivy, 1960; Varma and Krishna Rao, 1962; Desai, 1967; Umamaaeswara Rao, 1973 and Anon, 1978) Kerala coast (Koshy anb John, 1948); Goa (Untawale and Dhargalar' 1975); Maharashtra (Chauhan, 1978 and Untawale *et al.*, 1979); Gujarat (Sreenivasa Rao *et al.* 1964; Desai, 1967; Chauhan and Krishnamurthy, 1968; Bhanderi, 1984; Bhanderi and Raval, 1975; Bhanderi and Trivedi, 1975 and Chauhan and Mirch, 1978 Lakshadweep (Anon, 1979) and Andaman-Nicobar islands (Gopinathan and Panigrahy, 1983). To Study the potential resources of seaweeds and seagrasses in all the islands of Lakshadweep, investigation was conducted during January-March 1987 and the results are presented in this paper.

MATERIALS AND METHODS

In the present investigation, all the 12 islands of Lakshadweep namely Chetlat, Kiltan, Kadmat, Amini, Bitra, Bangaram, Agatti, Androth, Kavaratti, Kalpeni, Suheli and Minicoy were surveyed. In each island several equidistant transects were selected covering the inter-tidal region, lagoon, reef flat, reef and outer reef areas. Seaweeds were harvested from one square metre area from these areas along the transects and the biomass (wet weight) for individual species was determined. Samples from deeper areas were collected by skin diving. After measuring the biomass, representative samples were preserved for detailed examination in the laboratory and herbaria were also prepared for type specimens. Taxonomic identification was made later in the laboratory.

The quantification of biomass was done using the following formula:

$$\text{Estimable biomass from a zone} = \frac{\text{Total wt of seaweed harvested from the sampled area}}{\text{Area studied in the zone}} \times \text{Total area of zone}$$

Area of the zone was calculated by measuring the length and width of the extent of the vegetation cover and compared with the admirality chart. From each island, zone wise sampling was subjected to statistical analysis in order to give species wise resources estimates. *Gelidiella acerosa* and *Graci, laria edulis* are grouped under agarophytes-species of *Sargassum* and *Turbinaria* under alginophytes, and all other algae under 'other seaweeds'.

RESULTS

Seaweeds

Altogether 62 genera and 114 species of seaweeds were recorded from all the 12 Islands of which 18 genera and 43 species belong to Chlorophyceae, 11 genera and 14 species to Phaeopayceae, 30 genera and 54 species to Rhodophycea and 3 genera and 3 species to Cyanophyceae. The number of genera and species recorded in each island is given in Table 1. The list of seaweeds and seagrasses occurring in each island is given in have been shown in Figs 1 to 3.

Seag rasses

A total number of 6 species of seagrasses *Cymodocea rotundata, C. serrulata, Halodula uninervis, Halophila ovata, Syringdium* and *Thalassia hemprichii* occurred in the islands surveyed (see Table 2 given at the end). Seagrasses were found in 10 islands and not observed in Kiltan and Bitra.

ISLAND-WISE DISTRIBUTION AND ABUNDANCE

Chetlat: 34 species of seaweeds are from the potential area of 156 ha. The estimable biomass or seaweeds is 805.680 tonne (wet weight) consisting of 18.440 tonnes of agarophytes, 183.860 tonnes of alginophytes and 603.380 tonnes of other seaweeds.

Kiltan: From the potential area of 153 ha, a total of 33 species of seaweeds are recorded. The estimable biomass of seaweeds is 665.760 tonnes (wet weight) consisting of 25.900 tonnes of agarophytes, 78.200 tonnes of alginophytes and 561.600 tonnes of other seaweeds.

Kadamat: From the potential area of 179 ha, 30 species of seaweeds are recorded. The estimable biomass of seaweeds is 984.. 380 tonnes (wet weight), of which 143.200 tonnes are aragrophytes, 146.100 tonnes are

Table 1 Number of genera and species of marine algae collected from Lakshadweep

Name of the island	Chlorophyceae		Phaeophyceae		Rhodophyceae		Cyanophyceae		Tatal	
	Genera	Species	Genera	Species	Genera	Species	Genera	Species	Genera	Species
Chetlat	11	12	5	5	13	17	—	—	29	34
Kiltan	11	14	2	2	13	17	—	—	26	33
Kadamat	10	11	5	5	11	14	—	—	26	30
Amini	10	11	3	3	12	13	—	—	25	27
Bitra	4	4	3	3	9	10	1	1	17	18
Bingaram	6	6	6	6	17	20	—	—	29	32
Agatti	9	12	5	6	13	18	1	1	28	37
Androth	9	12	6	7	13	17	2	2	30	38
Kavaratti	13	17	4	4	18	23	3	3	38	47
Kalpeni	14	26	8	10	23	28	1	1	46	64
Suheli	6	7	7	8	13	16	2	2	28	33
Minicoy	12	21	6	6	18	23	2	2	38	52

Table 2 The estimated total standing crop of the marine algae for all the 12 islands was 19,345. tonnes (wet weight). The group wise biomass for each islands is given in table 3. The commercially important seaweeds *Gelidiella acerosa, Gracilaria edulis, Sargassum duplicatum* and *Turbinaria ornata* and some of the other common algal species collected

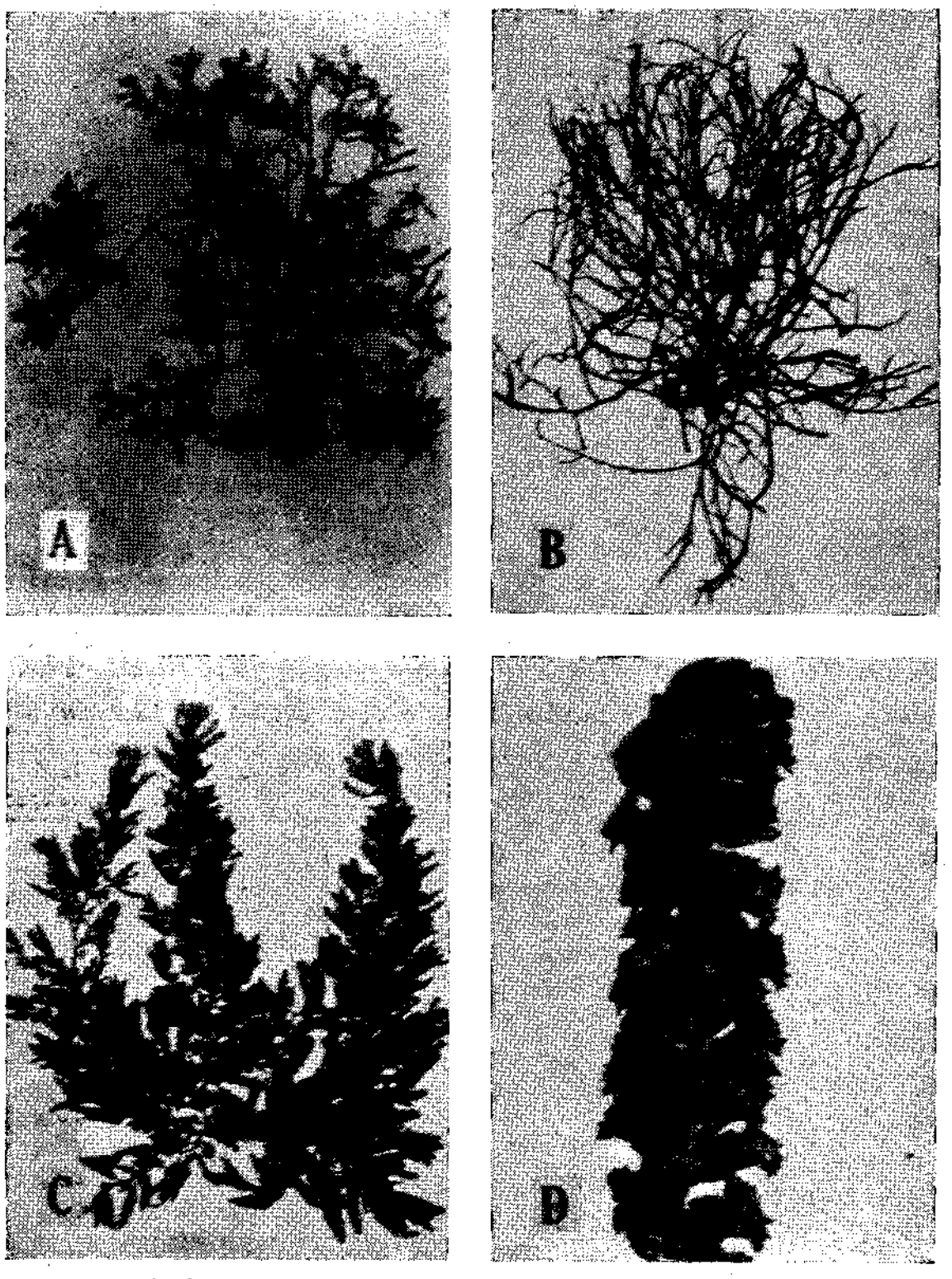

Fig. 1. A. *Gelidiella acerosa;* B. *Gracilaria edulis*
C. *Sargassum duplicatum;* D. *Turbinaria ornata*

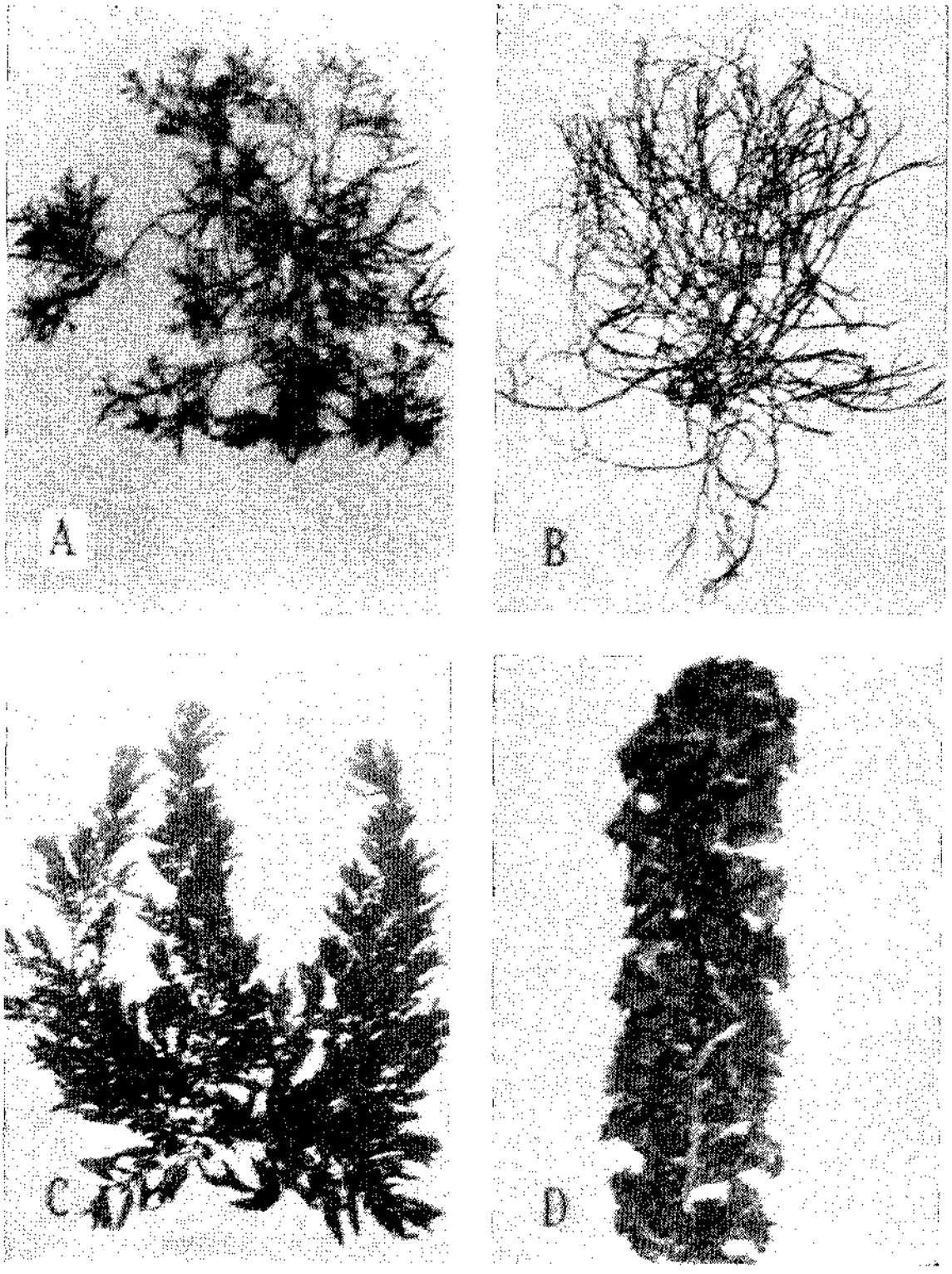

Fig. 1 A. *Gelidiella acerosa;* B. *Gracilaria edulis*
C. *Sargassum duplicatum;* D. *Turbinaria ornata*

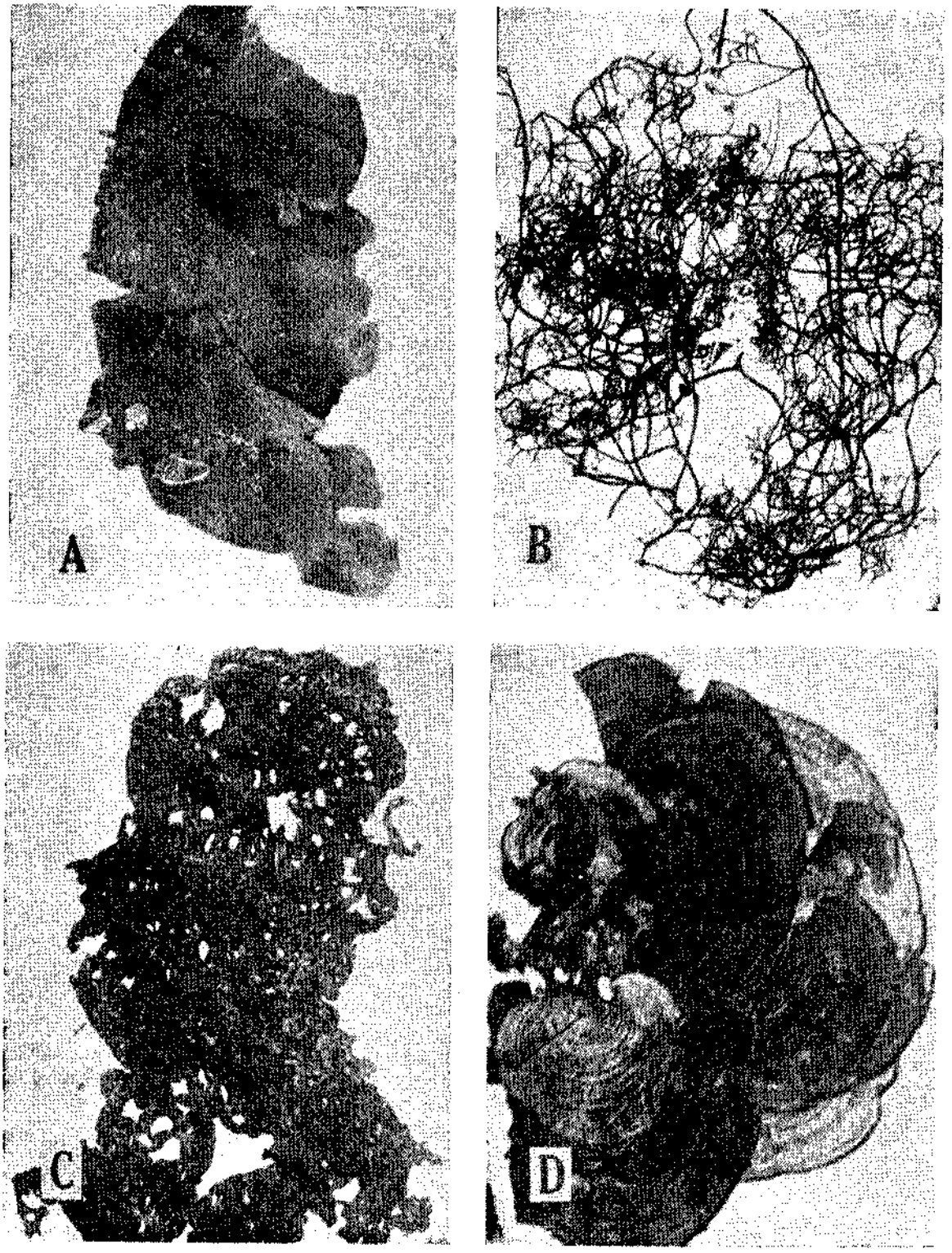

Fig. 2. A. *Dictyosphaeria cavernosa;* B. *Chnoospora implexa*
C. *Hydroclathrus clathratus;* D. *Padina boergeseni*

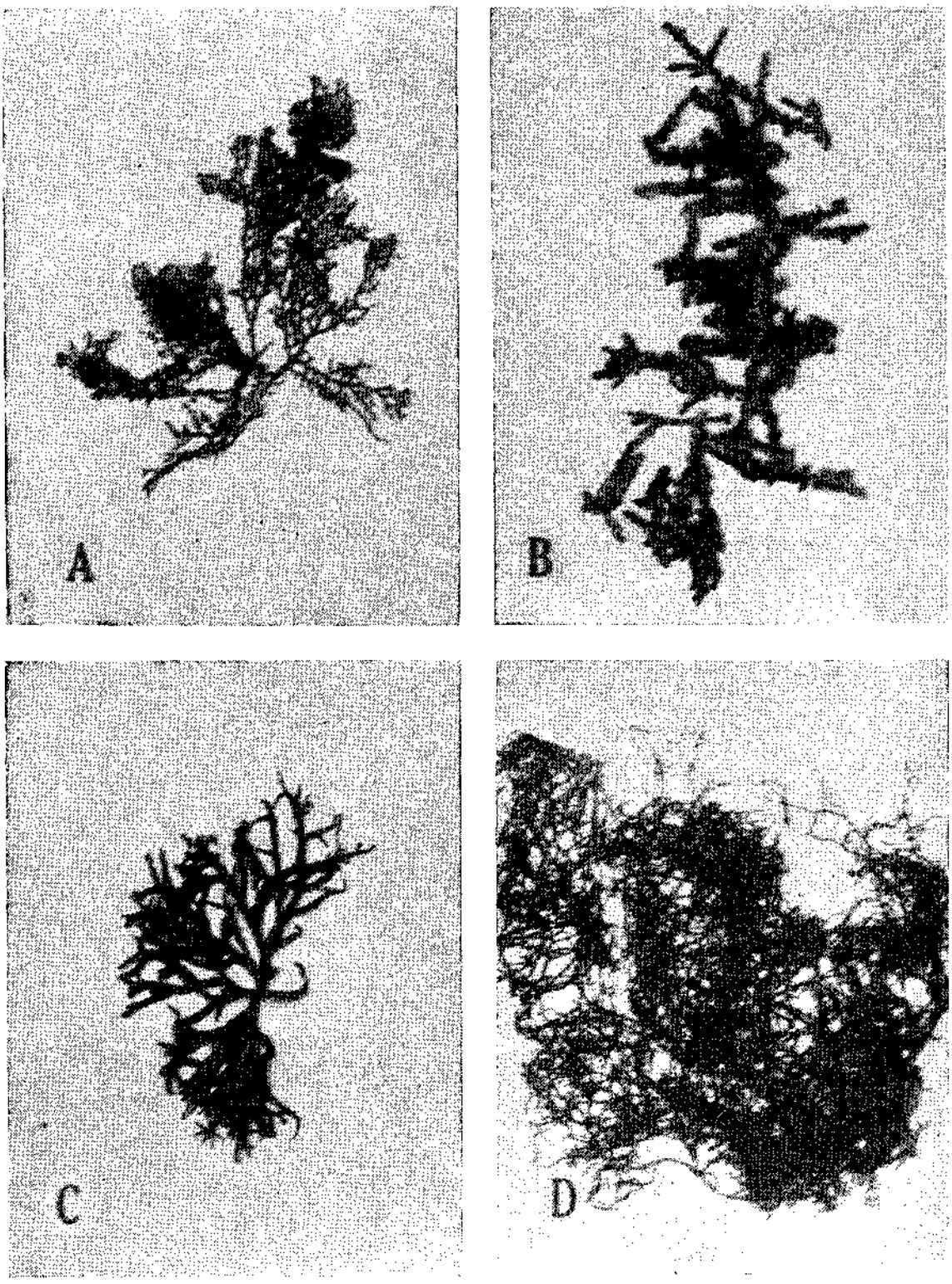

Fig. 3. A. *Chondrococcus hornemanii;* B. *Laurencia papillosa;* C. *Gracilaria arcuata;* D. *Hypnea valentiae*

Table 3 Estimated standing crop of agarophytes, alginophytes and other seaweeds in the islands of Lakshadweep

Name of the island	Agarophytes		Alginophytes		Other seaweeds	Total
	G. acerosa	*G. edulis*	*Sargassum* ssp	*Turbinarie* ssp		
Chetlat	18.440	—	18.160	165.700	603.380	805.680
Kiltan	25.900	—	11.200	67.000	561.660	665.760
Kadamat	143.200	—	18.400	127.700	695.070	984.370
Amini	72.400	—	—	84.200	357.150	513.750
Bitra	—	—	—	642.600	342.900	985.500
Bingatum	2.640	—	—	235.200	256.800	494.640
Agatti	6.325	415.250	—	768 075	2647.150	3836.800
Androth	0.800	—	0.100	2.200	273.600	276.700
Kavaratti	46.354	313.295	—	355.950	2167.208	2882.807
Kalpeni	30.725	70.175	0.350	18.200	1441.300	1560.300
Suheli	9.000	—	49.500	783.000	3796.260	4637.760
Minicoy	16.400	—	—	50.000	1635.000	1701.400
Total	371.734	798.720	97.710	3299.825	14777.478	19345.467

alginophytes and 695.070 tonnes are other species.

Amini: from the potential area of 148 ha 27 species of seaweeds are recorded, The estimable biomass (wet) of seaweeds is 513. 750 tonnes consisting of 72.400 tonnes of agarophytes, 84.200 tonnes of alginophytes and 355.150 tonnes of other algae.

Bitra: It has a very extensive lagoon with very deep middle area. the shore area is sandy and devoid of vegetation. Algal vegetation occurs in the areas extending from the reef to the middle lagoon attached to the dead corals. Among the islands surveyed, minimum number of algal species (18 species) were recorded with a total standing crop of 985.5 tonnes (wet weight). *Turbinaria ornata* is the only economically important alga growing in this island with a harvestable standing crop of 642.600 tonnes (wet weight).

Bangaram: The lagoon encircles four islands namely Bangaram, Tinnakara, Cheriya Parali and Valia Parali islands. The shore area is sandy and the vegetation is less with the growth of *Cladophora fasciculrais* and *Cheatomorpha area* attached to pebbles. *Gracilaria edulis* and *Sargassum* spp were not recorded. The standing crop of *Gelidiella acerosa* and *Turbinaria ornata* is 2.640 and 235.200 tonnes (wet weight) respectively. A total number of 32 species with a total standing crop of 494 640 tonnes were recorded.

Agatti; It consists of two islands, Agatti and Kalpitti. The lagoon exists in the western side. In the eastern side of the island the entire shore area is with rocks, dead corals and live corals. Totally 37 species with a standing crop of 3836.800 tonnes were recorded. Among the three islands with *Gracilaria edulis* vegetation, maximum biomass of G. *edulis* (415.250 tonnes-wet weight) was observed in Agatti. *G. edulis* was found growing attached to seagrasses in the nearshore area of the lagoon. *Gelidiella acerosa* and *Turbinaria ornata* occurred on the reefs in the eastern and western side of the island with a standing crop of 6.325 and 768.075 onnes respectively. *Sargassum* sp was not recorded in this island.

Androth: There is no lagoon in this island. Totally 38 species of algae were recorded. *Gelidiella acerosa* and *Turbinaria* ssp. were distributed sparsely on the reef at northern and southern side of the island in very small quantity. Very young plants of *Sargassum* sp were seen on the reef in the southern side

while *Gracilaria edulis* was not observed in this island. Among all islands surveyed the tatal standing crop of seaweeds was found to be very less in this island and it was only 276.700, tonnes (wet weight).

Kavaratti: Altogether 47 algal species with total biomass of 2882.807 tonnes (wet weight) were recorded in this island. More number of algal species were found growing in the lagoon side of the island. The vegetation was poor on the opposite side of the lagoon with only 10 species. *Gelidiella acerosa* and *Turbinaria ornata* occurred almost continuously in 50 m wide zone along the reef in the lagoon side. *Gracilaria edulis* was distributed discontinuously in the nearshore area of lagoon at the depth ranging from 0.5 to 3.0 m.

Kalpeni : It consists of 8 islands namely Cheriyam, Kodithala, Kalpeni, Tilakkam I, II and III and Pitti I and II. Maximum number of algae (64 species) with a total standing crop of 1560.300 tonnes (wet weight) were found growing in this island. Harvestable quantity of *Gelidiella acerosa* (30.275 tonnes - wet weight) occurred continuously in the 10 m wide zone of the intertidal rocky region from the light house in the northern side to the southern end of the island. *Gracilaria edulis* was found in 0 5 m depth near the jetty and in 1.0 m depth in the nearshore area of the lagoon at the southern end of Cheriyam island. Species of *Turbinaria* was sparsely distributed on the reefs at both sides of the island and it was not available in harvestable quantity (18.200 tonnes-wet weight). *Sargassum* spp with standing crop of only 0.350 tonnes (wet weight) were seen in the intertidal rocky area at the eastern side of the island.

Suheli: It consists of 2 islands namely Valiakara and Cheriakara with a wide lagoon. Totally 33 species of marine algae occurred in the submerged reef, lagoon and in the intertidal area around Cheriakara island. Among all the islands surveyed, maximum standing crop of seaweeds (4637.760 tonnes wet weight) occurred in Suheli. Abundant growth of *Turbinaria* spp (3796.260 tonnes wet weight) were seen in about 20 m wide zone along the entire reef area with continuous distribution. Detached plants of *Turbinaria* were seen floating on the sea around these two islands and large quantity was cast ashore. Plants of *Gelidiella acerosa* and *Sargassum duplicatum* were found on the reef. *Gracilaria edulis* was not observed at Suheli.

Minicoy : It consists of 2 islands Minicoy and Viringil with a vast lagoon. A total number of 52 algal species with a standing crop of 1701.400 tonnes (wet weight) was recorded in this island. *Gelidiella acerosa* and *Turbinaria ornata* occurred in the lagoon and the reef area around the islands. Only few plants of *Sargassum* sp were seen on the reef in the other side of the island and *Gracilaria edulis* was not observed in Minicoy.

REMARKS

The present survey indicates that seaweed and seagrasses resources of Lakshadweep is quite considerable in quantity. Harvestable quantities of agar yielding seaweeds *Gelidiella acerosa* and *Gracilaria edulis* are available at Kadmat, Amini, Agatti and Kalpeni and algin yielding seaweed *Turbinaria* spp in all islands. At present no commercial harvest of seaweeds is in practise in Lakshadweep. Hence the seaweed industry in the mainland can exploit these seaweeds from the above mentioned islands for manufacture of agar-agar and algin. Based on the available agarophytes and alginophytes resources agar and algin industry could also be established in Lakshadweep.

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Table 2. List of seaweeds and seagrasses collected from Lakshadweep

S. No.	Species	Chetlat (1)	Kiltan (2)	Kadmat (3)	Amini (4)	Bitra (5)	Bingaram (6)	Agatti (7)	Androth (8)	Kavaratti (9)	Kalpeni (10)	suheli (11)	Minicoy (12)
	Class: Chlorophyceae Order: Ulvales Family: Ulvaceae												
1.	*Enteromorpha clathrata* (Roth) J. Ag.							+					
2.	*E. compressa* (Linn.) Grev.		+	+	+		+				+	+	+
3.	*E. Intestinalis* (Linn.) Link	+		+	+								
4.	*E. tubulosa* Kuetz.							+		+			

S. No.	Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
5.	*Ulva lactuca* Linn.	+	+	+	+		+	+	+	+	+		+
6.	*U. reticulata* Forsskal							+					
	Order: Cladophorales												
	Family: Cladophoraceae												
7.	*Chaetomorpha aerea* (Dillw.) Kuetz.	+	+				+	+	+	+	+		+
8.	*C. antennina* (Bory) Kuetz.												+
9.	*C. linoides* (Ag.) Kuetz.	+	+	+	+						+	+	+
10.	*C. tortuosa* Kuetz.									+			
11.	*Cladophora fascicularis* (Mertens) Kuetz.	+					+	+	+		+	+	
12.	*Cladophora sp*			+	+			+	+	+	+	+	+
	Order : Siphonales												
	Family : Derbesiaceae												
13.	*Derbesia turbinata* Howe et Hoyt										+		
	Family: Bryopsidaceae												
14.	*Bryopsis pennata* Lamour.										+		
15.	*B. plumosa* (*Huds.*) *Ag.*	+	+		+						+		
	Family: Caulerpaceae												
16.	*Caulerpa cupressoides* (Vahl.) Ag.				+						+		+
17.	*C. microphysa* (Web. van Bosse) Feldmann										+		
18.	C. *peltata* Lamour.								+	+	+		+
19.	*C. racemosa* var. *macrophysa* (Kuetz.) Taylor	+	+								+		+
20.	*racemosa* var. *laetevirens f. cylindracea* (Sonder) Weber van Bosse												+
21.	*C. serrulata* var. *typica f. lata* (Weber van Bosse) Tseng		+				+						
22.	*C. sertularioides* (Gmelin) Howe										+		
23.	*C. taxifolia* (Vahl.) C. Ag.												+
24.	*Caulerpa sp*												+
	Family: Codiaceae												
25.	*Avrainvillea ridleyii*		+							+			
26.	*Codium adhaerens* Anderson		+		+					+	+		
27.	*C. tomentosum* (Hudson) Stackhouse		+										

+ Present

S. No.	Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
28.	*Codium* sp					—				—			
29	*Halimeda gracilis* Harv. ex J. Ag.	—	—	—	—	—	—	—	—	—	—	—	—
30.	H. *incrassata*										—		
31.	*H. macroloba* Decaisne								—		—		
32.	*H. opuntia f typica* (Lamour.) Barton									—	—		
33.	*Penicillus sibogae* Gepp.										—		—
	Family: Valoniaceae												
34.	*Anadyomene stellata* (Wulf. C. Ag.	—			—	—				—	—	—	—
35.	*Boergesenia forbesii* (Harv). Feldmann	—	—	—	—			—	—	—	—		—
36.	*Cladophoropsis zollingeri* (Keutz.) Boergs.	—	—	—	—	—		—					
37.	*Dictyosphaeria cavernosa* (Forssk.) Boergs.		—					—	—	—	—		—
38.	*D. favulosa* (Ag.) Decaisne								—	—	—	—	—
39.	*Microdictyon tenuis* (Ag.) Decaisne							—					
40.	*Valonia aegagrophila* C. Ag.	—		—						—			
41.	*V. macrophysa*										—		—
42.	*Valonia* sp												—
43.	*Valoniopsis pachynema* (Mertens) Boergs.								—	—			—
	Class: Phaeophyceae Order: Ectocarpales Family : Ectocarpaceae												
44.	*Ectocarpus* sp								—	—	—		—
	Order: Sphacelariales Family: Sphacelariaceae												
45.	*Sphacelaria furcigera* Kuetz.										—	—	
	Order: Dictyotales Family: Dictyotaceae												
46.	*Dictyopteris delicatula* Lamour.						—						
47.	*Dictyota barayresiana* Lamour.			—				—	—	—	—	—	—
48.	*D. dichotoma* (Huds.) Lamour.	—					—	—					
49.	*Padina boergesenii* Allender et Kraft	—		—	—	—	—	—	—	—	—	—	—

— Present

S. No.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
50.	*Lobophora minima* (Umamaheswara Rao) Krishnamurthy and Baluswami					—			—		—	—	—
	Order: Dictyosiphonales Family: Punctariaceae												
51.	*Hydroclathrus clathratus* C. Ag.							—	—				
52.	*Rosenvingea intricata* (J. Ag.) Boergs											—	
	Family: Chnoosporaceae												
53.	*Chnoospora implexa*	—		—			—	—			—		
	Order: Fucales Family: Sargassaceae												
54.	*Sargassum duplicatum* J. Ag.	—	—	—	—						—	—	
55.	*Sargassum* sp								—		—		—
56.	*Turbinaria conoides* (J. Ag.) Kuetz.								—		—	—	
57.	*T. ornata* J. Ag.	—	—	—	—	—	—	—	—	—	—	—	—
	Class: Rhodophyceae Order: Nemalionales Family: Chandransiaceae												
58.	*Acrochaetium* sp						—						
	Family: Chaetagiaceae												
59.	*Actinotrichia fragilis* (Forssk.) Boergs.							—		—	—		—
60.	*Galaxaura marginata* Lamour.												—
61.	*G. rugosa* Lamour. Family: Bonnemaisoniaceae				—								
62.	*Asparagopsis taxiformis* (Delile) Collins et Harvey								—	—	—	—	—
	Order : Gelidiales Family: Gelidiaceae												
63.	*Gelidium pusillum* (Stackhouse) Le Jolis	—			—				—		—		
64.	*Pterocladia heteroplaots* (Boergs.) Umamaheswara Rao and Kaliaperumal Family: Gelidiellaceae						—	—		—	—		—
65.	*Gelidiellacaea acerosa* (Forsk.) Feldmann et Hamel	—	—	—	—		—	—	—	—	—	—	—

— Present

S. No.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
66.	*G. indica* P. S. Rao										—		—
	Order: Cryptomemiales Family: Rhizophyllidaceae												
67.	*Chonerococcus hornemanii* (Mert.) Schmitz	—	—	—		—	—	—	—	—	—		—
	Family: Corallinaceae												
68.	*Amphiro anceps* (Lamk.) Decsne.	—	—										
69.	*A. fragilissima* (L.) Lamour.							—	—				—
70.	*Amphiroa* sp										—		
71.	*Cheilosporum spectabile* Harvay												—
72.	*Janie capillaceae* Harvey	—	—	—	—	—	—	—	—	—	—	—	—
73.	*J. iyengarii*			—									
74.	*Lithothamnion* sp										—	—	
	Family: Grateloupiaceae												
75.	*Halymenia floresia* (Clem.) Ag.		—	—						—			
76.	*H. gelinickii* Gruenow						—						
	Order: Gigartinales Family: Gracilariaceae												
77.	*Gelidiopsis intricata* (Ag. Vickers	—											
78.	*G. variabilis* (Grev.) Schmitz	—	—	—	—	—	—	—	—	—	—	—	—
79.	*Gracileria arcuata* Zanard.						—		—				
80.	*G. edulis* (Gmel.) Silva							—	—	—			
81.	*Gracilaria* sp				—				—				—
	Family: Solieriaceae												
82.	*Sarconema filiforme* (Sond.) Kylin						—						
83.	*S. furcellatum* Zanard.							—					
	Family: Hynpeaceae												
84.	*Hypnea musciformis* (Wulf.) Lamour.						—						—
85.	*H. pannosa* J. Ag.	—	—	—		—	—	—	—	—	—	—	—
86.	*H. spinella* J. Ag.						—	—		—			
87.	*H. valentiae* (Turn.) Mont.	—	—	—	—	—	—	—	—	—	—	—	—
	Family: Gigartinaceae												
88.	*Gigartina acicularis* (Wulf.) Lamour.										—	—	

— Present

S. No.	Species	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Order: Rhodymeniales												
	Family: Lomentariaceae												
89.	*Chimpia parvula* (Ag.) Harvey		—				—		—	—		—	
	Order: Ceramiales	—	—	—	—	—		—		—	—		—
	Family: Ceramiaceae												
90.	*Centroceras clavulatum* (Ag.) Mont.												
91.	*Ceramium diaphanum*					—							
92.	C. *fimbriatum* Setchell and Gardner						—			—	—	—	
93.	*Ceramium* sp	—	—	—									—
94	*Spyridia alternans* Boergs.											—	
95.	S. *filamentosa* (Wulf.) Harvey	—	—		—		—			—	—		
	Family : Dasyaceae												
96.	*Dictyurus purpuresens*	—									—		
	Family : Rhodomelaceae												
97.	*Acanthophora dendroides* Harvey									•		—	
98.	*Spicifera* (Vahl.) Boergs.		—	—	—	—	—	—	—	—	—	—	—
99.	*Chondira dasyphylla*								—	—	—		—
100.	C. *transversalis* Boergs.			—									
101.	*Herposiphonia secunda* (C. Ag.) Ambronn									—			
102.	*Laurenica ceylanica* J. Ag.							—		—			
103.	*L. nana* Howe							—					
104.	*L. obtusa* (Huds.) Lamour.							—	—		—		—
105.	*L. papillosa* (Forssk.) Greville	—	—	—	—	—	—	—	—	—	—	—	—
106.	*L. parvula* Boergs.	—	—										
107.	*L. poitei* (Lamour.) Howe	—	—	—					—	—	—	—	—
108.	*Laurenica* sp		—	—						—	—		
109.	*Leveillea jungermannioidea* (Martet Hering) Harvey				—	—	—				—		
110.	*Lophocladia lallemaudi* (Mont.) Schimtz											—	
111.	*Tolypocladia glomeruleta* (Sonder) Silva						—		—		—		—

— Present

S. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Class: Cyanophyceae												
Order: Nostacales												
Family: Oscillatoriaceae												
112. *Lyngbya confervoiees* C. Ag. Gomont					—		—	—	—	—	—	—
113. *Oscillatoria* sp									—		—	
114. *Phormidium* sp								—	—	—		—
SEAGRASSES												
Family: Potomogetanaceae												
1. *Cymodocea rotundata* Ehrenb. & Hemp. ex Aschers						—	—		—	—		
2. *C. serrulata* (R. Br.) Aschers & Magnus	—		—	—			—		—	—		—
3. *Holodule unirervis* (Forssk.) Aschers												—
4. *Syringodium isoetifolium* (Aschers) Dandy									—			—
Family: Hydrocharitaceae												
5. *Halophila ovata* Gaudin Freycin											—	—
6. *Thalassia hemprichii* (Ehrenb.) Aschers			—	—				—	—	—		

— Present

15. TURTLE RESOURCES

R. S. Lal Mohan

The common species of marine turtles namely *Chelonia mydas, Lepidochelus olivacea, Eretmochelys imbricata* and the *Dermochelys coriacea* are known to occur in the Lakshadweep Islands. (Bhasker, 1978a, b, c, d; 1979 Silas, 1984). Earlier reports deal with its occurrence, nesting habits, and trade (Ellis, 1924; Rammunni, 1965 and Mannadiar, 1976); Bhasker (op. cit) made detailed investigations and monitored the frequency of nesting, seasons of nesting and the occurrence of various species of turtles in the Islands. However the turtles of Lakshadweep require more attention with special reference to its reproductive bilogy, feeding habit and behaviour. The breeding population of *Chelonia mydas* needs special attention as the species does not nest in large numbers along the mainland.

The study was carried out from January to April 1987 covering all the inhabited and and a few uninhabited islands as a part of the effort to estimate the fishery potentials of the Lakshadweep islands. The information on the nesting, and nesting habits were collcted by observing the areas during the night and investigating the ecology of the nest. The ecology of the feeding grounds were studied by underwater observations by skin diving with the help of mask, snorkal and fins. The sea weeds and sea grasses were collected, identified and the total biomass was estimated for the major species.

The islands visited during the course of the study were Chetlat, Kiltan, Kadmat, Amini, Bitra, Agatti, Bangaram, Tinnakara, Kavarati, Suheli (Valiyakara and Cheriyakara), Kalpeni including Cheriyams, Androth and Minicoy.

Nesting grounds

Nesting grounds of *Chelonia mydas* were observed in Suheli Valiyakara, Tinnakara, Bangaram, Parli and Agatti. The largest nesting ground was found on the north eastern shore of Suheli Valiyakara (Lat: N. 10°, 08° long: E. 72°-18-20"). This island has a total area of about 0.5km² (48.56 Hectares). Seashore on the western side of the island is formed by the coral stones while about 100 meters on the north eastern side is sandy where the nests are made. The turtles make their nests about 20 meters away from the high tide mark below the thick growth of Rhododendron bushes locally known as 'Kanni,. Maximum number of nests found on the Suheli Valiyakara was 202 during June to Septmber, 1977. (Kar and Bhaskar, 1982). The number has come down to 119-132 nests during May to October, 1982. These nests were made by 20-27 turtles. However during the present investigation about 130 nesting craters were observed. The average length, breadth and the depth of five nesting crater were 219cm, 225cm, 62.5cm, respectively. The average distance between the craters was 45 cm. The turtle track of the *Chelonia mydas* on the Valiyakara beach measured 106 cm in width anteriorly 166 cm posteriorly and the width of lateral marking was 36 cm.

The nesting intensity was much less in other islands and no nesting was observed during the visit. At Tannakara, Bangaram, Pitti and Parli the number of nests observed were 11, 15, 8 and 10 respectively. (Bhasker, 1984).

2. *Nesting population*:- The nesting population of *Chelonia mydas* in Suheli par (Valiyakara) may be about 30 and that of all the other islands may be about 15. The intensity of nesting of other species of turtles in the Lakshadweep is less. One *Dermochelys coriacaea* nest was reported from Pitti island. (Silas; 1984).

3. *Nesting seasons*:- The peak nesting season for the green turtle is during the south-west monsoon, starting from June to September though a few nests may be made during other months also. Bhaskar (1984) observed 119-135 nests in Suheli Valiyakara made by 22-27 turtles during S. W. monsoon period from May to October. However, the collection

of neo-nates of *C. mydas* from Kadmat in February indicate that a few turtles may nest in December also. The Hawk bills and Olive ridley were found to nest in Androth, Kadmat, Agatti, Bangaram and Tinnakara. Silas (1984) recorded a nest of *Dermochelys coriacea* from the Pitty island on 5-2-'67.

During the present observation 28 species of sea weeds belonging to 24 genera were collected from the Suheli lagoon. Some of the species like *Gelidiella acerosa G. edulis,* and *sargassum* sp. were common forage species of C. *mydas.* Extensive beds of *Cymodoea* sp and *Halophila* ssp were observed in the

Table 1. Nesting sites or sighting of turtles in Lakshadweep islands

Name of	*E. mydas*		*L. olivacea*		*E. imbricata*		*D. coriaea*	
island	N	S	N	S	N	S	N	S
Chetlat	X	X	X	X	—	—	—	—
Kiltan	—	—	X	X	—	—	—	—
Kadmat	X	X	X	X	X	—	—	—
Amini	X	X	—	X	—	X	—	
Bitra	X	X	X	X	X	X	—	—
Agatti	X	X	X	X	X	X	—	—
Bangaram	X	X	X	X	X	X	—	—
Tinnakara	X	X	X	X	X	X	—	—
Pitti	—	—	—	—	—	—	X	—
Kavaratti	—	X	—	—	—	—	—	—
Suheli (Valiakara)	X	X	—	—	—	—	—	—
Kalpeni	—	X	—	X	—	—	—	—
Androth	—	X	X	—	X	—	—	—
Minicoy	—	X	—	X	—	—	—	—

N — Nesting S — Sighting

4. *Feeding grounds*:- Deraniyagala (1939) reports that *C. mydas* feeds on *Cymodocea halassia, Zostera, Halophila* and algae in Srilanka coast. Agastheesapillai and Thiagrajan (1979) found *Holophila ovalis, Thalassia testudinum, Gelidiella acerosa,* Cymodocea sp and other sea weeds in stomach of C. *mydas* caught from Gulf of Mannar and Palk Bay. Frazier (1971) found that turtles forage on Cymodocea sp., *Gelidium* sp., *Laurencia* and *Caulerpa* sp. in Aldabra Atoll. Hughes (1974) also observed *Gelidium, Codium duthieae* and *Caulerpa filiformes* in the stomach of green turtles of Mozambique. In Gulf of Aden, Hirth and Carr (1970) found that the green turtles feeds on *Posidonia oceanica* and *Syringodium* ssp. These studies illustrate that the green turtles feed on sea grasses and sea weeds.

lagoon. In Kalpeni 44 species of seaweeds were observed. The availability of *Gelidiella acerosa* the common food of the turtle was about 3 tonnes in the island, The other forage species of sea grass like *Cymodocea serrulata* C. *rotundata* and *Thalassia hemprichi* were found in abundance. *T. hemprichi* is one of the favoured forage species of C. *mydas.* (Mortimer, 1979). From Androth 39 species of sea weeds belonging to 28 genera were collected. *Gelidiella acerosa, Laurencia* spp. *Sargassum* spp. and *Thalassia hemprichi* were the common seaweeds and sea grasses found in the islands forming the food of C. *mydas.* The Minicoy island is also rich in seaweed and seagrass flora. 51 species belonging to 35 genera of seaweeds were observed in the lagoon. Of these green turtles feeds on

Gelidiella acrosa, *Sargassum* ssp. *Gracilaria edulis* and the seagrass *Cymodocea serrulata* *Halophlia ovata* and *H. uninervis*.

Similarly the lagoons of other islands also have extensive beds of seagrass and seaweeds on which the green turtles feed.

5. *Feeding population*:- During the survey, the turtles were observed in all the lagoons. The number of green turtles sighted in Suheliper were 17 whereas in Kalpeni, Kavaratti and Minicoy the number of turtles seen were 5, 4 and 7. In all the islands the estimated C. *mydas* population may be about 100. Two pairs of C. *mydas* were found mating on Kalpeni lagoon on 22-3-87. The mating of C. *mydas* was also observed in the lagoons of Kadmat and Bangaram.

6. *Fishery*:- Turtles are caught in the islands for meat, oil and shell. The turtle oil is used for painting the boats and making the screws of boats watertight. However there is no quantitative record of the turtle products used. It is estimated that about 59 turtles are killed annually in all the islands for their products. The turtles are caught by barbed harpoons by the islanders. The fishermen stand on the boat throw the harpoon on the feeding turtles and haul it up in to the boat. The turtles are caught as bycatch in the gill nets also.

7. *Conservation*:- The nesting ground of marine turtles of Lakshadweep are gradually shrinking due to human activities. Human population is increasing in the islands though the area available is limited. The total land area of the ten inhabited and 17 uninhabited islands is 28.5 Km^2 with a population of about 35.000. Hence the density of population is 1,228/Km^2 on the whole and 1315/Km^2 in the inhabited islands. Hence the conflict between the environmental preservation and human activities is inevitable. For example the number of fishing boats havs increased from 145 in 1978 to 350 boats in 1987. But all the islands cannot be inhabited due to the non-availability of fresh water. Hence at least the un-inhabited island may not become populated. One such island is Suheli Valiyakara. So it may be possible to declare the island as a sanctuary for the green turtle. The light house constructed very near to the turtle nesting site may have adverse effect on the nesting activities. Hence it should be shifted to some other place.

The turtles in the lagoon also should be protected from being killed. It is essential that the feeding population should be protected, The trade of the products of turtles like turtle scutes, turtles meat and turtle oil should be prohibited under appropriate provision of the Indian wild Life Act 1972.

8. *Recommandation*:-

1) Suheli Valiyakara and its lagoons should be declared as the sanctuary for *Chelonia mydas*. The human activities in the island should be reduced to minimum. The light house near the nesting site at Suheli Valiyakara may be shifted as it can disturb the nesting turtles. (2) The lagoon should be preserved as it has a feeding population of green turtles (3) Studies on reproductive parmeters, feeding, migration and behaviour of the green turtle should be undertaken.

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16. THE CORAL FAUNA OF LAKSHADWEEP

C. S. Gopinadha Pillai and S. Jasmine

INTRODUCTION

Despite the early works of Gardiner (1904, 1905) and Pillai (1971, 1971a, 1986, 1986a, 1987) the coral fauna of Lakshadweep, except for Minicoy, remained virtually unknown to the scientific community. A resume of corals and coral reef research from this area is presented by Pillai (1987) along with a discussion on the structure and composition of the fauna. During the survey of the marine resources by the Institute, corals were also collected from the various islands in Lakshadweep, and the present report embodies the information thus gathered along with data gleened from early literature. A detailed taxonomic treatment of the various species is not attempted in this communication. The material will be described in future work. An asterisk indicates a new record to this area. The classification adopted is that of Vaughan and Wells (1943) as modified by Wells (1956)

COMPOSITION OF THE CORAL FAUNA

In a previous paper, Pillai (1987) reported a total of 78 species of corals divided among 31 genera from Lakshadweep which was based on Minicoy and Kiltan. Out of these 27 genera and 69 species are hermatypes and the rest ahermatypes. Pillai (loc. cit) also felt that 40 to 45 genera of corals should occur in Lakshadweep. In the present account a total of 104 scleractinian corals divided among 37 genera are reported. Among the non. scleractanians, *Millepora*. *Heliopora* and *Tubipora* (The last mentioned for the first time) are also recorded. Out of the 104 species of scleractinians, 26 species including a few hitherto undescribed are new records to Lakshadweep waters. *Alveopora*, *Polyphyllia*, *Cyphastrea*, *Echinopora* and *Tubastrea* are the genera newly recorded. The present collection has also enchanced our knowledge of *Montipora* from

here which was previously known by a single species. However, a few widespread but less common Indo Pacific genera such as *Coscinarea, Siderastrea, Pachyseris, Oulophyllia, Trachyphyllia, Mycedium, Oxypora, Pierogyra* and *Seriatopora* still await detection from the reefs of Lakshadweep.

The following is a numerical representation of the various genera and species of scleractinians so far known from the different islands of Lakshadweep. Details of distribution of recorded genera are given below.

Island	*No. of genera*	*No of species*
Minicoy	28	73
Suheli	7	11
Kavaratti	18	38
Kalpeni	11	23
Androth	7	15
Agatti	10	27
Bingaram	5	8
Amini	15	37
Kadamat	21	43
Kiltan	19	42
Chetlat	23	57
Bitra	6	15
Total for Lakshadweep	37	103
Subgenus	1	1

The relatively low number of genera in some islands is not altogether a clear reflection of the paucity of the fauna. It can be due to less intense collecting. However, a sort of natural variation in the composition of the fauna at generic level seems to occur between Minicoy and the rest of the islands in the archipelago. For example, *Diploastrea, Podabacia* and *Lobophyllia* occured in Minicoy but were not found in central and northern islands. *Montipora* and *Cyphastrea* along with *Echinopora* are recorded from northern islands while *Cyphastrea* and *Echinopora* was never seen in the shallow waters of Minicoy. The extreme south (Minicoy) and north (Chetlat) have yielded the maximum number of genera and species.

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THE CORAL FAUNA

CLASS. ANTHOZOA
Order SCLERACTINIA
Suborder ASTROCOENIINA
Family Thamnasteriidae
Genus Psammocora Dana, 1846

Psammocora contigua 1797 (Esper)
Fig 1

Fig. 1. *Psammocora contigus*

Localities: Minicoy, Kavaratti, Kalpeni, Agatti Amini, Kadmat, Kiltan, Chetlat.

Distribution: widely distributed throughout the Indo-Pacific from Red Sea to Tahiti.

Remarks: This ramose species is fairly common on both the reef flats and lagoon shoals. It is especially abundant at Chetlat lagoon where it grows mixed with *Porites* (*Synaraea*) *convexa* among *Heliopora*.

Psammocora digitata Milne Edwards and Haime, 1851

Localities: Minicoy, Amini and Chetlat.
Distribution: From Seychelles to Fiji Islands.
Remarks: This species is not common in Lakshadweep. It was cellected from the inner rreefs.

Psammocora haimeana Milne Edwards and Haime, 1851

Localities: Minicoy, Kavaratti, Agatti, Amini Kadmat, Chetlat.

Distribution: East coast of Africa, Red Sea Madagascar, Maldives, Lakshadweep, East Indies, Great Barrier Reef, Cocos-Keeling islands Marashall Islands.

Remarks: This encrusting species is found over-growing dead coralline material in the lagoon. A few colonies are lying free as submassive nodules over growing the substratum.

Psammocora profundacella Gradiner, 1898

Localities: Minicoy, Kavaratti, Kadmat

Distribution: South Africa, Mauritius, Lakshadweep, Andamans, Great Barrier Reef, Philippines, Taiwan, Japan, Funafuti, Fanning Island.

Remarks: Rare. Habitat the same as *P. haimeana*. The relationship between these two needs further studies.

Family Pocilloporidae

Genus *Pocillopora* Lamarck, 1816

Pocillopora damicornis (Linnaeus, 1758)

Localities: Found fairly common in all the islands of Lakshadweep.

Distribution Widespread from Red Sea to Hawaii in the Indo-Pacific.

Pocillopora ligulata Dana, 1846

Localities Minicoy, Chetlat.

Distribution: Maldives; Lakshadweep, Palau Island, Marshall Island, Solomon Islands, Cook Islands, Hawaii.

Remarks : Not very common. A few specimens were observed in Minicoy in 1969. The specific status of this species is still doubtful.

Pocillopora meandrina var *nobilis* Dana, 1846
Fig 2

Localities: Kalpeni, Androth. Agatti, Amini, Kadmat and Chetlat.

Distribution: Through out the Indo-Pacific but not Red Sea.

Remarks: Living colonies are not found in shallow waters. However dead branches are found washed ashore especialay at the windward side of the islands indicating that it lives in deeper surf beaten habitat.

Fig. 2. *Pocillopora meandrina* Var. *nobilis*

Pocillopora eydouxi Milne Edwards and Haime, 1860.

Localities: Minicoy, Kavaratti, Bitra.

Distribution: A fairly widespread Indo-Pacific species from Lakshadweep eastward to Hawaii.

Remarks: Living colonies rarely found in shallow reefs. Dead branches found washed ashore along with *P. meandrina, nobilis*.

Pocillopora verrucosa (Ellis and Solander, 1786

Localities: Minicoy, Suheli, Kalpeni, Bitra, Bangaram, Amini, Kadmat, Bitra.

Distribution: Red Rea (Scheer and Pillai, 1983) to Hawaii and Cook Islands.

Remarks: Lagoon and reef flats.

Genus *STYLOPHORA* Schweigger, 1819.

Stylophora pistillata (Esper, 1897)
Fig. 3

Localities: Minicoy, Amini, Kadmat, Kiltan, Chetlat.

Distribution: Red Sea eastward to Fiji and Samoa but not known from the southeast coast of India.

Remarks: The genus *Stylophora* is rare in Lakshadweep. Colonies were collected mostly from the inner protectd reefs.

Fig. 3. *Stylophora pistillata*

Family ACROPORIDAE Verrill, 1902

Genus *ACROPORA* Oken, 1815.

Acropora intermedia (Brook, 1891)

Localities: Minicoy, Kavaratti, Kalpeni, Agatti, Bangaram, Chetlat.

Distribution: Maldives, Lakshadweep, Great Barrier Reef.

Remarks: This arborescent species is found mixed with *A. formosa* in lagoon. These two are very close to each other except for the angle of the radial corallites.

Acropora formosa (Dana 1846)

Localities; Found in all the islands.

Distribution: East Africa eastward to Tuamotu Archipelago. Fairly common.

Remarks. The habitat is the same as *A. intermedia*.

Acropora abrotanoides (Lamarck, 1816)
Fig. 4

Localities : Minicoy, Kavaratti, Androth, Amini Kadmat, Chetlat.

Distribution: Maldives, Lakshadweep, Singapore, Great Barrier Reef, Marshall Islands, Tahiti, Cocos-Keeling Islands.

Remarks: The species which forms arborescent clusters with very thick main branches is common at the south side of the Minicoy atoll. On the reef flats the branches are more stunted.

Acropora efflorescens

Localities: Minicoy, (Pillai, 1971)

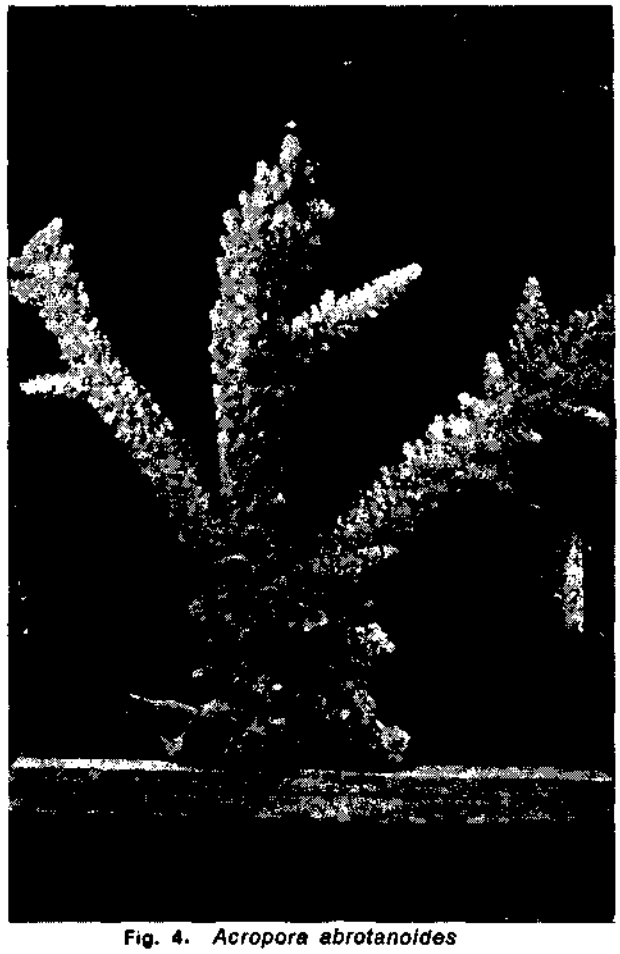

Fig. 4. *Acropora abrotanoides*

Distribution: Maldives, Lakshadweep Singapore, Sri Lanka.

Remarks: The species is rare in Minicoy. Only one colony was observed and collected.

Acropora robusta (Dana, 1846)

Locality: Minicoy.

Distribution: Chagos to Tahiti.

Remarks: This is the same as one reported by Pillai (1987) as *A conigera*. The species is essentially found on reef flat with a large encrusting base and thick stunted digitiform branches.

Acropora teres (Verrill, 1866)

Localities: Minicoy, Kalpeni, Agatti: Bitra. But should occur in all the islands.

Distribution: Maldives, Lakshadweep, China Sea, Philippines, Marshall Islands, Samoa.

Remarks: Forms large arborescent colonies in the deeper parts of the lagoon. It was very abundant in the southern half of Minicoy till seventies. Mostly dead at present.

Acropora irregularis (Brook, 1892)

Locality: Chetlat.

Distribution: Rodriguez, Seychelles, Maldives, Lakshadweep, Cocos-Keeling Islands.

Remarks: Only one colony was observed at the reef front of the lagoon reef of Chetlat in the deep groove.

Acropora corymbosa (Lamarck, 1816)
Fig. 5

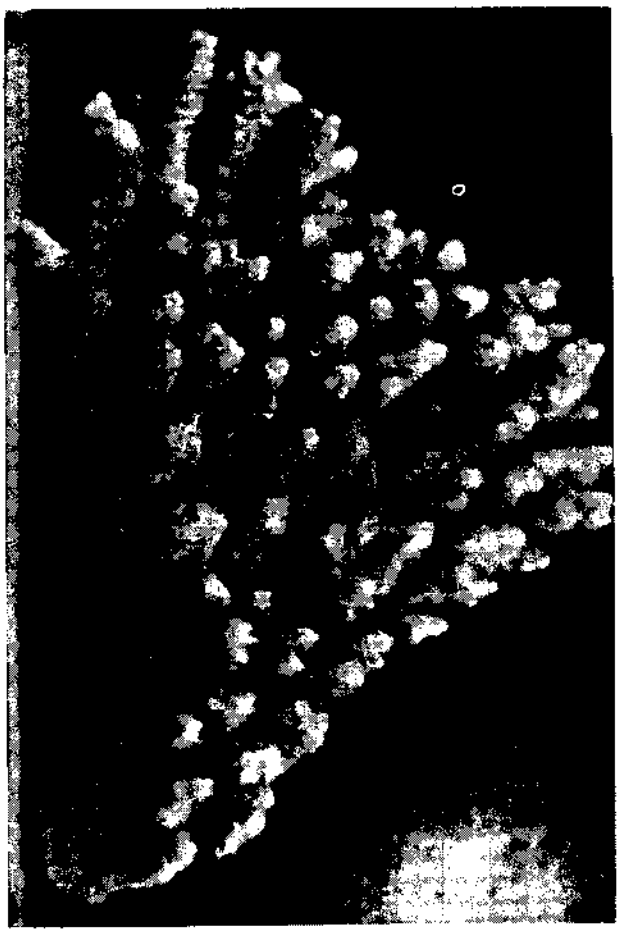

Fig. 5. *Acropora corymbosa*

Localities: Minicoy, Kavaratti, Kalpeni, Agatti, Amini, Kadmat, Kiltan and Chetlat. Probably occurs in all the islands.

Distribution: Red Sea, and eastward to Tuamotu Archipelago.

Remarks: Lagoon shoals and reef flat. A microhabitat for many economically important small species of fishes.

Acropora hyacinthus (Dana, 1846)

Localities: Found along with *A. corymbosa* in all localities.

Distribution. Red Sea eastward to Tuomotu Archipelago.

Acropora nasuta (Dana, 1846)

Localities: Minicoy, Kalpeni, Androth

Distribution: Widespread from Red Sea eastward to Tahiti.

Remarks: Reef flat and lagoon shoals as small corymbose or caespitose colonies.

Acropora humilis (Dana, 1846)
Fig. 6

Localities: This species occurs in all the atolls.

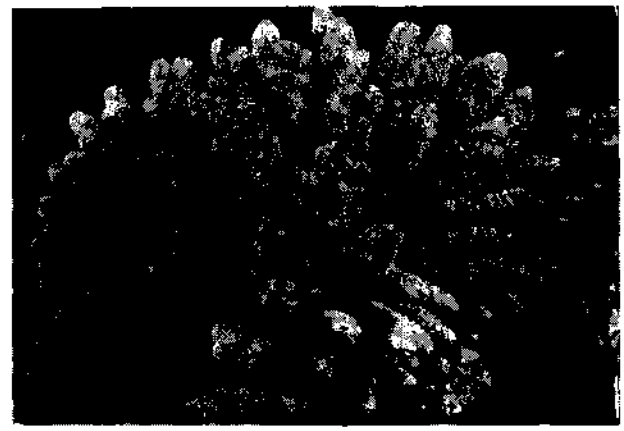

Fig. 6. *Acropora humilis*

It is fairly common both on lagoon and reef flats.

Distribution: A widespread and common Indo-Pacific species.

Acropara squarrosa (Ehrenberg, 1834)

Localities: Minicoy, Kavaratti.

Distribution: Red Sea, Seychelles, Maldives, Lakshadweep, Philippines, Great Barrier Reef, Murray Island, Marshall Islands and Tahiti.

Remarks: Not common.

Acropora monticulosa (Brueggemann, 1879)

Localities: Kadmat, Chetlat.

Distribution: Rodriguez, Lakshadweep, Eastern Australia.

Remarks: The identification of this species here in tentative. It's relationship with *A. conigera* needs further study.

Acropora granulosa (Milue Edwards and Haime, 1860)

Locality: Minicoy.

Distribution: Red Sea, Mascarene, Archipelago, Reunion, Maldives, Minicoy, Nicobar Islands, China Sea, Great Barrier Reef, Marshall Islands, Fiji, and Tahiti.

Remarks : A few specimens of this species was recorded from Minicoy in 1969 and reported under the name *A. ramableri* (Pillai 1971)

Acropora echinata (Dana, 1846)

Localities: Minicoy, Kavaratti, Kalpeni and Kiltan.

Distribution: Maldives, Lakshadweep, Marshall Islnds, Samoa.

Remarks: Not very common. Found in the deeper parts of the lagoon.

Acropora aspera Dana, 1846

Localities: Minicoy, Kavaratti, Agatti, Bangaram Amini, Kadmat, Kiltan, Chetlat, Bitra.

Distribution: Central Indian Ocean eastward to Fiji.

Remarks: Very common species throughout Lakshadweep both on lagoon and reef flats forming large thickets.

Acropora hemprichi (Ehrenberg, 1834)

Locality: Minicoy.

Distribution: Red Sea, East Africa, Mascarene Maldives, Minicoy, Sri Lanka, Great Barrier Reef, Solomon Islands.

Remerks: Rare. Was found mixed with other *Acropora* in Minicoy lagoon.

Acropora indica (Brook, 1893)

Localities: Minicoy, Kavaratti, Chetlat, Bitra.

Distribution: Lakshadweep, east coast of India.

Remarks; Isolated colonies of this species are found on open reef flats and inner lagoon reefs.

Acropora palifera (Lamarck, 1816)

Localities: Minicoy, Kavaratti, Agatti, Banagaram, Amini, Kadmat, Kiltan, Chetlat.

Distribution: Western Indian Ocean eastward to Samoa.

Remarks: *A. palifera* with large palmate branches is essentially a lagoon species throughout Lakshadweep. It is nowhere abundant.

Acropora forskali (Ehrenberg, 1834)

Localities: Minicoy (Pillai, 1971).

Distribution: Red Sea, Persian Gulf, Maldives, Minicoy.

Remarks: Rare. One colony was collected from Minicoy in 1969.

Genus *ASTREOPORA* de Blainville, 1830

Astreopora myriophthalma Lamarck, 1816

Localities: Minicoy, Kavaratti, Chetlat.

Disiribution: Widely distributed in tropical Indo-Pacific from Red Sea to the south Pacific.

Remarks: Found along with massive Porites on inner lagooh reefs. The species is common in Chetalt Island.

Astreopora listeri (Bernard, 1896)

Localities: Amini, Kadmat, Chetlat.

Distribution: Maldives, Lakshadweep, Nicobar Islands, Philippines, Marshall Islands, Cook Islands.

Remarks: The habitat is the same as *A. myriophthalma*

Genus *MONTIPORA* de Blainville

Montipora teberculosa (Lamarck, 1816)

Localities: Minicoy, Kadmat, Chetlat.

Disiribution: Wide spread Indo-Pacific species from Red Sea to Samoa.

Remarks: Mostly found as small encrustations on littoral reef flats.

Montipora explanata Brueggemann, 1897

Locality. Chetlat.

Distribution : Mauritius, Lakshadweep, south-east coast of India.

Remarks : This species was observed on the leeward reef flat of Chetlat island in fair numbers. Larger colonies were up to 30 cm in greater spread often with pink colour to the living corallum.

Montipora turgescens Bernard, 1897

Localities : Amini, Chetlat.

Disttibution : Central Indian Ocean, Great Barrier Reef, Solomon Islands, Philippines, Marshall Islands, Ellice Islands.

Remarks : Found as encrustations on reef flat.

Montipora venosa (Ehrenberg, 1834)

Locality : Amini, Chetlat.

Distribution : From Red Sea eastward to Marshall Islands.

Remarks : Rarely found on reef flat.

Monitipora foliosa (Pallas, 1766)
Fig. 7

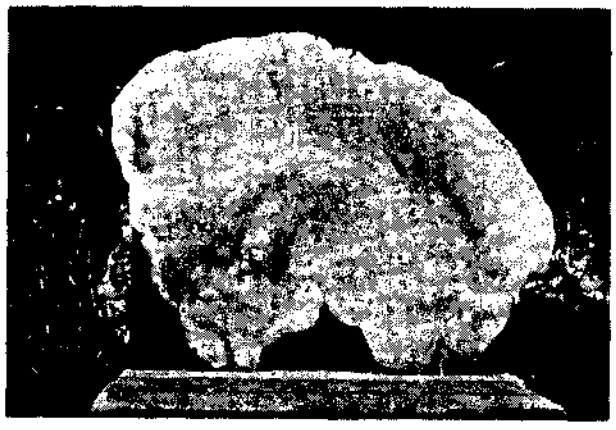

Fig. 7. *Montipora foliosa*

Localities : Kadmat and Chetlat.

Distribution : Indo-Pacific but not known from Red Sea.

Remarks : The species was found as forming small foliaceous colonies on the windward side of the reef at Kadmat. A few specimens from Chetlat from the same habitat was however, having closely set folia.

Montipora sp nov. 1

A few specimens obtained from Kadmat could not be placed satisfactorily to any of the known species known to the authors. These will be reported in a subsequent communication.

Montipora sp nov. 2

Localities : Amini, Chetlat. Reef flat.

Suborder FUNGIINA Verrill

Family AGARICIIDAE Gray

Genus *PAVONA* Lamarck, 1893.

pavona varians Verril, 1801
Fig. 8.

Localities: Minicoy, Kavaratti, Kalpeni, Androth, Kadmat, Kiltan Chetlat.

Distribution : Red Sea througout Indo-Pacific as far east as Panama.

Remarks: The species form small encrustations in all habitats. It is much more common on the northern Lakshadweep Islands than at Minicoy. Display wide range of skeletal variations.

Pavona maldivensis (Gardiner 1905.)

Localities : Minicoy (Gardiner, 1905), Chetlat.

Distribution: Red Sea, Maldives, Lakshadweep Nicobar Islands, East Indies, Palau Islands and Marshall Islands and Tahiti.

Fig. 8. *Pavona varians*

Remarks: Gardiner (1905) reported this species from Minicoy. But subsequent collections from Minicoy did not include this species. One specimen in the present collection is doubtfully placed under this species.

Pavona duerdeni Vaughan, 1907.

Localities : Minicoy, Kiltan and Chetlat.

Distribution : Abd-el-Kuri, Seychelles, Maldives. Lakshadweep, Nicobar Islands, Great Barrier Reef, Palau Islands, Caroli Islands, Marshall Islands and Hawaii.

Genus *GARDINEROSERIS* Scheer and Pillai, 1974

Gardineroseris planulata (Dana 1846)

Localities: Minicoy, Kavaratti, Kadmat, Chetlat.

Distribution : Red Sea, eastward to eastern Pacific.

Remarks : This species is found among lagoon shoals though not a conspicuous element of the coral fauna.

Family FUNGIIDAE Dana, 1846

Genus *CYCLOSERIS* Milne Edwards and Haime, 1849.

Cycloseris sp

Locality : Bangaram.

Remarks : There is only one specimen in the collection. Determination to species level is rather difficult.

Genus FUNGIA Lamarck, 1801

Fungia scutaria Lamarck, 1801.
Fig. 9

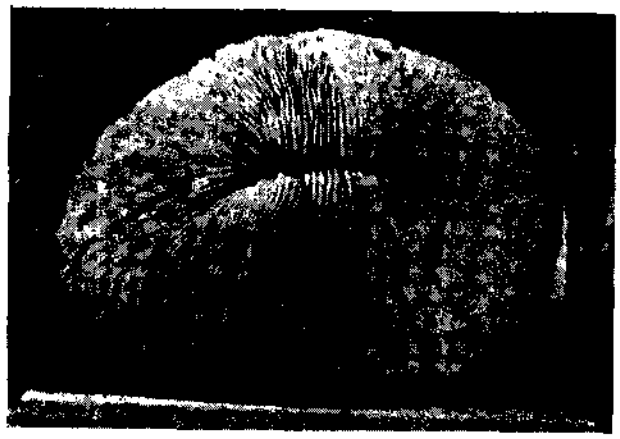

Fig. 9. *Fungia secutaria*

Localities: Minicoy, Kavaratti, Suheli, Androth, Agatti, Bangaram, Amini, Kadmat, Kiltan, Chetlat, Bitra.

Distribution : Widespread Indo-Pacific species from Red Sea to Tuamotu Archipelago.

Remarks : This is the most common species of *Fungia* found in Lakshadweep. Often found in lagoon shoals among *Acropra*. At Chetlat and Kadmat this species is extremely common.

Fungia somervillei Grandiner, 1901.

Locality: Minicoy.

Distribution: Seychelles, Lakshadweep, Amirantee, Nicobar Islands, Andamans, Mergui Archipelago, Sulu Sea.

Remarks: A Single specimen was collected in 1969 (Pillai, 1971). It was not found later in Minicoy nor the present collection include any.

Fungia danai Milne Edwards and Haime, 1851

Locality: Minicoy.

Distribution: Wide spread from Red Sea to Tahiti.

Remarks: A few large specimens of this species were collected from the southern half of the Minicoy lagoon in 1969. The present collection does not include any specimen of this species.

Fungia fungites ((Linnaues, 1758)

Locilities: Minicoy, Suheli, Androth, Agatti, Amini, Kadmat, Kiltan, Chetlat, Bitra.

Distribution: A very widespread Indo-Pacific species.

Remarks: Generally found on lagoon shoals in Lakshadweep.

Genus *POLYPHYLLIA* Quoy and Gaimard, 1830

Polyphyllia talpina (Lamarck, 1816)

Locality: Kadmat.

Distribution: Maldives, Lakshadweep, Mergui, Archipelago, Andaman, Nicobar Islands, Singapore, Philippines, Japan, Great Barrier reef, Palau Islands.

Remarks : Only one specimen of this species is obtained from Kadmat. The genus is rare in Lakshadweep reefs. It was found on the inner lagoon reef flat.

Genus *PODABACIA* Milne Edwards and Haime, 1849

Podabacia crustacea (Pallas, 1766)

Locality: Minicoy

Distribution: Red Sea east ward to Tuamotu Archipelago.

Remarks: This species is observed only at Minicoy near the Boaz Point towards the lagoon side at a site, where it is fairly common. It has a restricted occurrence in Minicoy.

Family PORITIDAE Gray, 1841

Genus *GONIOPOPRA* de Blainville, 1830

Though this genus is not profuse in Lakshadweep, the collection include at least four species. Two of them from the northern Lakshadweep appear to deserve new specific names, They are listed here as sp nov 1 and sp nov 2.

Goniopora stokesi Milne Edwards and Haime, 1860.

Localities: Minicoy, Kadmat.

Distribution : Red Sea, East Africa, Seychelles, Maldives, Lakshadweep, East coast of India, Nicobar Islands, Mergui Archipelago, East Indies, Philippines.

Remarks : This species is very conspicuous in living condition by its large expanded polyps during day time. It is rare in Lakshadweep.

Goniopora minor Crossland, 1952

Locality : Minicoy, Kiltan.

Distribution : Red Sea, Seychelles, Maldives, Lakshadweep, Sri Lanka, Great Barrier Reef, Philippines.

Goniopora sp nov. 1

Locality : Amini, Kadmat, Kiltan.

Goniopora sp. nov. 2

Localities : Amini, Kiltan.

Genus *PORITES* Link, 1807

The genus *Porites* is the most dominant coral on reefs in Lakshadweep though the number of species hitherto recorded is relatively low. Massive forms such as *P. solida, P. lutea* and *P. lobata* (tentative identification) are dominant on reef flats especially on the lagoon reefs in all the islands. The branching *Porites* such as *P. andrewsi and P. (Synaraea) convexa* are essentially lagoon forms. Two or three forms of *Porites* in the present collection could not be assigned to any named species known to the authors and appear to deserve new binominal names.

Porites solida (Forskal, 1775)

Localities : Minicoy, Kavaratti, Amini, Kadmat, Kiltan, Chetlat. This species should occur in all islands though not collected.

Distribution : Red Sea to Hawaii.

Remarks : Fairly common often forms large massive corallum.

Porites lutea Milne Edwards and Haime, 1860
Fig. 10

Fig. 10. *Porites lutea*

Localities: Minicoy, Suheli, Kavaratti, Kalpeni, Agatti, Amini, Kadmat, Chetlat, Bitra.

Distribution : Red Sea eastward in the Indo-Pacific as far east as Tuamotu Archipelago.

Remarks: Reef flats and lagoon, fairly common.

Porites lobota? Dana, 1846.

Localtiies: Kavaratti, Amini, Kadmat, Kiltan, Chetlat, Bitra.

Distribution : Lakshadweep, Nicobar Islands Great Barrier Reef, Hawaii, Galapagos Islands.

Porites lichen Dana, 1846.

Localities: Minicoy, Suheli, Kavaratti, Kalpeni Kiltan, Chetlat.

Distribution: Red Sea to Samoa and Fiji.

Remarks: Fairly common both on reef flat and lagoon. Small encrusting to submassive colonies occur in all habitats.

Porites sp nov. 1

Localities: Amini, Kadmat, Chetlat.

Bemarks: It is a massive species fairly common.

Porites sp nov. 2

Localities: Kadmat.

Remarks: Corallum massive.

Porites andrewsi Vaughan, 1918

Localities Minicoy, Kavaratti, Kalpeni, Agatti, Bangaram, Amini, Kiltan, Chetlat, Kadmat.

Distribution: Madagascar, Maldives, Lakshadweep, Nicobar Islands, Java, Palau Islands Marshall Islands, Solomon Islands, Great Barrier Reef, Samoa, Fiji.

Remarks; This ramose species of *Porites* is very common in lagoon of most of the Lakshadweep atolls. However, it is rarely recorded from the reefs. Recently mass mortality to this species also occurred in Minicoy and Kiltan.

Porites minicoiensis Pillai, 1969

Locality. Minicoy

Distribution: Known only by the type from Minicoy.

Subgenus *SYNARAEA* Verrill, 1864

The Subgenus *Synaraea* of *Porites* is hitherto not recorded from Lakshadweep, though found to be fairly common in some of the northern Lakshadweep islands such as Chetlat.

It occurs in Minicoy near the Boaz Point. It is essentially a lagoon form found mixed with *Psammocora contigua* and *Porites andrewsi* in Chetlat, often forming large colonies 50 to 60 cm in greater spread and height. Only one species as listed below is recorded.

Porites (*Synaraea*) *convexa* (Verrill, 1864)
Fig., 11

Fig. 11. *Porites (Synaraea) canvexa*

Localities: Minicoy, Kavaratti, Kalpeni, Chetlat
Distribution: Maldives, Lakshadweep' Singapore, Samoa, Tahiti.

Genus *ALVEOPORA* de Blainville, 1830

The genus *Alveopra* does not include in the present collection nor there is any record of this genus from Lakshadweep in literature. The senior author of this paper has examined a specimen among the collections of the museum at Kavaratti which is tetentetively reported here as follows.

Alveopora superficialis Pillai and Scheer, 1976
Locality : Kavaratti.
Distribution : Maldives, Lakshadweep,.

Suborder FAVIINA, Vaugham and Weels, 1943
Family FAVIIDAE, Gregory, 1900.

Genus *PLESIASTREA* Milne Edwards and Haime,

Plesiastrea versipora (Lamarck, 1816)

Localities : Minicoy, Kadmat, probably more wide spread in Lakshadweep.

Distribution : Throughout Indo-Pacific from Red Sea to Fiji.

Remarks : Gardiner (1904) mentioned its occurrence in Minicoy, but could not be re-collected. This species was fairly common on lagoon shoals in Kadmat.

Genus *FAVIA* Oken, 1815

Favia stelligera (Dana, 1846)

Localities : Minicoy, Kiltan, Chetlat.
Distribution : Red Sea to Hawaii.

Remarks : This small calicled *Favia* which forms massive or columnar growth is rare in Lakshadweep.

Favia pallida (Dana, 1846)
Fig. 12

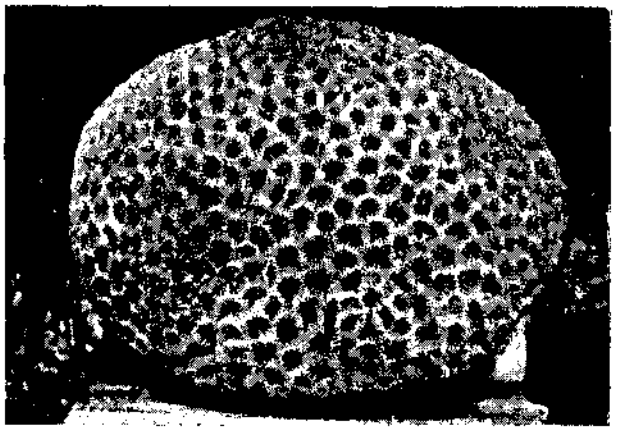

Fig. 12. *Favia pallida*

Localities : Minicoy, Amini.

Distribution : Red Sea to Hawaii.

Remarks: This is one of the most common Indo-Pacific *Favia*. However, it is not very conspicuous in Lakshadweep. It might occur more widely than is recorded from the Lakshadweep at present.

Favia speciosa (Dana, 1846)

Localities : Minicoy, Amini, Chetlat.

Distribution : Red Sea to Tuamotu Archipelago.

Favia favus (Forskal, 1775)

Localities : Minicoy, Kavaratti.

Distribution : Red Sea eastward to Tuomotu Archipelago.

Remarks: Rare. Ocurs on Reef flats and lagoon shoals.

Favia valenciennesii (Milne Edwards and Haime, 1948)

Localities : Kiltan.

Distribution : Red Sea, Lakshadweep, Gulf of Mannar, Andaman and Nicobar Islands, Banda, Philippines, Taiwan, Great Barrier Reef, Japan, Marshall Islands, New Caledonia.

Remarks : A dead specimen of this species was collected from Kiltan from the eastern shore. Living specimens could not be obtained.

Genus *FAVITES* Link, 1807

Like *Favia*, the genus *Favites* is also not a very conspicuous element of the coral fauna of Lakshadweep. Isolated and patchy colonies are found both on reef and lagoon.

Favites abdita (Ellis and Solander, 1786)

Localities : Minicoy, Kavaratti.

Distribution : Red Sea eastward to Fiji.

Favites complanata (Ehrenberg, 1834)

Locality. Minicoy.

Distribution : Red Sea, Lakshadweep, South-east coast of India, Gulf of Kutch, Australia, New Caledonia, Tuamotu Archipelago, Japan.

Remarks : *F. complenata* and *F. helicora* is one and the same and the species has a wide distribution in the Indo-Pacific.

Favites flexuosa (Dana, 1846)

Localities : Kadmat, Kiltan and Chetlat.

Distribution: Red Sea, Maldives, Lakshadweep, Nicobars, Gulf of Kutch, East Indies, Philippines, Japan, Great Barrier Reef, New Caledonia, Solomon Islands, Marshall Islands, Fiji and Cook Islands.

Favites pentagona (Esper, 1794)

Locality : Minicoy.

Distribution : Red Sea eastward to new Caledonia.

Remarks : Rare.

Favites melicerum (Ehrenberg, 1834)

Locality: Minicoy, Kalpeni, Agatti.

Distribution: Red Sea, Maldives, Lakshadweep, Providence Island, Southeast coast of India, Mergui Archipelago, Cocos-Keeling Island, New Caledonia.

Genus *GONIASTREA* Milne Edwards and Haine, 1848

Three species of *Goniastrea* occur in Lakshadweep of which one *viz. G. australensis* is a new record to this area. The genus is fairly common in all microhabitats, except the meandering australensis recorded only from Chetlat Island

Goniastrea retiformis (Lamarck, 1816)

Localities: Minicoy, Kavaratti, Kadmat, Chetlat.

Distribution: Red Sea eastward to Samoa.

Remarks: This species was very common in Minicoy at the northern end opposite to the Old Leper Colony till early seventies. However, they are mostly dead due to dumping or dredged soil.

Goniastrea retiformis (Ehrenberg, 1834)

Localities: Minicoy, Kavaratti, Kadmat, Chetlat.

Remarks: Red Sea eastward to Samoa. Fairly common.

Goniastrea australensis (Milne Edwards and Haime, 1857)

Locality: Chetlat.

Distribution: Red Sea, Natal coast, Seychelles Lakshadweep, Lanka, Great Barrier Reef Kermadic Islands, New Caledonia.

Genus *PLATYGYRA* Ehrenberg, 1034

Platygyra daedalea (Ellis and Solander, 1786)

Localities: Collection includes samples from Minicoy, Agatti, Chetlat, Kalpeni, Amini, Kilton and Chetlat. Should occur in all the islands.

Distribution: A wide spread Indo-Pacific species.

Platygyra sinensis (Milne Edwards and Haime, 1848)

Localities: Found along with P. *daedalea* in all localities.

Distribution: Similar to P. *daedalea*.

Genus *LEPTORIA* Milne Edwards and Haime, 1848

The genus is monotypic. In Lakshadweep

it is not very common though can be collected from the inner reef flat and lagoon shoals.

Leptoriaphrygia (Ellis and Solander, 1786)
Fig. 13

Fig. 13 *Leptoria phrygia*

Localities: Minicoy, Amini, Chetlat.

Distribution: Widely distributed in the Indo-Pacific and known from almost all coral growing areas.

Genus *HYDNOPHORA* Fisher de Waldheim, 1807.

Hydnophra microconos (Lamarck, 1816)

Localities: Minicoy, Suheli, Kavaratti, Kalpeni, Agatti, Amini, Kadmat, Kiltan, Chetlat and Bitra.

Distribution: Red Sea, throughout Indo-Pacific upto Cook Islands.

Remarks: The genus *Hydnophora* is represented only by *H. microconos*.

Genus *LEPTASTREA* Milne Edwards and Haime, 1848

Leptastrea bottae Milne Edwards and Haime, 1849

Locality: Minicoy

Distribution: Red Sea, Somaliland, Reunion, Chagos, Maldives, Minicoy, Cocos-Keeling Islands, Philppines, China Sea, Great Barrier Reef, New Caledonia, Marshall Islands, Ellice Islands, Tahiti.

Remarks: The present collection does not include samples of this species. The inclusion of the species herein is based on early record by Gardiner (1904).

Leptastrea purpurea (Dana, 1846)

Localities: Minicoy, Kavaratti, Amini, Kalpeni, Kadmat, Kiltan and Chetlat.

Distribution: Red Sea to Hawaii in the Indo-Pacific.

Remarks: This species differs from *L. transversa* in larger calices and relatively more number of septa.

Leptastrea transversa Klunzinger, 1879

Localities: Minicoy, Kavaratti, Amini, Kadmat, Kiltan and Chetlat.

Distribution: A common and wide spread species of *Leptastrea*, Often found in all places where *L. purpurea* occurs.

Genus *DIPLOASTREA* Matthai, 1914

Diploastrea heliopra (Lamarck, 1816)

Locality: Minicoy

Distribution: Red Sea weastward to Fiji and Samoa. It is not recorded from Southeast coast of India or Gulf of Kutch.

Remarks: The genus is monotypic. It was found only in Minicoy among the Lakshadweep Islands, that too at the northern part of the lagoon along the shore. (Pillai, 1971).

CYPHASTREA Milne Edwards and Haime, 1848

Cyphastrea seralia (Forskal, 1775)

Localities: Kavaratti, Kalpeni, Agatti, Amini, Kadmat, Kiltan, Chetlat.

Distribution: Widespread from Red Sea to Hawaii

Remarks: Inspite of very intensive collecting over several years the species or the genus was not found in Minicoy, though it was fairly common in northern Lakshadweep, especially on lagoon reefs.

Cyphastrea? microphthalma (Lamarck, 1816)

Localities: Suheli, Amini.

Distribution: Red Sea east ward to Tahiti.

Remarks: A few specimens in the present collection display variation in the septal numbers. Some calices show three cycles of complete septa as in *C. seralia* while others have only 28 as in *microphthalma*

Genus *ECHINOPORA* Lamarck, 1816

The genus *Echinopora* is recorded for the first time from Lakshadweep.

The genus apparantly does not occur in Minicoy.

Echinopora lamellosa (Esper, 1795)
Fig. 14

Fig. 14. *Echinopora lamellosa*

Localities : Kadmat. Androth.
Distribution : Red Sea to Tahiti. For details of areas reference may be made to Scheer and Pillai. (1983).
Remarks : Open reef flat, Rare. Colonies are small, sometimes with closely set flat folia.

Family OCULINIDAE Gray, 1847.

Genus *GALAXEA* Oken, 1815.

Galaxea fascicularis (Linn, 1758)

Localities : Minicoy, Androth, Kadmat, Chetlat, Kiltan
Distribution : Red Sea eastward to Fiji.

Family MERULINIDAE Verril, 1866

Genus *MERULINA* Ehrenberg, 1834

Merulina ampliata (Ellis and Solander, 1786)

Locality Minicoy.
Distribution : Red Sea (Scheer and Pilli, 1983) to Samoa.
Remarks: The genus *Merulina* does not include in the recent collection from Lakshadweep. Its inclusion is based on Gardiner (1905). One of us (Pillai) made carefull search for it at Minicoy over a long period but failed to detect its presence.

Family MUSSIDAE Ortmann, 1890.

Genus *LOBOPHYLLIA* de Blainiville, 1830.

Lobophyllia corymbosa (Forskal, 1775)

Locality : Minicoy.
Distribution: Red Sea to Tahiti. But not known from the southeast coast of India.
Remarks : The genus *Lobophyllia* is known from Lakshadweep only from Minicoy. Even at Minicoy it has a very restricted occurrence at the northern tip of the lagoon where it was once very common. It is almost dead at present due to dumping of dredged soil in the area.

Genus *ACANTHASTREA* Milne Edwards and Haime, 1848

Acanthastrea echinata (Dana, 1816)

Localities : Minicoy, Kalpeni, Chetlat.
Distribution : Red Sea to Tuamotu Archipelago.
Remarks : Not common any where.

Genus *SYMPHYLLIA* Milne Edwards and Haime, 1848

The inclusion is based on early record by Gardiner. The recent collections of corals from Lakshadweep do not include the genus

Symphyllia nobilis (Dana 1846)

Locality : Minicoy.
Distribution : Western Indian Ocean eastwards to Samoa.

Symphyllia radians Milne Edwards and Haime, 1848

Locality : Minicoy.
Distribution : Maldives, Lakshadweep, Gulf of Kutch, Great Barrier Reef, Japan, Rotumana, Tongatabu.

Suborder CARYOPHYLLINA Vaughan and Wells, 1943

Family CARYOPHYLLIIDAE Gray, 1847

Subfamily CARYOPHYLLIINAE Gray, 1847

The two genera viz. *Caryophyllia*, *Stephanocyathus* are listed here based on the deep water collections of Investigator reported by Alcock (1898, 1902) from the Laccadive sea. *Caryophyllia* is known by *C. clavus* Scacchi and *C. areucta* Milne Edwards and Haime. *Stephanocyathus* is known by *S. nobilis* (Mosely). Alcock (1898) may be consulted for the details.

Subfamily EUSMILIINE Milne Edwards and Haime, 1857

Genus *EUPHYLLIA* Dana, 1846

Euphyllia glabrescens (Chamisso and Eysenhardt, 1821)

Localities : Minicoy, Chetlat.

Disiribution : East Africa, Red Sea, Saya de Malha, Maldives, Lakshadweep, Sri Lanka, Nicobars, Mergui Archipelago, Singapore, Philippines, Japan, Great Barrier Reef, Palau Islands, Marshall Islands, New Caledonia, Rotuma.

Remarks : The genus is rare in Lakshadweep. One colony was collected from Minicoy lagoon in 1969 and two from Chetlat in 1987. In Chetlat it is found on the inner lagoon reef on the sides of *Heliopora*.

Super family FLABELLICAE Bourne, 1905

Family FLABELLIDAE Bourine, 1905

Genus *FLABELLUM*

Flabellum pavonium Alcock, 1902

Locality Lakshadweep sea (Alcock) Investigator collection.

Suborder DENEROPHYLLIINA Vaughan and Wells, 1943

Family DENDROPHYLLIIDAE

Genus *TURBINARIA* Oken, 1815

One of the species of Turbinaria from the northern Lakshadweep could not be satisfactorily assigned to any known species. It is listed as *sp nov.* and will be described in a later communication.

Turbinaria mesenterina (Lamarck, 1816)

Localities : Minicoy, Kavaratti, Agatti, Chetlat, Kiltan

Distribution : Red Sea, Rodriguez, Maldives, Lakshadweep, Caroline Island, Marshall islands.

Turbinaria crater (Pallas, 1766)

Localities : Agatti, Kadmat.

Distribution : Central Indian Ocean to Marshall Islands.

Turbinaria sp nov

Loalities : Agatti, Kadmat and Chetlat.

Remarks : The calices are level and large.

Genus *TUBASTREA* Lesson, 1834

Tubastrea aurea (Quoy and Gaimard,1833)

Locality: Chetlat.

Distribution: Red Sea to Hawaii.

Remarks: The species occurs on the leeward reef of Chetlat under boulders. Living coral red in colour.

NON SCLERACTINIAN CORALS

Among the non-scleractinian corals *Heliopora* is the most dominant genus in all reefs of Lakshadweep. *Millepora* occurs in lagoon, while *Tubipora* is only once collected.

Subclass OCTOCORALLIA Haeckel, 1866

Order STOLONIFERA Hickson 1883

Family TUBIPORIDAE Ehrenberg, 1820

Genus *TUBIPORA*

Tubipora musica Linnaues, 1758

Locality: Bangaram.

Disttibution: Red Sea throughout Indian Ocean and Pacific but not found in southeast coast of India.

Remarks: The genus was not observed in living condition on any collection sites but a small dead fragment was obtained from the shore of Bangaram.

Order *COENOTHECALIA* Bourne, 1895

Family Helioporidae Mosely, 1876

Genus *HELIOPORA* de Blainville, 1830

Heliopora coerulea (Pallas, 1766)

Fig. 15

Fig. 15. *Heliopora coerulea*

Localities: Occurs in all the islands in fair numbers especially on the lagoon reefs. At Minicoy and Chetlat the species covers extensive areas.

Distribution: Widespread Indo-Pacific species.

CLASS HYDROZOA

Order MILLEPORINA Hickson, 1901

Order MILLEPORIDAE Flemming, 1828

Genus *MILLEPORA* Linnaeus, 1758

Millepora platyphyllia Ehrenberg, 1834

Localities: Minicoy, Suheli.

Distribution: Red Sea to Tahiti

Millepora exesa (Forskal, 1775)

Localities: Minicoy, Suheli, Kalpeni, Agatti, Amini, Kadmat, Chetlat

Distribution: Red Sea to Tuamotu Archipelago.

Millepora dichotoma (Forskal, 1775)

Localities: Minicoy, Kavaratti, Amini, Kalpeni,

Distribution: Red Sea to Tuamotu Archipelago.

Table. 1. Distribution of recorded genera of corals from the different islands in Lakshadweep

	Localities											
	Minicoy	Suheli	Kavaratti	Kalpeni	Androth	Agatti	Bangaram	Amini	Kadmat	Kiltan	Chetlat	Bitra
	1	2	3	4	5	6	7	8	9	10	11	12
Name of Genus												
Pasammocora Dana	X	—	X	X	—	X	—	X	X	X	X	—
Pocillopora Lamarck	X	X	X	X	X	X	X	X	X	X	X	X
Stylophora Schweigger	X	—	—	—	—	—	—	X	X	X	X	—
Acropora Oken	X	X	X	X	X	X	X	X	X	X	X	—
Montipora de Blainville	X	—	X	—	—	—	—	X	X	X	X	—
Astreopora de Blainville	X	—	X	—	—	—	—	X	X	—	X	—
Pavona Lamarck	X	—	X	X	X	—	—	—	X	X	X	—
Gardineroseris scheer and Pillai	X	—	X	—	—	—	—	—	X	—	X	—
Cycloseris	—	—	—	—	—	—	X	—	—	—	—	—
Fungia Lamarck	X	X	X	—	X	X	X	X	X	X	X	X
Polyphyllia Q & G	—	—	—	—	—	—	—	—	X	—	—	—
Podabacia MED-H	X	—	—	—	—	—	—	—	—	—	—	—
Porites Link	X	X	X	X	X	X	X	X	X	X	X	X
Goniopora de Blainville	X	—	—	—	—	—	—	X	X	X	—	—
Alveopora de Blainville	—	—	X	—	—	—	—	—	—	—	—	—
Plesiatrea MED-H	X	—	—	—	—	—	—	—	X	—	—	—
Favia Oken	X	—	X	—	—	—	—	X	—	X	X	—
Favites Link	X	—	X	X	—	X	—	—	X	X	X	—

	1	2	3	4	5	6	7	8	9	10	11	12
Goniastrea MED-H	X	—	X	—	—	—	—	—	X	X	X	—
Platygyra Ehrenberg	X	X	X	X	—	X	—	X	—	X	X	X
Leptoria MED-H	X	—	—	—		—	—	X	—	X	X	—
Hydnophora de Waldheim	X	X	X	X	—	X	—	X	X	X	X	X
Leptastrea MED-H	X	—	X	X	—	—	—	X	X	X	X	—
Diploastrea Matthai	X	—	—	—	—	—	—	—	—	—	—	—
Cyphastrea MED-H	—	X	X	X	—	X	—	X	X	X	X	—
Echinopora Lamarck	—	—	—	—	X	—	—	—	X	—	—	—
Galaxea Oken	X	—	—	—	X	—	—	—	X	X	X	—
Merulina Ehrenberg	X	—	—	—	—	—	—	—	—	—	—	—
Lobophyllia Blainville	X	—	—	—	—	—	—	—	—	—	—	—
Acanthastrea MED-H	X	—	—	X	—	—	—	—	—	—	X	—
Symphyllia MED-H	X	—	—	—	—	—	—	—	—	—	—	—
Caryophyllia Lamarck	—	—	—	—	—	—	—	—	—	—	—	—
Stephanocyathus Seguenza	—	—	—	—	—	—	—	—	—	—	—	—
Flabellum Lesson	—	—	—	—	—	—	—	—	—	—	—	—
Euphylli Dana	X	—	—	—	—	—	—	—	—	—	X	—
Tubastrea Lesson	—	—	—	—	—	—	—	—	—	—	X	—
Turbinaria Oken	X	—	X	—	—	X	—	—	X	X	X	—
Non Scleractinian Corals												
Millepora Linnues	X	X	X	X	X	—	X	X	X	X	X	—
Hellopora Blainville	X	X	X	X	X	X	X	X	X	X	X	—
Tubipora Ehrenberg	—	—	—	—	—	—	X	—	—	—	—	—

X = recorded
— = not recorded and not a negative indication of its occurrence

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17. SOME OBSERVATIONS ON THE MARINE MAMMALS AND MARINE BIRDS

R. S. Lal Mohan

INTRODUCTION

The marine mammals found in the sea around Lakshadweep are not well documented. Our information on the distribution is based on a few records of cetaceans washed ashore. The remote nature of the islands may be the reason for the poor knowledge of the marine nammals occurring there.

The birds of the Lakshadweep are better known and have attracted the attention of the naturalists as early as 1876, when A. O. Humes (1876) published an account on the birds of Lakshadweep. He visited Pitti, Baliyapani and other islands where he found large nesting grounds of birds. Later Alock (1902) observed nesting ground of birds in Pitty, Baliyapani, Bitra and other islands giving a lucid account of the bird population. Betts (1938) also described the birds of Lakshadweep. Later Ramunni (1965) while serving as the Administrator of the islands evinced great interest in the study of the birds of the islands. He visited the Pitti Island in 1962. The Bombay Natural History Society under the leadership of Dr. Salim Ali, undertook several trips to the island to study migration and ecology of the nesting grounds of the birds (Mathew and Ambedkar, 1964). These studies paved way for the protection of nesting populations and prevention of egg collection, resulting in the declaration of Pitti island as a bird sanctuary. Recently Livingston (1987) recorded 23 species of marine birds and described the association of the birds and the tuna fishery.

During the present study all the inhabited and a few uninhabited islands were visited from January to April, 1987 and the marine mammals and birds of the islands were observed. Information were collected by enquiry and observing the tuna shoals and the birds, and the tuna shoals and the dolphins.

MARINE MAMMALS

Background information: Nishiwaki (1983) considered that 46 species of Cetaceans belonging to 28 genera inhabit the Indian

Ocean. James and Soundararajan (1979) while studying the data on the cetaceans, stranded or washed ashore along the main land of India, reported 11 spp of cetaceans. Recently James and Lal Mohan (1987) summarised the information available on all the 20 species of cetaceans found to occur along the Indian Coast and provided a field key to the identification of the species. Lal Mohan (1987) brought to focus the need for intensifying research on marine mammals with special reference to Indian Ocean as it is declared as a sanctuary for the whales by the International Whaling Commission in 1979. Pillai (1987) reported the occurrence of *Ziphius cavirostris* from Minicoy. The occurrence of *Pseudorca crassidens* also can be inferred to occur in the islands as it's skeleton is displayed in the Kavaratti museum.

By-catch of dolphin

Though we have some information on the by-catch of dolphins along the Indian Coast (Lal Mohan, 1985) we have no data on the number of dolphins caught in Lakshadweep. Dolphins are not consumed in Minicoy island but it is taken in the northern islands like Kavaratti, Agatti, Amindevi and Kadmat. Altogether about 50 dolphins are caught annually in all the islands.

During the survey two spinner dolphins, *Stenella longirostris* of length 1390 mm and 1395 mm were harpooned and killed for its meat at Kavaratti by the fishermen. The meat was sold at a rate fo Rs. 5/- per Kg. it was also observed that the flippers and caudal flukes and the dorsal fins of the dolphins are dried along with the shark fin and adulterated with it.

The common species of dolphins involved in the by catch are *Stenella longirostris, Sousa chinensis. Tursiops truncatus aduncus* and *Delphinus delphis tropicalis*. 60% of the catch belongs to *Stenella longirostris* and 20% to *Tursiops truncatus aduncus* and the rest to *Sousa Chinensis* and *Delphinus delphis tropicalis*.

The dolphins are caught mainly during October to April during fair fishing reason. Masudi, the great traveller recorded that the ambar (ambergris) was found abundantly in in the islands and were available in different hues—black, white and dark bay colour (Ramunni, 1965).

Tuna fishery and the dolphins

The association of the dolphin with the tuna fishery of the Tropical Pacific is well documented (Perrin; 1968, 1969, 1970). Very high mortality of dolphins are reported (Martin, (1975) in Pacafic in the purse seines operated for tuna. Though large scale killing of dolphins has not been observed, the situation has to be watched closely as there are proposals to introduce purse seines for tunas around Lakshadweep Island.

Fishermen consider citing of dolphins as an indication for tuna shoals (*Ketsuwonus pelamis*). The species of dolphins involved with the tuna shoal are *Stenella longirostris* and *Delphinus delphis*. The association of dolphin and tuna may be probably due to sharing of the food by the two.

Though there are reports of collection of ambergris (Ramunni, 1965) there no authentic report of it, in recent years.

BIRDS

The Lakshadweep attracts the attention of the conservationalists because of the bird nesting grounds like the Pitti island. Protection of these nesting grounds goes a long way for the preservation of the species.

Bird fauna of the island

The common species of birds found in the islands are given below:

Sterna anaethetus (Brown winged tern)
Sterna fuscata nubilosa (Sooty tern)
Sterna bergii veloz (Large creasted tern)
Sterna bengalensis (Lesser creasted tern)
Anous stolides pileatus (noddy tern)
Egretta gularis (Reef heron)
Pluvialis squatarola (Grey plover)
Pluvialis dominica (Golden plover)
Dromas ardeola (Crab plover)
Charadrius alaxandrinus (Kentish plover)
Numenius phaseopus (Whimbrel)
N. arguata (curlew)
Tringa hypoleucos (Common sandpaper)

TABLE 1 : Distribution of the birds in various islands of Lakshadweep.

Name of Birds	1	2	3	4	5	6	7	8	9	10	11	12
1. *Sterna anaethtus*	x	xxx	xxx	xx	x	x	xxx		x	—	x	x
2. *S. fuscata nubilosa*	x	xx	xx	xx	x	x	xx	x	x	—	x	x
3. *S. Bergii veloz*	x	xx	xx	x	x	x	xx	x	—	—	—	—
4. *S. bengalensis*	—	x	x	x	x	x	xx	—	—	x	—	—
5. *Anous stolides pileatus*	x	xxx	xx	xxx	x	x	xxx	x	x	x	x	x
6. *Egretta gularis*	x	x	x	x	x	x	x	—	—	—	—	x
7. *Pulvialis squatarola*	xx	—	—	x	x	—	—	x	—	—	—	—
8. *P. dominica*	x	—	—	—	—	—	—	—	—	—	—	—
9. *Dromas ardeola*		—	x	—	—	x	—	x	—	—	—	x
10. *Charadrius alexandrinus*	x	—	—	x	—	—	x	x	x	x	—	—
11. *Numenius phaeopus*	x	x	x	—	—	—	x	x	x	—	—	x
12. *N. arguata*	x	x	x	x	x	x	—	x	—	—	—	x
13. *Tringa hypoleucos*	x	—	—	x	—	x	x	—	—	x	x	x
14. *Arnaria interpres*		—	—	x	—	—	—	—	—	x	—	—
15. *Calidris minutus*	x	x	x	—	—	—	—	—	x	x	x	—
16. *Oceanites oceanicus*	x	x	x	—	—	—	—	—	x	x	—	x
17. *Oceanodroma leucorhoa monorhis*	x	x	x	x	x	—	—	—	—	—	—	—
18. *Ardeola grayii*	—	x	x	x	—	—	—	—	—	—	—	—
19. *Sreptopelia orientalis*	—	—	—	—	—	—	x	x	—	—	—	—
20. *Eudjnamys scolopacea*	—	—	—	—	—	—	—	—	—	—	x	—
21. *Alcodo atthis*	—	x	x	x	—	—	—	—	—	—	x	—
22. *Hirundo rustica*	—	—	—	x	—	x	—	—	—		x	x
23. *Delichon urbica*	—	—	—	—	—	—	—	—	—	—	—	—
24. *Motacilla flava thunbergi*	—	—	—	—	—	—	—	—	—	—	—	—
25. *Zosterops palpebrosa*	x	x	x	x	x	x	x	—	—	—	—	—

x - Stray number 1. Agatti. 2. Bangram 3. Tinnakara- Parali 4. Bitra. 5. Kadmat. 6.
xx 5 to 100 numbers 7. Suheli 8. Kalpeni 9. Androth 10 Chetlat 11. Kiltan 12. Amini
XXX more than 100.

Arnaria interpres (Turnstone)
Calidris minutus (Little stint)
Oceanites oceanicus (Wilson strom petrel)
Oceanodroma leucorhoa monorhis
Ardeola grayii (Pond heron)
Streptopelia orientalis (Rufous turtle dove)
Eudynamys scolopacea (Koel)
Alcedo atthis (Common King fisher)
Hirudo rustica (Swallwo)
Delichon urbica (House marlin)
Motacilla flava thunbergi (Grey head)
Zosterops palpobrosa (White eye)

The distribution of the birds observed in the islands are given in Table 1. The birds found in large numbers are *Amous stolides pileatus, S. fuscata nubliosa, S. anaethetus.* Some of the birds are migratory while others are residents.

Pitti island

The Pitty island deserves special mention. Located at longitude 10° 46"-30-"N. and 72°-31"-30"E, the island has an area of about 1 21 hectres lying about 10 K. M. north west of Kavaratti. The shore of the island is bound by reef with sandbanks on the southern end. The island is devoid of vegetation. It is difficult to land on the island due to the heavy breakers and boulders. The fishermen land on the northern side of the island in country crafts. The island is a favoured nesting ground of the sooty tern (*S. fuscata nubilosa*) and the nody terns, *Anaus stolidus pileatus.* Humes (1876) found thousands of chicks of terns

hatching from the eggs when he visited Pitti island during February, 1876. Alcock (1902) visited the island in 1891 and stated that ground above the high water mark was literally carpeted with young terns of two species, many dead and rotting and many reduced to clean picked skeleton with only the quill feathers, still sticking to the wing bones. He attributed the reason for the wholesale destruction of the young birds to the swarm of large hermit crabs (Coenobita). When Ramunni (1965) visited the islands in 1962 found thousands of birds, most of them sitting on their eggs. He observed that apart from the chicks which did not move, the birds hovered around like a cloud. He could see only two types of birds "Sooties and terns" and did not see any dead birds or carcases. There were plenty of hermit crabs also. Later many teams from organisation like Bombay Natural History Society and Zoological Survey of India (Venkateswarlu, 1982) have visited the island to study the migration, and nesting habits of the birds. The island has been declared as a bird sanctuary. Mathew and Ambedkar (1969) observed the large scale nesting of *Sterna anaethetus* at Baliyapani island. Bitra island was nesting ground for flocks of sea birds before 1940 (Ramunni, 1965). During the survey large number of noddy terns of about 5000 were observed in Agatti. The sooty terns *(S. fuscata)* numbering 8.10 thousands were also found on the shore of Bangaram and Bitra.

Nesting season:- The noddy terns and the sooty terns start laying eggs from late December to January and their eggs are of the size of the hen with brown blotches. Humes (1876) observed fully fledged chicks in February in Pitti island.

Bird-Tuna interaction:-

The terns are known to follow the tuna shoals in Minicoy (Ramunni, 1964) which help the fisherman to locate the tuna shoals. This association seems to stem from the food habits of the birds and tuna. The birds involved are *Anous stolides, S. terna bergii, S bengalenis* and *S. fuscata*. Livingston (1987) described, the utlity of the birds in locating the tuna shoals in Minicoy. He found a positive co-relation between the number of sea birds observed and the number of tuna caught. The two peaks in the occrrence of the birds, coincide with the two peaks of the tuna landing in Minicoy island. However his postulation that the birds feed on the mucus and the copepod parasites attached to the tuna appear untenable as the beaks of the birds are neither suitable for picking the parasites or taking mucus from the body of the tuna. Further no tuna (*Katsuwonus palamis*) was found infected with parasites to the extent of being picked up by the seabirds. As the tuna and marine birds feed on fishes, the occurence of the forage fishes may be attracting the birds and tuna to the same place. Further when the tuna forages on the shoals of fishes, the fishes jump out of the water attracting the birds.

The marine birds also have enriched the mineral resources of island consisting of low grade phosphates derived from the bird droppings for many thousands of year. It is one of the reasons for the fertility of some of the islands. (Ramunni 1964, Jones, 1986).

Conservation:- It is suggested that regular monitoring should be carried out on the dolphin catch and the whale beaching. C.M.F.R.I. has recently initiated a project to monitor the dolphin catch and stranding of whales in Lakshadweep. As the islands are far apart it will be difficult to collect data by a single individal. Hence the fisheries inspectors of Lakshadweep administration should be instructed to monitor the dolphin catch. The local people also should be made aware of the endangered status of the species. The Wild Life Act of 1972 should be implemented so that the killing of dolphin is prevented. Historically marine birds were nesting in large numbers in some of the islands like Bitra and Baliyapani about hundred years before. Now birds no more nest in these islands in large numbers due to human interference. The same fate should not fall on Pitti island weich is the only island left for birds to nest. Though it has been declared as a sanctuary it is reported that the eggs are being collected surreptiously. This should be prevented. The local fishermen and the people should be informed by suitable attractive print outs and pamphelets, the delicate and vulnerable position of the birds. The emphasis

should be placed on the importance of saving the eggs and the nesting population. If the hermit crabs are found to attact the hatchlings as observed by Alcok (1902) steps should be taken to control them. It is needless to say that but for scientific studies the nesting populations should not be disturbed even from the tourist point of view.

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18. HYDROBIOLOGY OF LAGOONS

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ABSTRACT

The hydrography, productivity, zooplankton biomass and faunistic composition of the lagoons of Lakshadweep were studied during January-March 1987 period. The surface temperature of lagoon waters off Agatti and Kalpeni reached the maximum temperature of 38°C. Even during night period the temperature was in the range of 32-33°C in the Minicoy lagoon. Salinity values of surface samples of lagoons of Kalpitti, Bangaram and Kalpeni were in the range 36‰ to 39.39‰. Low dissolved oxygen value of 1-15 ml/litre was observed in Suhelipar lagoon. In most of the lagoons the secondary production was very poor but biomass of zooplankton from the seaward side of the lagoons was slightly higher suggesting that the oceanic zooplankton might be nourished by coral reef community. Minicoy lagoon is an exception where the biomass of zooplankton was very high being 61.25 ml and the biomass of samples collected from the sea was 9.5 ml. Swarming of *Lucifer* sp, Copepods and *Linglea* sp. (algae) has increased the standing crop of lagoon. In most of the lagoons, decapod larvae and copepods constituted the dominant items, other zooplankters like fish eggs, chaetognaths, siphonophores and appendicularians also occurred in small numbers. In lagoon samples of Bangaram and Kavaratti fish eggs formed 8.73% and 17.38% of total biomass respectively.

INTRODUCTION

The hydrobiological studies *viz.* physical, chemical and biological parameters of the marine environment of Lakshadweep islands have been studied by different groups of scientists based on the data collected during the survey of these islands and also during the oceanography cruises undertaken on board R. V. Varuna, R. V. Kalava, R. V. Gaveshani, R. V. Sagar Kanya. R. V. Bluefin and FORV. Sagar Sampada. A complete list of bibliography of marine biological and fisheries research in Lakshadweep is given in MFIS (1986) of which the following few are pertaining to environmental features of Lakshadweep seas. Jones (1959) reported the importance and special ecological conditions of this area. Cooper (1957) and Jayaraman *et al.* (1959, 1960) have studied the oceanographic conditions of this sea. The chemical characteristic of the Lakshadweep waters were studied by Sankaranarayanan (1973), Rao *et al.* (1966) Rao *et al.* (1970) Rao *et al.* (1976) reported the oceanographic conditions around Lakshadweep islands.

Primary productivity and secondary productions of this sea were studied by Nair and Pillay (1972), Gardiner (Ed) (1906), Wolfenden (1906), Prasad and Nair (1964) Qasim and Bhattathiri (1971), Silas (1972), Tranter and George (1972), Goswami (1973), Nair & Rao (1973), Madhu Pratap (1977), Silas *et al.* (1985) and Mathew (M. S).

The present studies are confined to lagoons of Lakshadweep islands during Jan. March '87. Three teams surveyed 13 islands *viz.* I team-Kadmat, Kiltan, Chetlat, and Amini during Jan. '87, II team-Agatti, Kalpitti, Bangaram and Bitra during February '87 and III team-Kavaratti, Suhelipar, Kalpeni, Androth and Minicoy during March '87 to study the fishery potential of the lagoons and coral reefs of Lakshadweep islands. Along with these investigations fishery environmental studies covering physicochemical conditions, productivity and plankton were also undertaken to get a complete picture of the lagoons during Jan. to March 1987.

MATERIALS AND METHODS

The physico-chemical conditions *viz.* temperature, salinity and dissolved oxygen of surface samples of different lagoons and open sea along with their maximum and minimum during 24 hours based on diurnal studies are given in Table 1. For Agatti, Kalpitti, Bangaram and Bitra islands, the maximum and minimum different physicochemical parameters during day time alone were given and diurnal studies could not be undertaken.

Table 1: Physico-Chemical Parameters (Min-Max) of Lagoons of Lakshadweep Islands

	Kadmat	Chetlat	Kiltan	Amini	Agatti	Kalpitti	Bangaram	Bitra	Kavaratti	Suheliper	Kalpeni	Minicoy
	January				February				March			
ATMOSPHERIC TEMPERATURE (MIN-MAX)°C	25-25.5	26-30	26-31.8	24-30	33-38	36	35-37	36-38	28.2-31.5		28-32	29-33
SURFACE TEMPERATURE (MIN-MAX)°C	27-29.2	28-31.3	27.5-31	26-31	34-38	36	34-36.2	35-36	25-31	29.2-30	30-38	30-35
SURFACE SALINITY‰	34-34.5	34.4-34.69	33.61 - 33.91 -	34.59- 35.48	33.4 - 39.5	39.2	36.2 - 36.9	37.2 38.2	29.5 - 34.4	33.38- 35	34.68 - 39.30	31.93 - 35.41
SURFACE DISSOLVED OXYGEN ml/litre	3.32 - 4.86	3 64 - 5.7	2.79 - 5.70	3.4 - 6.43	2.8 - 6.7	4.8	5.2 - 6.3	4.34 5.8	2.54 - 6.1	1.01 6.6	1.15 - 6.52	3.39 - 6.2

Productivity studies were also conducted in lagoons of some islands.

Surface townet collections of zooplankton of 10 minute duration were taken with ¼ meter plankton net at different stations of lagoons and also outside the reef to study the faunistic composition of zooplankton. Samples of lagoon and open sea are pooled separately and analysed and their average biomass and occurrence of major zooplankters are calculated and given in % for composition. Biomass was determined by displacement volume method and depending on the volume of zooplankton a set sample of 12½% to 25% was examined for numerical abundance and the number of organisms was calculated for the whole sample.

TABLE 2 Estimated average number of zooplankton (in percentage) per standard haul in the lagoons and open sea of Lakshadweep islands January 1987.

Organism	Kadmat		Kiltan		Chetlat	
	Lagoon	Sea	Lagoon	Sea	Lagoon	Sea
Displacement Volume	0.65	3.15	0.2	6.0	2.3	4.1
Copepod	13.59	69.0	33.37	35.80	5.95	50.83
Decapod	59.46	3.63	35.99	38.95	79.55	1.50
Alima larva	1.62	1.24	0.11	0.04	0.10	0.11
Appendicularia	—	3.08	5.81	1.52	—	0.27
Chaetognath	0.41	5.36	9.45	2.69	0.74	8.73
Cladocera	—	2.10	1.13	0.14	—	1.16
Doliolid	—	0.14	0.11	0.24	—	0.11
Heteropod	—	0.96	1.25	1.02	0,03	0.69
Lamellibranch	1.43	2.21	9.23	6.96	0.68	11.38
Medusa	—	0.04	9.11	0.07	—	0.11
Siphonophore	0.05	0.67	0.23	2.08	0.52	18.34
Gastropod	0.62	4.76	0.57	0·75	0.07	1.81
Pteropod	0.04	0.19	—	0.19	—	0.27
Foraminifera	22.48	4.33	1,03	0.50	12.02	0.58
Echinoderm Larva	—	0.05	—	0.02	—	0.08
Fish Eggs	0.11	1.88	—	8.60	0.11	2.77
Fish Larvae	0.10	0.13	0 46	0.07	0.09	0.23
Salp	0.01	0.01	0.01	0.04	—	0.08
Ostracod	0.06	—	0.34	0.05	—	0.04
Amphipod	0.01	0.01	0.46	0.08	0.03	0.35
Ctenophore	0.01	—	—	0.01	—	—
Lucifer	—	0.04	—	0.01	0.01	0.42
Polychaete	—	0.17	0.23	0.07	—	0.11

RESULTS

SURVEY TEAM I JANUARY '87. ISLANDS COVERED - KADMAT, KILTAN, CHETLAT AND AMINI (TABLE 1, 2)

KADMAT

Temperature: The surface temperature range in the lagoon was from 26.0° to 29 0°C. The minimum and maximum were observed at 04.00 hrs and 14.00-18.00 hrs respectively. The maximum atmospheric temperature of 27.5°C was observed during 10.00-14.00 hrs and the minimum of 24°C was noticed at 04.00 hrs.

Salinity: The salinity range in the lagoon was 34.20 to 34.50‰ In the sea the range was 34.40 to 34.89‰.

Dessolved oxygen: The range of dissolved oxygen in the sea was 3.76 to 4.25ml/l. In the windward side it was 4.49 to 5.34ml/l

In the lagoon reef the range was 4.37 to 4.9 ml/l. In the diurnal studies marked change was observed in the dissolved oxygen distribution inside the lagoon. The dissolved oxygen of 4.86 ml/l observed at 1800 hrs gradually decreased to 3.40 ml/l (minimum) at 08.00 hrs. and then gradually increased to 4.86 ml at 16.00 hrs.

Productivity : The estimated gross production of surface waters of lagoon was 154 mg C/m³/ day in January 1987.

Biomass and faunistic composition

The average zooplankton biomass in the lagoon was 0.65 ml indicating that the secondary production is poor whereas outside the reef in the sea it was 3.15 ml.

In the lagoon decapod constituted the dominant portion (59.46%) followed by foraminifera (22.48%), Copepod (13.59%), Lamellibranch (1.43) and the other groups chaetognath, siphonophore, gastropod, pteropod, salp, ostracod, amphipod, ctenophore, fish eggs and fish larve were less than 1% each. Appendicularia, cladocera doliolid, heteropod, madusa, echinoderm larva, lucifer and polychaete were absent (Table 2)

Table 3

Estimated average number of zooplankton (in percentage) per standard haul in the lagoons and open sea of Lakshadweep Islands February '87.

	Agatti		Kalpitti		Bangaram		Bitra	
	Lagoon	Open Sea	Lagoon	Open Sea	Lagoon	Open Sea	Lagoon	Open Sea
DISPLACEMENT VOLUME	Negligiable	5.8ml	—	1 ml.	0.5ml	—	0.6 ml	—
DECAPODS		93.10	—	23.4	90.13	—	73.4	—
COPEPODS	90.25	5.3	—	2.2	0.22	—	18.59	—
FISH EGGS	4.25	0.88	—	73.7	8.73	—	3.05	—
GASTROPODS	0.85	0.4	—	0.15	0.14	—	0.4	—
FISH LARVAE	0.85	0.001	—	0.2	0.09	—	0.08	—
APPENDICULARIA	0.40	0.03	—	—	—	—	—	—
LAMELLIBRANCH	0.85	0.4	—	—	0.15	—	0.39	—
FORAMINIFRA	0.85	0.8	—	—	0.31	—	0.53	—
MEDUSAE	1.7	0.001	—	—	0.01	—	—	—
POLYCHAETES	—	0.01	—	0.1	0.01	—	0.15	—
AMPHIPODS	—	0.01	—	0.1	0.11	—	0.04	—
CLADOCERA	—	0.05	—	—	—	—	0.59	—
CHAETOGNATH	—	0.36	—	—	—	—	2.45	—
ALIMA	—	0.01	—	—	0.04	—	0.53	—
HETEROPODS	—	0.01	—	0.05	—	—	0.06	—
PTEROPODS	—	0.002	—	0.1	0.5	—	—	—
SIPHONOPHORE	—	0.05	—	—	0.01	—	—	—
OSTRACOD	—	0.1	—	—	—	—	—	—
LUCIFER	—	0.01	—	—	—	—	—	—
CEPHALOPODS	—	0.003	—	—	—	—	—	—
DOLIOLUM	—	0.003	—	—	—	—	—	—
ECHINODERM LARVAE	—	—	—	—	—	—	—	—

In the sea the dominant group was copepod (69.0%) followed by chaetognath (5.36%), gastropod (4.76%), foraminifera (4.33%), decapod (3.63%), appendicularia (3.08%), lamellibranch (2.21%) cladocera (2.10%) fish egg (1.88%), alima larva (2.24%) and other groups (doliolid, heteropod, medusa, siphonophore, pteropod, echinoderm larva, salp, amphipod, *Lucifer* and polychaete, were less than 1% each (Table 2)

KILTAN

Temperature : The maximum temperature of surface water was 31.0°C at 1600-1800 hrs and the minimum was 27.5°C at 0600 hrs. The range of bottom temperature was 27.0°. From 30.0°C at 1800 hrs, it gradually came down to 27.5°C at early morning 0600 hrs and again gradually increased to 31.0°C during 0200–0400 hrs and it started increasing gradually to maximum (31.8°C) at 1200 hrs.

Salinity : The salinity range was 33.61 to 33.91‰ in the lagoon and 34.20‰ in the sea.

Dissolved Oxygen : The range of dissolved oxygen was 4.25 to 4.37 ml/l in the sea outside the lagoon. In the windward reef the range 3.88 to 4.25 ml/l. In the lagoon reef the oxygen range was 5.10 to 5.34 ml/l. In the diurnal studies from 1800 hrs to 1800 hrs, 5.34 ml/l observed at 1800 hrs gradually decrease to 2.79 ml/l (minimum) at 0.400 hrs and then it gradually increased to 5.22 ml/l at 1400 hrs and 5.70 ml/l (maximum) at 1800 hrs. A decrease in the oxygen level was observed in the night.

Productivity : The estimated gross production of surface waters of the lagoon were 238 mg C/m³/day in January 1987.

Biomass and faunistic composition

The average displacement volume of zooplankton in the lagoon was 0.2ml and in the sea it was 6.0ml.

In the plankton samples collected from the lagoon decopod larva (35.99%) and copepod (33.37%) dominated in the sample followed by chaetognath (9.45%), lamellibranch (9.23%), appendicularia (5.81%), heteropod (1.25%), cladocera (1.14%), foraminifera (1.03%) and others (alima larva, doliolid, medusa, siphonophore, gastropod, fish larvae, saelp, ostracod, amphipod and polychaete) less than 1% each.

In the sea, the major groups were decapod (38.95%) and copepod (35.80%) followed by fish eggs (8.60%), Lamellibranch (6.96%), chaethgnath (2.69%), siphonophore (2.08%) appendicularia (1.52%), heteropod (1.52%) and others (alima larva, cladocera, doliolid, salp, medusa, gastropod, pteropod, foraminifera, echinoderm larva, fish larva, ostracod, amphipod, ctenophore, lucifer, polychaetete) less than 1% each.

CHETLAT

Temperature: The water temperature in the lagoon ranged from minimum of 28.0°C during 2400 to 1000 hrs to 30.0° during 1400-1800. hrs The range of atmospheric temperature was 25.0°C to 30.0°C.

Salinity: The salinity range was 34.4 to 34.69‰ in the lagoon and 34.69‰ in the sea.

Dissolved Oxygen: The range of dissolved oxygen was 2.79 to 4.13 ml/l in the windward reef. In the lagoon reef the range was 5.34 to 7.28 ml/l. The maximum value was obtained from the area where live coral and seaweeds were found in very good numbers. The value in the sea was 3.88ml/l. In the diurnal studies conducted inside the lagoon the oxygen fluctuated between 3.13 to 5.70 ml l. The maximum (5.70 ml/l) was observed at 1800hrs. The oxygen gradually decreased to 4.13m/l (minimum) at 0600 hrs. Again it gradully increased 4.13ml at 1000 hrs, 4.86 ml/l at 1400 hrs and 5.10 ml/l at 1800 hrs.

Productivity: The estimated gross production and net production were 392 mg C/m³/day and 309 mg C/m³,day respectively.

Biomass and faunistic composition

The average displacement volume of zooplankton was 2.3 ml in the lagoon and 4.1 ml in the sea showing higher secondary production.

In the lagoon decapod (79.65%) was the dominant group followed by foraminifera (12.02%) copepod (5.95%) and others (alima larva, chaetognath, heteropod, lamellibranch, siphonophore, gastropod, fish eggs, fish larvae, amphipod and lucifer) less than 1% each.

In the sea major group was copepod (50.83%) followed by siphonophore (18.34), lamellibranch (11.38%), chaetognath (8.73%), fish eggs (2.77%), gastropod (1.81%) decapod (1.50%), cladocera (1.19%) and others each (alima larva, appendicularia, doliolid, salp, heteropod, medusa, pteropod, foraminifera, echinoderm larvae, fish larvae, ostracod, amphipod, lucifer, polychaete) less than 1%. The decapod which was 79.65% in the lagoon was only 1.50% in the sea.

AMINI

Temperature: The surface temperature in the lagoon was in the range of 26.5° to 30.0°C. The temperature at 1800 hrs (28.0°C) gradually decreased to 27.0°C at 2200 hrs and remained same upto 0400 hrs and came down to 26.5°C at 0600 hrs. Then it increased to 30.0°C at 1400 hrs and showed a decrease towards 1800 hrs. The atmospheric temperature was in the range of 24.0° to 30.0°C A drastic increase of 3°C was observed between 0600 and 0600 hrs.

Salinity: The salinity in in the lagoon was in the range of 34.40 to 34.79‰. The salinity range was 35.48 to 35.87‰ in the windward reef.

Dissolved Oxygen: The range of dissolved oxygen was 3.04 to 6.43ml/l in the windward reef In the lagoon reef the dissolved oxygen range was 4.49 to 5.70ml/l. During the diurnal studies the range was 3.16 to 6.43ml/1. From 4.61 ml/l at 1800 hrs, the dissolved oxygen value gradually came down to 3.16ml/l at 24.00 hrs. Then it gradually increased to 3.52 ml/l at 0400 hrs, 3.88ml/l at 1000 hrs, 6.43 ml/l at 1600 hrs and started coming down afterwards. Higher values were obtained during afternoon period and lower values in the night.

Due to shallowness of the lagoon of this island plankton net could not be operated in the lagoon.

Productivity

The estimated gross and net production of surface waters of Amini Island were 785mg C/m³/day and 154mg C/m³/day respectively.

SURVEY TEAM II: FEBRUARY '87, ISLANDS COVERED, AGATTI, KALPITTI, BANGARAM AND BITRA TABLE. 1 & 3

AGATTI

Temperature: The maximum and minimum temperature in the lagoon were 38.0°C and 33.0°C respectively.

Salinity: The salinity values of the surface waters of lagoon bluctuated between 34.4 and 39.5‰. In the open sea the range was 36.5 to 40.5‰.

Dissolved Oxygen: The dissolved oxygen level of surface water was in the range of 2.80 to 6.70ml/l in the lagoon. The samples collected from outside the reef showed wide fluctuations (3.80 to 7.60ml/l).

Biomass and Faunistic Composition

The biomass of plankton collected from the lagoon is very low where as in the open sea, outside the reef the average displacement volume of zooplankton was 5-8ml.

The order of abundance of zooplankton in the lagoon was decapod (90.25%), copepod (4.24%), foraminifera (1.7%) and others (gastropod, appendicularia, lamellibranch, fish eggs and fish larve) each less than 1%.

In the open sea the dominant group was decapods (93.13%) followed by copepod (5.3%) and othets (gastropod, appendicularia, lamellibranch, polychaete, madusa, amphipod, cladocera, chaetognath, alima, heteropod peteropod, siphonophore, ostracod, *Lucifer*, cephalopod, doliolid, fish eggs, and fish larvae) each less than 1%.

KALPITTI

Kalpitti is a tiny island situated inside the the lgoon of the Agatti Island.

Hydrography: Surface water samples collected from the lagoon in the forenoon showed temperature of 36.0°C, salinity and dissolved Oxygen values 39.2‰ and 4.80ml/l respectively.

Biomass and Faunistic Composition: The volume of zooplankton collected from the sea was 1.0ml and comprised of fish eggs (73.7%),

TABLE 4 Estimated average number of zooplankton (in percentage per standard haul) in the lagoons and open sea of Lakshadweep Islands. March - 1987

	Kavaratti		Suhelipar		Androth		Minicoy	
Lagoon	Open Sea	Lagoon	Open Sea	Lagoon	Open Sea	Lagoon	Open Sea	Lagoon	Open Sea
DISPLACEMENT VOL. ml.	3.33	0 9	2.66	2.5	0.89	3.5	3.3	61.25	9.5
MEDUSAE									
SIPHONOPHORE	1.6	0.43	4.35	5.68	—	2.42	6.0	1.78	5.69
POLYCHAETE LARVAE			3.75	—	—	—	—	—	—
EVADNE SP.	—	3.00	2.55	—	—	0.80	—	0.89	—
COPEPODS	25.50	55.25	17.65	27.93	46.66	86.65	45	34.88	57.55
AMPHIPODS	2.47	—	—	—	0.19	0.40	— —	—	—
DECAPOD LARVAE	50.42	22.50	56.30	52.68	41.64	0.40	— 10	11.65	5.0
ACETES									
LUCIFER SP.	—	0.66	—	0.21	0.85	0.80	—	23 82	6.00
GASTROPODS	—	1.63					4.27	18.62	6.66
BIVALVES							5.48		
CHAETOGNATHS	2.63	3.45	2.50	1.23	1.66	6.62	7 56	5.24	9.50
PELAGIC TUNICATES	—	—	1.45	0.3	—	1.31	3.27	—	—
FORAMINIFERA									
APPENDICULARIA	—	3.08	3.20	5.97	—	—	5 27	—	7.00
FISH EGGS	17.38	10.00	8.25	6.00	8.38	0.60	13	3.12	2.60
FISH LARVAE	—	—	—	—	0.62	—	0.15	—	—

decapod (23.4%), copepod (2.2%) and others (gastropod, fish larvae, polychaete, amphipod, heteropod and pteropod) each less than 1%.

BANGARAM

Hydrography

The minimum temperature record was 34.0°C and the maximum 36.2°C.

The minimum and maximum salinity values recorded were 36.2 and 36.9‰ respectively.

Dissolved oxygen values were in the range of 5. 2 to 6.3 ml/l.

Biomass and Faunistic Composition :

The average displacement volume of zooplankton was only 0.5 ml inside the lagoon.

The dominant group was decapod (90.13%) followed by fish eggs (8.73%). The other groups such as copepod, gastropod, fish larve, lamellibranch, foraminifera, polychaete, medusa, amphipod, alima, pteropod and siphonophora were each less than 1%.

BITRA

Temperature : The maximum and minimum temperatures recorded were 36.0° and 35.0°C respectively. Where as the maximum and minimum atmospheric temperatures recorded were 38.0°C and 36.0° respectively.

Salinity : The salinity values ranged between 37.2 and 38.2‰.

Dissolved oxygen : Dissolved oxygen of the surface water fluctuated between 4.34 and 5.89 ml/l.

Biomass and Faunistic Comp^mposition :

The average zooplankton displacement volume was 0.6 ml in the lagoon. The major group present was decapod (73.4%) followed by cropepod (18.59%), fish eggs (3.05%) and chaetognath (2.45%). The other groups each below 1% were gastropod, fish larva, lamelli-branch, foraminifera, polychaete, amphipod, cladocera, alima and heteropod.

SURVEY TEAM III MARCH-1987
ISLANDS COVERED - KAVARATTI, SUHELIPAR, KALPENI, ANDROTH AND MINICOY
Table 1 & 4

KAVARATTI

Temperature:- The maximum and minimum surface temperatue of lagoon waters recorded during 24hrs was 31.5°C and 28.2°C. The atmospheric temperature was in the range of 25°C to 31°C.

Salinity:- In the lagoon the maximum salinity value of 34.4‰ was recorded at 20.00 hrs and the minimum of 29.5‰ was noticed at 08.00 hrs. In the open sea the salinity of surface sea water was 32.28 to 32.45‰.

Dissolved Oxygen: The minimum and maximum values of dissolved oxygen recorded from the surface waters of lagoon were in the range 2.54/ml/litre to 6.1 ml/litre. In the surface waters of open sea it was 5.51 ml/litre.

Productivity: The estimated gross and net productivity values of lagoon waters of Kavaratti during March '87 were 294.44mg C/m³,day and 48.59mgC/m³/day respectively.

Biomass and Faunistic Composition:

The average displacement volume of plankton collected from lagoon is 3.33ml. Decapod larvae consitituted 50.42%, copepods 25.50%, fish eggs 17.38% and chaetognath 2.63%. The other organisms which occurred less than 5% were chaetognaths, amphipods, appendicularians, *Evadne* sp. and *Lucifer* sp. In the open sea samples collected outside the reef area, copepods were dominant (55.25%) and decapod larvae formed 22.50% followed by fish eggs which constituted 10.00%.

SUHELIPAR

Temperature: The surface temperature of lagoon water samples ranged between 29.2°C to 30°C.

Salinity: The salinity was within the range of 33.38 to 35.0‰.

Dissolved Oxygen: The dissolved oxygen values were in the range 1.01 ml/litre to 6.6ml/litre. The low values of 1.01ml/litre was noticed in the lagoon waters very close to shore. This was either due to decomposition or putrification of gut contents of tuna which were thrown into the sea by the fishermen before the fish is boiled and sundried for making mas. A close examination of the water samples and plankton collected from this area did not show the presence of any organisms which might cause red water phenomenon or depletion of dissolved oxygen.

Productivity: The estimated gross and net production values of Suhelipar lagoon surface water samples were 244.41mgC/m³/day and Nil respectively.

Biomass and faunstic Composition: The average displacement volume of plankton collected from the lagoon area was 2.66ml. Decapod larvae and copepods which constituted 56.30% and 17.65% were the two major groups of zooplankton. The other groups which occurred in less than 10% were fish eggs, siphonophores, chaetognaths, appendicularians, pelagic tunicates, gastropods and *Evadne* sp. In the open sea plankton collections also the decapod larvae and copepods were the dominant items which accounted for 52.68% and 27.93% respectively.

KALPENI

Temperature: The temperature of surface water samples of lagoons fluctuated between 30°C to 38°C within 24hrs of observation. From 02.00 hrs to 08.00 hrs the temperature was only 30°C and it increased to 32°C at 10.00 hrs and then there was a sudden increase to 36°C anb 38°C at 12.00 and 14.00 hrs respectively and it gradually decreased from 37°C at 16.00 hrs to 32°C at 24.00 hrs. The maximum and minimum atmospheric temperature recorded during 24 hrs of observation were 32°C and 28°C. The lagoon surface water sample has reached maximum temperature of 38°C higher than the maximum atmospheric temperature of 32°C.

Salinity : Salinity values of the surface water samples of lagoon showed high range within

24 hrs of diurnal studies The maximum recorded value was 39.39‰ and the minimum was 34.68‰ .

Dissolved Oxygen: The dissolved oxygen values fluctuated from minimum of 1.15 ml/litre. The low oxygen values were recorded during the hrs 02 00 to 08.00 when there was no sunlight or less light. But the higher values were recorded during the period 12.00 to 20.00 hrs.

Productivity :

The gross and net production of Kalpeni lagoon surface waters were 1072.30 mg/m³/day and 328 88 mgC/m³ day respectively during March '87.

Biomass and faunistic composition :

The standing crop of the plankton samples collected from lagoon area was just 0 89 ml and it is the lowest figure compared to lagoons of all the other islands. Decapod larvae and copepods formed 41.62% respectively. Fish eggs formed the third group in order of abundance (8.38%). In the open sea collections formed the bulk of plankton (86.55%) and chaetognaths constituted only 6.62%

ANDROTH

This is an island without lagoon. However plankton and water samples were taken from, a small area in between the shore and the coral reefs, areas outside the coral reef in the open sea, so as to study and compare the occurrence of various zooplankters in this island, with that of other islands.

Temperature : The temperature of surface waters of the inshore and open sea were in the range 31°C to 32.8°C during day time, coinciding with the atmospheric temperature.

Salinity : Salinity values of surface water samples were higher and fluctuated between 33.60 to 35.12‰.

Dissolved Oxygen : Dissolved oxygen of surface waters were in the range 3.18 ml/litre to 3 60 ml/litre.

Biomass and faunistic composition :

The displacement volume of plankton collected inshore area is 6 ml whereas the biomass was less in samples collected outside the reef in the open sea.

In the inshore area copepods constituted 44.99%, decapod larvae and chaetognaths constituted 11.24% and 10.44% respectively. Fish eggs formed 8 8% and siphonophores formed 8 5%. Other organisms which occurred in small numbers are *Limacina* sp. (a gastropod,) pelagic tunicates and appendicularians. The same trend was seen in samples collected from other stations outside the reef in the open sea, except fish eggs which occurred in slightly larger numbers ranging from 12.5% to 20%.

MINICOY

Temperature :- The surface water temperature of lagoon was maximum of 35°C at 16.00 hrs and minimum was 30°C at 06.00 hrs, 1200 hrs and 20.00 hrs The temperature was always 30°C and above throughout the day and night. The atmospheric temperature was in the range 29°C to 33°C.

Salinity :- The salinity fluctuated between 31 93 to 35.41‰ during different periods of day and night.

Dissolved Oxygen : The maximum dissolved oxygen value was noticed at 12.00 hours it being 6.2 ml/litre and the minimum of 3.39 ml/litre was noticed at 08.00 hrs.

Productivity : The surface water samples of lagoon collected during March '87 indicate that the gross and net productions were 551 mgc/m³/day and 369.36 mgc/m³/day respectively.

Biomass and faunistic composition :

The average standing crop of zooplankton samples collected from the lagoon area was very high during March '87 being 61.25 ml. This is mainly due to flowering of algae (*Lingbea* sp.) Other zooplankters which occurred in large numbers were copepods (34.88%) and *Lucifer* sp. (23.82%). The other minor constituents of plankton were gastropods (18.62%), decapod larvae (11.61%) and chaetognaths, fish eggs and siphonophores occurred in very meagre numbers. In the open sea samples collected outside the coral reef the volume of plankton was just 9.5 ml and *Lucifer* species and gastropods occurred only in less numbers (6.31%) and (6.66%) respectively.

DISCUSSION

The Lakshadweep sea comprising of 10 inhabited islands and 17 uninhabited islets with a total land area of 32 Sq. km with total extent of lagoon of almost 420 sq.km is an important zone in the fishery potential map of the Indian Ocean. A knowledge of the environmental conditions of the water in and around (including lagoons) Lakshadweep is essential for studying several problems of new and existing fishery resources.

The Central Marine Fishers Research Institute is a pioneer in starting detailed oceanographic investigations of the environmental conditions of Lakshadweep Sea (Jayaraman *et al.*, 1959, 1960) and since then several investigators have added more information on this aspect. A detailed uptodate riview of the literature on the environmental features of the Lakshadweep Sea has been given by James *et al.* (1986), Nair *et al.* (1986), which covers wind system, sea surface circulation, hydrographic conditions (Water masses, water movements, chemical charscteristics of waters, sea surface temperature, dissolved oxygen maxima and minima, water characteristics, convergence and divergence zones) and environmental features in relation to fishes.

The salient findings of physico-chemical conditions and plankton of lagoons and seas around the Lakshadweep islands based on the studies conducted by three survey teams during Jan, Feb and March '87 respectively are as follows.

The high value of 38°C temperature of surface waters observed in Agatti and Kalpeni lagoons during February and March is significant. In Minicoy the surface temperature of lagoon waters remained in the range 32°C to 33°C, higher than the atmospheric temperature even during the night time (20.00 hrs to 04.00 hrs) after sunset and before sunrise. Otherwise the sea surface temperature observed in the open Arabian sea was high during May-June period and low in the month of July '87.

During the period Jan.-March '87 the high salinity values of surface samples of lagoon waters observed were, Kalpitti lagoon (39.2‰), Bangaram (36‰), Bitra (38.2‰) and Kalpeni (39.39‰). These high salinity values could be attributed to heavy evaporation due to high atmospheric temperature and heat within the lagoon and also poor inflow of oceanic waters from outside the reef into the lagoon and maximum saturation of chemicals of the coral reef with the water masses inside the lagoon.

The minimum and maximum dissolved oxygen values of surface waters lagoon fluctuated between 2ml/litre to 6 ml/litre in most of the lagoons except Suhelipar where the minimum value of 1.16 ml/litre was noticed. This has resulted in the mortality of polychaetes, clams and crabs. The sudden changes in the same place might be due to water movements, circulation and mixing and different biological changes of different marine erganisms including phytoplankton, seaweeds and sea grass.

It is reported by Rao *et al.* (1966) that from the distribution of temperarure, salinity, dissolved oxygen and density that up welling occurrs during the Nov.-December period in the Lakshadweep Sea close to minicoy and this phenomenon is confined to only upper 150 metres depth. It is also found that a divergence vone (around 71°E and9°30 N) and a convergence zone (with an axis roughly along 79°E and 8°N) be in the same area.

The waters of lagoons of Lakshadweep are productive and production rate during Jan. March '87 showed wide variation in different islands (Table-1). Earlier reports (Tranter and George; 1972) indicate that inside the lagoon the secchi disc visibility is 27 metres and extenction coefficient is 0.017 and rate of production is 3.7gms c/m³/day. Nair *et al* (1986) reported that the euphotic zone of the Lakshadweep sea is almost over 90m. As such thd production per unit volume in the surface waters may not be high. However according to them the integrated value for the whole water column is of the range of almost 300mgC/m²/day and this high value is highly significant for oceanic waters.

different authors reported different aspects of secondary production in the lagoon and open sea of Lakshadweep Islands. Silas (1972) studied bioscattering in the shallower depths off Minicoy, Agatti, Pitty, Kavaratti, Kalpeni, and Androth islands and of Snheripar. According to him the estimated monthly mean standing crop of zooplankton varied between 26 and

144ml per 1000m³ of water in rhe sea around Lakshadweep. According to Mathew (MS) euphausid fauna is an important constituent in the DSL and it is the staple food for tunas and bill fishes which form the main fishery of Lakshadweep Sea. He has reported occurrence of 19 species of Euphausids from this area but according to him there has been no record of catching any of these species from the coral lagoons and atolls. Tranter and George (1972) who studied zooplankton abundance of Kavaratti and Kalpeni atolls during October and December period observed swar- of ostracods, *Cypridina* sp. According to them the biomass was greatest seaward of the western lagoon of Kavaratti and gets depleted enroute ocean to lagoon. From zooplankton samples collected from the lagoons of different islands during Jan-March'87, Eupshausid specimens could not be obtained. The biomass of zooplankton of most of the lagoons is negligible except Minicoy. The occurrence of *Lucifer* sp, copepod sp. and *Lingbea* (Algae) in the lagoon has increased the standing crop of zooplankton to 61.5ml. The lower values of biomass of the lagoon sample than the open sea sample might be due to feeding of zooplankton by reef communities during their transit across the reef to lagoon as reported by Tranter and George (1972). Goswamy (1973) studied the zooplankton assemblages of the lagoons and seas of Lakshsdweep. He has recorded very high value of 178ml of zooplankton biomass per 1000^{8} and encountered different species of copepods (52sp), chaetognaths (8sp), mysids (3sp) polychaetes (5sp) amphipods (28 sp) decapods, fish eggs and larvae. Most of the above mentioned organisms occurred in plankton samples collected from the Lakshadweep lagoons during this survey conducted during Jsn-March'87. In most of the lagoons decapod larvae and copepod the constituted the dominant items of zooplankton sample. The other zooplankters which occurred in moderate quantities were siphnophores, chaetognaths, fish eggs, bivalves and appendicularians. A plankton sample collected near Kalpitti, a tiny island, just outside the reef showed very high concentration of fish eggs (73.2%) followed by decapod larvae constituting 23.4%. The high precentage of decapod larvae in the lagoon or outside the reef samples show that the coral reefs form an ideal ground for settlement for crustaceans especially crabs. The occurrence of zoea and megalopa larvae is also an indication to show that the lagoon and adjacent areas are ideal breeding grounds for crabs and this is proved by the presence of berried crabs in coral reefs during the period Jan-March '87.

Other organisms which occurred in very small numbers in the plankon samples of lagoon were Pluteus larva, of Ophuroid and Echinoida, Bipinnaria larvae of starfishes and Auricularia larva of holothurians. *Evadne* sp, amphipods, polychaete larvae, pelagic tunicates, foraminifera, ostracods and fish larva also occurred in lesser numbers.

An intensive study of the physio-chemical conditions and productivity studies with special reference to various zooplankton asemblages of the lagoon during different seasons is essential to get a complete picture of marine fishery resources which include Tuna and Billfishes, ornamental fishes, echinoderms, sea weeds, sponges, molluscs, crustaceans and corals.

ACKNOWLEDGEMENT

The authors are grateful to Dr. P. S. B. R. James, Director and Dr. Alagarsamy, Joint Director, Central Marine fisheries Research Institute, for active encouragement. The field work at various islands was possible only with the facilities provided by the Lakshadweep. Administration and the willing co-operation of its officers especially Mr. George Verghese, Director of Fisheries.

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19. ENVIRONMENTAL DAMAGE AND CONSEQUENCES

P. S. B. R. James, C. S. Gopinadha Pillai, P. A. Thomas, D. B. James and Said Koya

INTRODUCTION

The atoll environment, in general, is a relatively restricted ecosystem where the impact of interference of man and nature will manifest conspicuously within a short time. The habitat is fragile, diverse and easily vulnerable and the effects of adverse factors on such systems are often of very serious consequences. Almost all inhabited atolls of the world today are facing environmental stress both in the terrestrial and aquatic habitats. The post Worldwar II activities on the Indo-Pacific atolls, such as active settlement, extensive cultivation of crops, military establishments, atomic tests, oil exploitation, pollutions of various kinds, over exploitation of resources, wanton destruction of fauna and flora, introduction of exotic plants and animals, dredging and construction activities among the man made factors; cyclones, sea erosion, El-Nino, pests and predators coupled with natural senescence of corals among the natural factors are the major agents that have effected notable changes in the physiography, morphology and biotic communities of the atolls all over the world. Lack of large buffer zones around oceanic islands is a major impediment in the replenishment of the fauna, if subjected to depletion due to causes either natural or man made.

Many of the oceanic islands are threatened, endangered or modified. The protection and conservatian of various atolls needs different approaches and this can be achieved only with the understanding, co-operation and support of the local people and administrators (Dhal, 1985).

The Lakshakweep atolls are no exception to this global phenomenon of deterioration of reefs and their environs. The post independent years have witnessed brisk developmental activities in these atolls which have visibly improved the living conditions of the inhabitants but not without side effects on the marine and terrestrial habitats (Pillai, 1983; 1985, 1986; Pillai and Madan Mohan, 1183). Pillai (1989) has presented a detailed account of the environmental damages in the Minicoy atoll based on his observations both in the terrestrial and marine habitats over a period of 15 years. Wells (*in lit*) has presented a status report on the ecological problems faced by these atolls stressing the need for conservation of the islands. During the present survey attention was paid to the ecological conditions in man. islands including factors such as siltation, death of corals, bio-erosion etc., and their consequences. These observations are reported in the present communication.

CHANGES IN SURFACE MORPHOLOGY

Ever since human settlement, the natural surface morphology of the islands appears to have been altered. The surface soil was removed in many places and dumped to form hillocks as seen in Minicoy by early settlers to make the land cultivable. Lime stone and sand stones were mined in large quantities as in Minicoy, Kadmat and Kiltan for construction work. In Minicoy the eastern side has still several pits from where lime stone is quarried, In Kadmat island there is solid lime stone stratum at the central part of the island which is mined in large quantities for construction work. Kiltan has a sand stone stratum at a depth of about 1 m which was cut out into large slabs for the construction of residential buildings (Figs. 1, 2). A large number of pits and ponds present are all man made. These longterm activities have changed the terrestrial face of the Lakshadweep atolls as in the case of many other inhabited Indo-Pacific islands.

VEGETATION

Mangroves are not found in Lakshedweep at present. The natural vegetation dominated by *Thespesia* and *Pandanus* along with many others are almost lost. Pillai (1983) has pointed out the recent destruction of natural vegatatien at Minicoy atoll in the last few

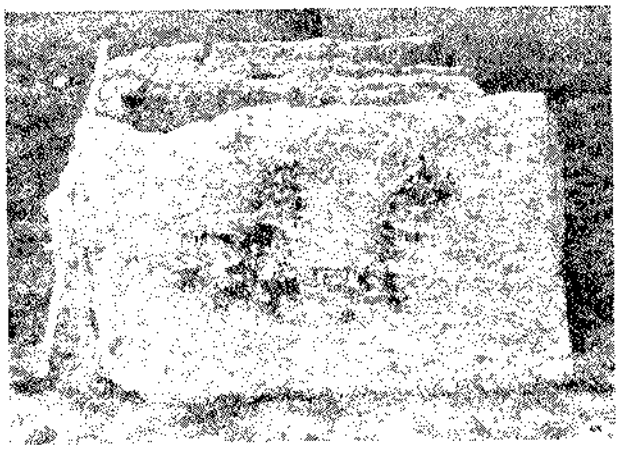

Fig. 1. Sandstone mining at Kiltan, 1974.

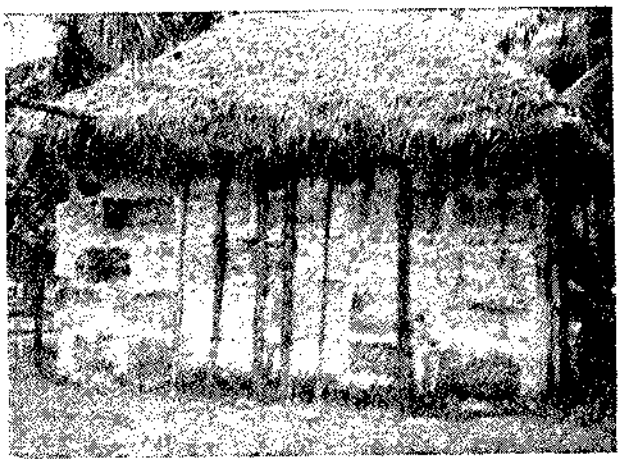

Fig. 2. A dwelling hut constructed with sandstone blocks at Kiltan.

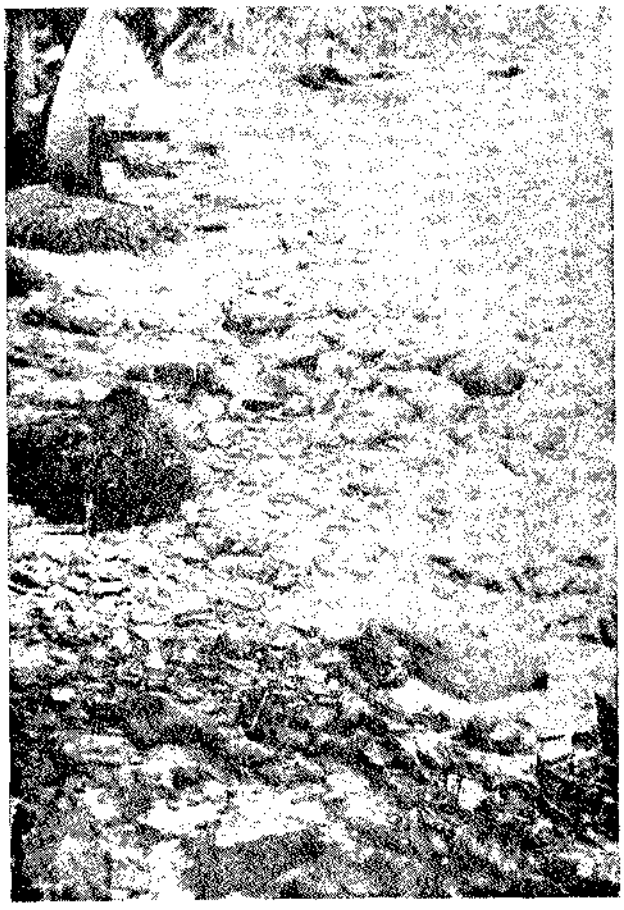

Fig. 3. Human refuse thrown at the Minicoy lagoon, 1982.

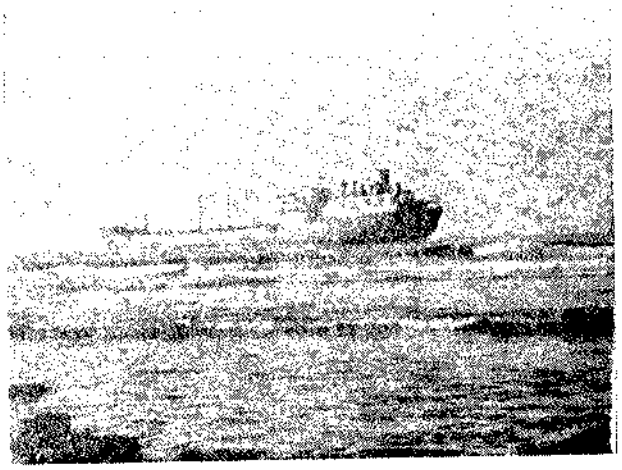

Fig. 4. The American tanker *Transhuron* aground at Kiltan in 1974.

Fig. 5. Transhuron as seen in 1987 January.

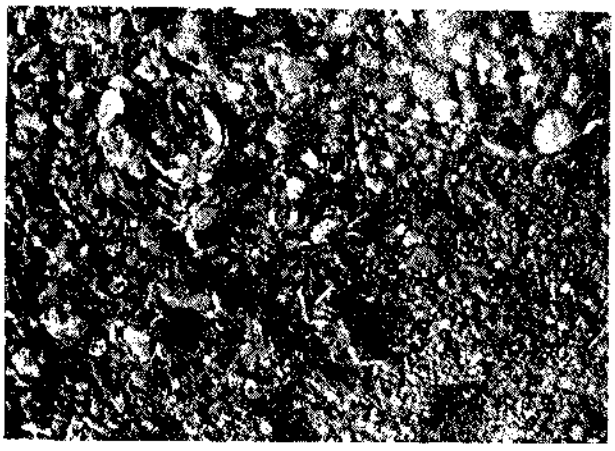

Fig. 6. The blackened intertidal reef flat and dead shore crabs at Kiltan as a result of Transhuron oil spill, 1974.

Fig. 9. A closer view of the area with sea grass and holothurians.

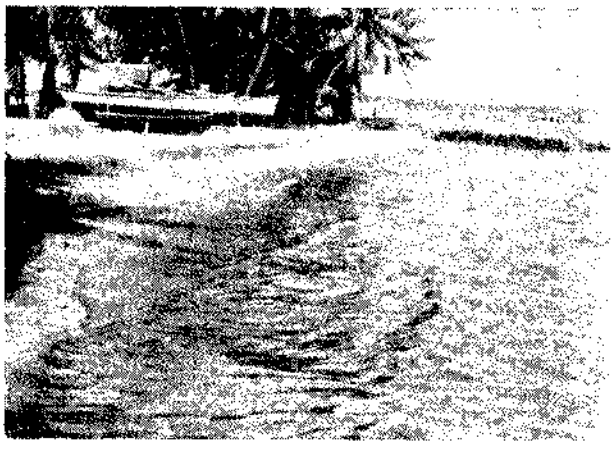

Fig. 7. An instance of oil pollution at Minicoy from undetermined source in 1981.

Fig. 10. Sea erosion at the windward side of of Amini Island, causing deposition of sand on windward reef flat.

Fig. 8. Interference of sand flat on reef flat at the windward side of Amini restricting coral growth to the outer zone.

Fig. 11. Sea erosion of very high magnitude at the lagoon shore of Minicoy as seen in 1992.

Fig. 12. Granite bunds and concrete tripods against sea erosion at Minicoy Atoll.

Fig. 15. Fishing with cast net and breaking dead and live corals at Kiltan lagoon.

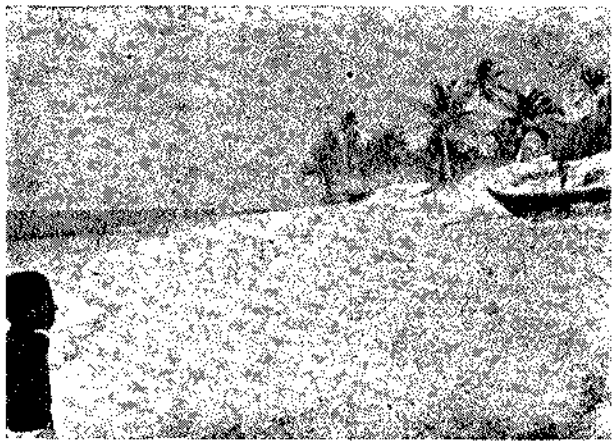

Fig. 13. The lagoon beach of Chetlat Island.

Fig. 16. The shruby thickets of *Thespesia* seen in Kiltan in 1974. None exist today. The vegetation is fast vanishing.

Fig. 14. The northern tip of Kiltan lagoon is almost filled with deposition of dredged soil. Local people search for *Octopus* along with dead shoals.

Fig. 17. Destruction to recent natural thickets of *Pandanus* in Minicoy (1982) for expanding settlement and agriculture.

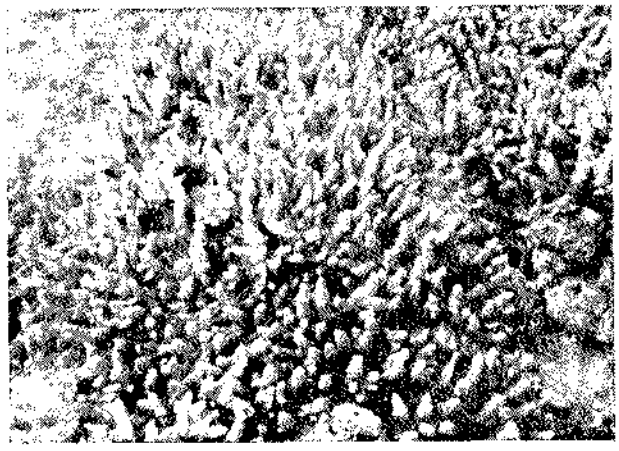

Fig. 18. A thicket of *Acropora aspera* at the windward reef of Amini island (south side).

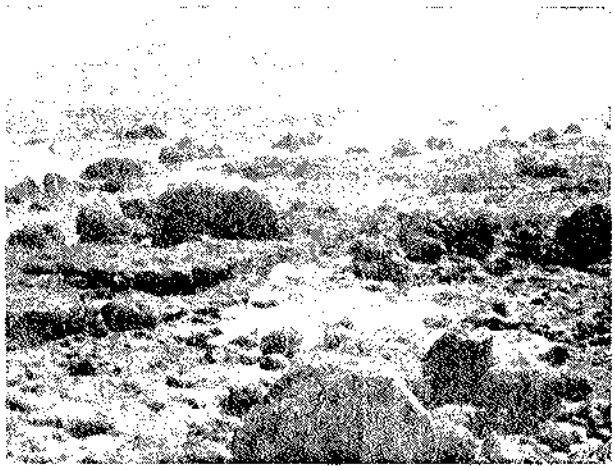

Fig. 21. Stones turned upside down and left-Minicoy reef flat.

Fig. 19. Mass mortality to corals at Minicoy lagoon as a result of excessive silting. The giant clam *Tridacna* is also dead in large numbers (1982).

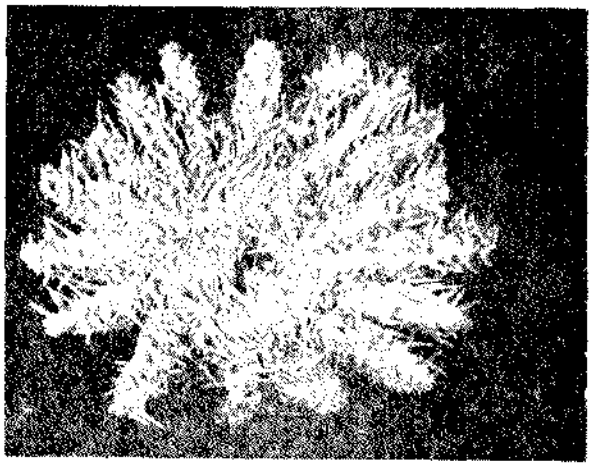

Fig. 23. The crown of thorn *Acanthaster planei*.

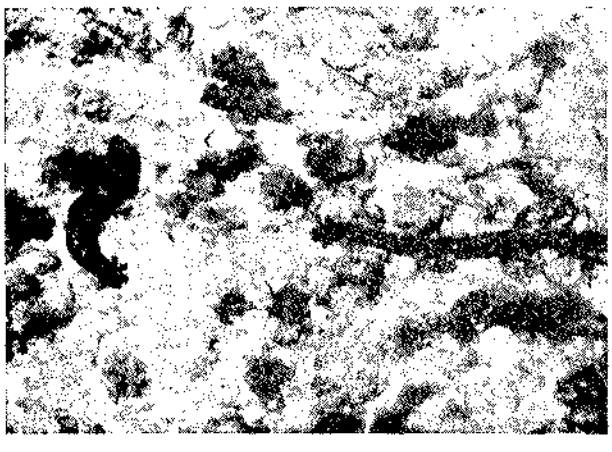

Fig. 20. *Holothuria (Mertensiothuria) leucospilota* feeding on algae to convert in to lagoon sand at Androth.

years as a consequence of expanding settlement and agricultral operation (Figs. 16, 17) During a study visit to Kiltan in 1974 thickets of *Thespesia* were observed at the northern half. However, none was visible in 1987. The introduction of cattle and goats into atolls has also put servere grazing preassure on the ground vegetation and most atolls in Lakshadweep will shortly face fodder scarcity unless the level of live-stock is scientifically managed (Pillai, 1983). On the whole the natural vegetation of the atolls is fast vanishing and plants introduced from the mainland are taking roots.

THE COASTAL ZONES

The coastal zones of the islands have been subjected to many changes. These include construction activities, sea erosion and

pollution of the beaches. Sea erosion is rampant in many atolls as is evident at Minicoy, Kavaratti, Amini and Chetlat (Figs. 10, 11, 12, 13). The loss of land to sea in these tiny islands is of relatively very high magnitude. Preventive measures by putting tripods have already taken shape. But a more careful and effective costal zone management for these islands are called for to protect them from sea erosion. The effect of sea erosion is also manifested in the lagoon by way of the deposition of sediments affecting the coral growth.

POLLUTION

Coastal zones of the atolls are also subjected to pollution by human refuse (Fig. 3), excreta and fish wastes. In Minicoy, the landing places are strewn with the wastes from tunas. The tendency to defecate on the beaches by the local people due to lack of modern facilities is also a major problem along the beaches in many islands.

During monsoon, tar balls and oil from undetermined sources reach the shores of Lakshadweep and was observed in Minicoy. Large quantities of withered oil reached Minicoy in 1981 and got deposited on the beaches near the Jetty (Pillai unpub. observ ation, Fig. 7). But no mortality to animals was observed.

A large scale oil pollution (Figs. 4, 5, 6) from the American Tanker "Transhuron" took place in Kiltan Atoll in September 1974. There was considerable spillage of oil at the northern tip of the atoll and large quantities got deposited along the intertidal and upper reef flats and lagoon shore. A long term study of the immediate and subsequent effects of this spill on marine fauna of Kiltan atoll was undertaken by the scientists of C.M.F.R.I. Approximately 3325 tonnes of oil was thought to be spilled from the Tanker as per the estimate of the officials of Indian oil Corporation who visited the Thanker on aground. The northern tip of the island was the worst affected. Upper zones of the reef flat and the shores were blackened. The southern side of the island along the lagoon beach was also polluted by oil. Floating oil was present for a week in the lagoon along the shore. It was furnace oil with a pungent smell. There was no major fish mortality. However, intertidal organisms met with instant mortality. After a week of the oil spill (5th of October, 1974) large number of the planktonic ostracod *Cyprinida dentata* was found dead and washed ashore on the lagoon side, though vertical and horizontal hauls for plankton in the lagoon and open waters revealed no dead plankton soon after the oil spill. Due to the continued presence of oil at the low water mark in the lagoon the benthic and interstitial organisms in the lagoon and shore slowly started dying after a fortnight of the spill. The worst affected were the holothurians *Holothuria pardalis* and *H. impetiens* in the lagoon; many of which were found dead and washed ashore. *H. rigida* was struggling in shallow waters where oil presisted. many eviscerated and died slowly. *Stichopus chlorodotus* which were profusely present in Kiltan during 1974 also died in large numbers (at present there is a marked reduction in their number in the lagoon). Polychaetes such as *Mesochaetopterus minutes* came out of the tubes and died after a week onwards. However, *Hippa* which were very common in the lagoon shores were healthy and active even after a fortnight of the oil spill. The beach clam *Mactra cuneata* started surfacing on the affected shores after two weeks and many died, showing that prolonged exposure to oil is lethal to them, though they can survive short exposures to crude oil by rightly closing the shells.

On the northern shore, the shore crabs *Eriphia smithi, Leptodius exaratus, Grapsus albolineatus, Actaeodes hirstutissimus, Pseudoliomera lata* and *P. variofosa* were the species that met with instant mortality. The isopod *Ligia exotica* also faced mass mortality. The hermit-crabs, though found heavily coated with oil on their shells, were not affected. The intertidal gastropods such as *Cellana radiata, Trochus radiatus* and *Drupa tuberculata* were found to be dying after two weeks of the first oil spill. They all met with a slow death.

Live corals were not affected by this spil either on the reef flats or on lagoon shoals. Oil generally floats on the water and unless it gets clogged on the coral colonies oil

spills generally do not cause mortality to corals. However, prolonged and chronic oil pollution can affect them adversely.

No beach cleaning operation or any detergent was used at Kiltan during this oil spill. The cleaning was effected by the natural process of wave action. A team (including one of us,) (Pillai) again visited the Atoll in March 1975 to study the prospect of recolonisation of intertidal organisms where mortality was observed soon after the spill. Though adult crabs were absent, smaller ones were observed in rock pools and on intertidal rocks. This indicated that recolonisation was not due to the migration of adults but was only due to the recruitment of larvae after the conditions were improved. However, in the intertidal sandy shores there was no noticeable improvement in the interstitial fauna. Examination of the affected area in 1987 January, nearly after 12 years of the Transhuron oil spill in Kiltan, shows that the area is still having a paucity of shore crabs.

Although there is no major pollution now at Lakshadweep, the coconut husks kept for retting along the beach under stones is one source of pollution. The essence from the coconut fibres oozes into the sea water killing all the intertidal organisms. It has been observed at Kiltan and Chetlat Islands that there are no intertidal organisms under stones where the coconut husks are kept. There is also a coir factory in Kadmat Island from where considerable amount of effluents are let into the sea.

THE MARINE HABITATS

The marine, especially the lagoon habitat in almost all habited atolls in the Lakshadweep has undergone drastic changes. Lack of earlier surveys and documentation of the fauna, except perhaps in Minicoy and Kiltan, as well as paucity of continuous observations by marine biologists is a major handicap in tracing recent change, if any. We have such continuous observations in Kiltan and Minicoy at least for a period of 12 to 15 years based on which some conclusions are already drawn (Pillai, 1971, 1983, 1985, 1985; Pillai and Madan Mohan, 1986). Some habitats are threatened, others endangered, though not fully modified. During the present survey most of these atolls were studied with a view to assessing the effect of human interference. But as already pointed out, effective comparison is not possible due to lack of early information on the ecology and fauna of most of the atolls. Dredging of the reef flats at the channels and lagoon bottom, construction of jettys in the lagoon and near shore, sea erosion and exploitation of the limited resources without restriction are the major factors that have adversely affected the lagoon habitats.

DREDGING

The deleterious effects of dredging (both direct and indirect or instant and long term) on corals was stressed by many scientists (Nashihira and Yamazato, 1994; Wells, 1956). Pillai (1983) has pointed out dredging as a major factor that killed large number of corals in the Minicoy lagoon. The lagoons of Lakshadweep including Minicoy, Kavaratti, Amini, Kadmat and Kiltan were subjected to long term dredging by the Lakshadweep Harbour Department to permit entry of the mechanised vessels into the lagoon. At least in Minicoy and Kiltan it was observed that dredged soil was deposited on the lagoon shoals (as in Minicoy) and lagoon reef flat (as in Kiltan) (Fig. 14) killing corals of extensive areas. Instances of mass mortality of corals are still visible at the northern end of Minicoy near the shore (opposite to old Leper's colony) and at Kiltan. Subsequent sediment transport in the lagoon is adversely affecting the coral growth. For some time in the past the administration stopped all types of dredging in the Lakshadweep, but it was re-started in Amini in January 1987. Amini is an island with mostly filled up lagoon and very few corals and fishes are found in the habitat. Without dredging it is rather impossible for the mechanised boats to enter the lagoon. Since the coral growth is poor and there is no live-bait fishery associated with corals the effect of this operation in Amini will be only minimum. However, in Kavaratti, Minicoy and as far as seen at Kiltain dredging has certainly done damage to coral growth.

Natural calamities: Natural calamities like cyclones, storms and tidal waves take a heavy toll of the fauna of the coral reefs. Cyclones not only destroy the vegetation but also the coral reefs and their fauna. An account of cyclones that hit Lakshadweep island has

been given by Jones (1989). Though the natural calamities cannot be prevented it is essential to document the damage done to the reefs and associated fauna after cyclones.

THE STATE OF CORAL GROWTH IN LAKSHADWEEP

Corals all over the world are fast dying out due to several reasons. They have dominated the benthic marine communities of the tropical waters for several millions of years and might be experiencing natural senescence and may vanish from the warm waters in course of time following the footsteps of their ancestral-tetra corals. But such an assumption is no solution to the mass mortality of corals experienced in several reef provinces all over the world due to many man made causes and sudden natural calamities Dredging, chronic oil pollution, sedimentation, prolonged exposures El-Ninos, cold water runoff on to the reefs, exploitation, predators and overexploitation for industrial purposes (Pillai, 1975) are some the major factors that hasten the destruction of recent reef corals.

Some of these factors are certainly in operation on the reefs of Lakshadweep and the deleterious effect is apparent, especially during the last two decades, concomitant with developmental activities. Mass mortality to corals has occurred in minicoy in some sites as a direct result of dredging. The large colonies of *Lobophyllia*, *Diploastrea* and faviids mentoined and charted by Pillai 1917 opposite the Leper's colony are all found dead by 1981 as a result of deposition of dredged soil on them. The *Heliopora* and other ramose coral thickets found in 1974 (Pillai unpub.) in Kiltan were mostly found dead in 1987. Dredging has also a long-term consequence on coral growth. The silt and sediments generated by dredging and their excessive transportation over the reefs and into the lagoon coupled with saa erosion are slowly killing many corals.

In Minicoy and Kiltan many massive corals were found to be dead at the top due to silting, and the growing zone of large massive colonies is confined to the periphery. Even without human interference this natural process is taking place on reefs to some exetnt. The small-polyped *Acropora* which forms the dominant lagoon coral in Lakshadweep, is perhaps, the most sensitive to silting (Pillai, 1975). This may be the reason for their large scale death and disintegration in the recent past. In 1974 the lagoon of Kiltan was found to have a very luxuriant growth of *Acopora teres*, *A. aspera* (Fig. 17), *A. corymbosa* and *A. humilis* along with large thickets of *A. formosa*. However, the present survey has indicated that the corals of the Kiltan lagoon have vastly died. Enquires with local people have revealed that there was intensive interference from the local people in the lagoon habitats in the recent past. The lagoon fishes found in association with corals were exploited for food especially by the women folk at low tide They put small nets over the coral colonies and break the branches to drive away the fishes (Fig. 15). During the low tide many people particularly women and children turn the coral stones to collect cowries and other gastropods. They leave the stones upside down without putting them back to original position. All these have caused the disintegration of already dead and live corals throughout the lagoon, Today, Kiltan lagoon looks depopulated and is getting filled up fast due to siltation.

During the present studies one of us (Thomas) made an attempt to estimate quantitatively the percentage coverage of dead and live corals in some sample plots of the islands both in lagoon and reef flat habitats. The sample plots were of the area af approximately 25 sq. m. General observations on the state of growth of corals was also made as summarised below.

Minicoy: The damage to corals in the lagoon of Minicoy has already been brought to the notice of the scientific public (Pillai, 1983). Thomas found that the coverage of corals in sample plots ranged from 5 to 10% of the bottom area. Of these 50 to 80 present was dead - a clear indication of the paucity of live corals in the lagoon at present. The southern portion of the lagoon is fast getting filled with excessive sedimentation, for the sediments brought by the water current from the north of lagoon has no escape further into open ocean since the reef flat is elevated and remain exposed most of the time acting as an effective barrier.

Kavaratti The reef front at windward side of the atoll has a reasonable growth of ramose and massive corals, At the southwest of atoll both in the lagoon and reef there is excessive deposition of silt causing significant damage to corals The coral growth in the lagoon is not rich. The inner side of the lagoon reef has some coral growth but the top portion of the colonies are dead due to silting. At the central part of the lagoon ramose corals are mostly dead with living layers of over growth on some. The Kavaratti lagoon has been subjected to intense construction activities. The percentage coverage of both dead and live corals in sample plots in both lagoon and reef varied from 10 to 60 percent of the area, of which on an average 50 percent of the corals are dead. This indicates more than 50% of corals of Kavaratti is represented by dead and disintegrating corals.

Suheli Par: The lagoon is very deep and wave conditions at the time of visit permitted only limited sampling. The area is not much subjected to any human interference and mortality to corals is due to natural reasons. The reef flats have luxuriant live coral coverage. There was little sign of excessive deposition of sediments anywhere. The lagoon and lagoon reef also have massive and ramose corals. Percentage of dead corals (estimated from the top) varied from 5 to 15% of the total bottom coverage.

Kalpeni: At Kalpeni harbour there is relatively profuse growth of corals throughout the lagoon. especially ramose forms. The lagoon reef flats have massive *Porites*. The northern half of the atoll is more rich in coral growth than the southern half It is one of the atolls that has not been subjected to much interference and exploitation of the marine resources. The lagoon still presents a natural look. Percentage of dead corals in sample plots ranged from 10 to 25 and the total coverage of coral growth is from 25 to 50% of the bottom.

Amini: The lagoon of Amini is very shallow with vast areas of sea grass beds. It is being continuously dredged. The lagoon habitat is unsuitable for any significant coral growth though occasional ramose colonies are seen, The inner side of the leeward reef harbours some corals but at the southern half it was observed to be mostly dead. The windward side is subjected to sea-erosion and there is a vast and flat (Figs 8, 9) sea grass meadow between the reef front (algal ridge) and the shore. There is a fairly rich growth of corals at the northern side of the windward side. The dominant species include *Psammocora contigua*, *Pocillopora* spp., and *Acropora aspera* (Fig. 18) the last mentioned species often forming large thickets. In Amini, coral growth is richer in the reef habitats than in the lagoon. There is excessive silting on the windward side and the reef flat is mostly covered with sand that prevents any coral growth near the shore on the windward side of the island.

Kadmat Island: The Kadmat island is long and narrow with a vast lagoon. The lagoon is dredged. There are many shoals most of which are dead without any live corals. On the sandy bottom there are patches of ramose corals of the genera *Acropora* and branching *Porites*, and in that sense the coral growth in the lagoon bottom is fairly rich at many places. The lagoon reef flat and inner side of the lagoon reef harbour a fairly rich coral fauna and the present day growth is very healthy. Massive *Porites* dominate at many sites. The northern half, as in other atolls, is richer in corals than the southern half. *Heliopora* is also a dominant genus on reef flats. From the vast sand flats of Kiltan harbour, sprats (*Spratelloides*) are exploited as live-baits for pole and line fishing for tuna. *Octopus* is common on coral shoals and is collected by local fishermen. On the whole, the present survey revealed that the coral growth in Kadmat is still rich though the terrestial habitat is much altered due to mining of lime and sand stones.

Kiltan: The marine fauna and coral reefs of Kiltan were studied in detail in 1974 by the scientists of CMFRI One of us (Pillai) also studied the corals and coral reefs of this island in 1974 and again in 1975 and the present survey after a decade made him aware of the changes that took place both in the lagoon and reef habitats. On the terrestrial side, mining for sandstones was more intense and there was a total loss of natural vegetation. The coral in the lagoon is mostly dead. All the *Acropora* thickets noticed in 1974 were found to be dead and disintegrating. As already pointed out, the coral colonies were broken by the local people to fish from them, resulting in almost total destruction. Dredging in the lagoon has certainly

killed many corals and large areas of lagoon reef flat is (F.g. 15) covered by the soil dredged and dumped on the reef flat. The lagoon is mostly filled at the southern tip and there are few corals. The dominant species of corals in the lagoon in 1974 were *Acropora aspera, A. formosa, A. intermedia A. corymbosa* and *Porites andrewsi* all of which formed large thickets. However, these are not certainly found there at present in a great profusion though the species can be collected still from the various habitats. On the eastern reef flat, near the shore just opposite the Dak Bungtow, there was a profuse growth of *Acropora* in 1974. A re-examination of the site in 1987 showed very little corals in this site. The inescapable conclusion is that the coral growth of Kiltan was affected due to natural silting as well as dredging. The disintegration of ramose corals in the lagoon was hastened by human interferences

Chetlat Island : Chetlat seems to have retained most of its natural conditions in the lagoon habitats. The northern side of the lagoon is shallow, mostly exposed at low tide, and the bottom is covered upto 60% with large dome-shaped colonies of *Heliopora caerulea, Psammocora contigua, Porites andrewsi* and *Porites (Synaraca) convexa*. Other reef corals, though occur, are not very dominant. The inner lagoon reef flat is covered predominantly with the massive coral, *Porites*. No sign of large scale death of corals due to excessive interference from natural or artificial factors was recorded from Chetlat. The reefs and reef associated organisms are rich and the marine habitat presents a healthy look. However, the lagoon is also getting filled by natural processes. The open reef flats have a profusion of encrusting *Montipora* and *Porites*. Fishing activities in the lagoon are very limited and it is learnt that only during active monsoon, the local people fish in the lagoon for food. Live-baits are not exploited in any large quantities from this atoll. Sea erosion is taking place at some sites and preventive measures are being taken by the local administration.

The state of coral growth in some islands such as Androt and Agatti is reported to be good. In the absence of any lagoon in Androth the coral growth on the reef flat alone is of any importance. Agatti is rich in corals and interference, if any, is yet to be ascertained.

PREDATORS

Of recent, the role of the crown of thorns starfish, *Acanthaster planci*, in the mortality of corals in various parts of Indo-Pacific has been stressed by many authors. A review of the recent works on this aspect is presented by Endean (1973). The occurrence of *A. planci* was reported at Kavaratti (Sivadas, 1977) and Minicoy (Murty *et al.*, 1980). Predation of *Acropora* spp. by this starfish (Fig. 22) and consequent death was recorded at Minicoy and Kavaratti. However, the number of the starfishes was not in any great proportion to call it a plague. Recent surveys have not shown the presence of these predators in many of the islands.

BIOFOULING

According to Nair and Dharmaraja (1983) fouling on man-made objects in Lakshadweep is not very severe when compared to mainland waters. The structure and abundance of fouling community is insignificant though rock oysters and serpulids are found on jetties and other coastal installations, as seen in Minicoy, Kavaratti, Amini, Kadmat and Chetlat. Major fouling organisms such as barnacles, bryozoans, mussels and hydroids are extremely rare. Wood boring bivalves and crustaceans occur that cause damage to timber structures.

BIOEROSION

Many boring organisms attack both living and dead corals. The major groups that cause erosion to coral skeleton include algae, sponges, polychaetes, sipunculids, bivalves and echinoderms. The activities of these organisms on both massive and ramose corals cause their break down. The sediments that are produced by the boring activities also contribute to filling up of the lagoon. Though many of these agents occur on the reefs of Lakshadweep, to date no serious study on their occurrence and role in the breakdown and erosion of calcareous material in our waters was taken up. During the present study some observations were made on boring sponges, molluscs and the role of holothurians in converting calcareous algae into sand which are given below:

Sponges:

Many species of sponges are well known for their capacity to bore into calcareous objects such as shells, corals, calcareous algae etc. Studies made in the past have shown that the sponges etch out minute calcareous particles of an average size 56 x 47 x 32μ (length x width x height) from the interior of the substratum by the activity of filopodial structures produced by certain specialised cells so common at the site of boring. These filopodial structures grow and form fine crevices around a future chip. subsequently, these filopodial structures borne by different such cells fuse together to form a filopodial basket around a future chip and then it is pulled out from the site. Such chips are expelled through the excurrent stream of water. These chips contribute much to the mineral fraction of sediments produced in the reef environment and in the Fanning Island, it is estimated that, such chips contribute to about 30% of the total sediment load (Rutzler, 1975 Rutzler and Rieger, 1973).

The quantity of calcareous chips thus produced by the activity of sponges vary considerably both in time and space. It was calculated that in Bermuda reef the total chipping activity of sponge release as much as 250 gm $^{-2}$ year $^{-1}$ which corresponds to a coral layer of 0.1 mm thick. In areas of high sponge concentration this figure may go up to 3 kg $^{-3}$ year $^{-1}$ (or 1mm/year). From these figures the part played by sponges in the bioerosion of the reef environment can be well imagined (Rutzler,1975). It has also been calculated that only 2-3% of the eroded substratum is removed in dissolved form.

Composition of boring sponge population in Lakshadweep: An interesting feature noted with regard to the sponge fauna, both island-wise and morphozone-wise, is dominance of boring species in relation to non-boring ones. The percentage occurrence of boring species in the total number of species represented at each island may be given as follows : Kavaratti-46.4%; Kalpeni-36.1%; Suheli-48.3%; Androth-66.6%; Minicoy-50.0%; Amini-38.4%; Kiltan-20.0%; Agatti-60.0% and Kadmat-58.3%.

The number of species of boring sponges recorded is 18 as listed below:

Phylum porifera Grant
Glass Demospongiae Sollas
Order poecilosclerida Topsent
Family Raspailiidae Hentschel

1. *Rhabderemia prolifera* Annandale

Order Hadromerida Topsent
Family Spirastrellidae Hentschel

2. *Spirastrella coccinea* (D & M)
3. *S. cuspidifera* (Lamarck)
4. *S. inconstans* (Dendy)
5. *S. aurivilli* Lindgren

Famfly Clionidae Gray

6. *Amorphinopsis excavans* Carter
7. *Aka minute* Thomas
8. *A. laccadivensis* n. sp.
9. *Cliona celata* Grant
10. *C. vasiifica* Hancock
11. *C. viridis* (Schmidt)
12. *C. carpenteri* Hancock
13. *C. ensifera* Sollas
14. *C. mucronata* Sollas
15. *Thoosa ermata* Tapsent

Order Epipolasida Sollas
Family Jaspidae de Laubenfels

16. *Japis penetrans* (Carter)

Order Carnosida Carter
Family Halinidae de Laubenfels

17. *Halina plicata* (Schmidt)
18. *Samus anoyma* Gray

In order to get clear picture on the abundance of the various boring species in each island the total incidence of each species was estimated for Kavaratti, Suheli, Kalpeni, Androth and Minicoy separately, and this indicated that *Cliona celata* Grant dominates in both Kavaratti and Suheli, *C. ensifera* Sollas in Kalpeni and *C. mucronata* Sollas in Androth. However, the distribution pattern noted at Minicoy is quite different since both *C. celata* Grant and C. *vastifica* Hancock are equally dominant. Summarising the distribution pattern of both *C. mucronata* Sollas and *C. ensifera* Sollas, it may be stated that these two are typical coral

boring species in both reef and lagoon habitats. At Androth the former dominates while in Kalpeni, the latter. In these two lagoons the activity of *C. celata* and C. *vastifica* is at a low level, and it is not known fully at present whether they are being checked by the activities of *C. mucronata* or *C. ensifera*.

Four species of the genus *Spirastrella* are commonly found in various lagoons surveyed; of which two, viz., *S. inconstans* (Dendy) and *S. cuspidifera* (Lamarck), show the tendency to overgrow the substratum after disintegrating it totally (gamma stage). Both of them usually make extensive galleries inside massive corals. It is very interesting to note that both *C. margaritifera* Dendy and *C. lobata* Hancock which have infiltrated into the molluscan beds of the mainland, mainly along the southwest coast (Thomas, 1983) recently, have not yet made their appearance in the Lakshadweep. it is possible that these may invade the Lakshadweep water also. Attempt to transport pearl oyster, mussel, edible oyster etc., infested with these borers to Lakshadweep, can cause their introduction. Hence, any consignment of molluscs for culture from the mainland or elsewhere to Lakshadweep must be screened properly before it is despatched.

Hartman (1958) feels that the coral reefs do not present as wide a variety of clionids as might be expected. De Laubenfels (1950, 1954) could report only two species from Bermuda and five from the West Central Pacific, while Burton (1934) could record no clionids from the Great Barrier Reef. But the present survey indicates that the boring sponge fauna is rather rich and varied in Lakshadweep.

Damage caused to corals: Analyses of the data collected from the various islands during the present survey indicate a very high rate of infestation in all the islands surveyed. It is noted that the sponge can bore into both live and dead corals alike. The death of coral will never affect the activities of the boring sponge since there is no trophic relationship between them. Under this situation the chipping of calcium carbonate material can go on incessantly even after the death of corals and this will considerably weaken the entire reef frame-work making it more susceptible to the wear and tear caused by waves. Such a weakened substratum will, no doubt, accelerate the activity of secondary borers such as polychaetes, molluscs, sipunculids etc.

Boring sponges can make extensive galleries inside the coral, but the magnitude of damage caused cannot be assessed by exrernal examination alone. This is because the outer layers of the coral remain practically untouched and more or less intact except for a few pores for the excurrent and incurrent papillae to project out. Atleast some of the massive corals examined from different islands were in this advanced stage of boring, and their interior was found practically hollow except for a few calcareous pillars stretching across the different tunnels within the skeleton.

An *Acropora* colony (partly dead) weighing 600 g with a maximum diameter of 15 cm, bearing 48 upright branches arising from a flat base, was collected from Kavaratti, It was found that out of 48 branches 34 were infested severely by boring sponges. Species-wise break up of incidence may be given as follows: *C. ensifera* on 12 branches; *C. celata* on 11 branches, *C. mucronata* on 6 branches; *C. vastifica* on 4 branches and C. *viridis* on 1 branch. Apart from the above mentioned species, other borers such as polychaetes were found boring on two branches, molluscs on two and sipunculids on one branch. The above details indicate that sponges, as a group, dominate among the various groups of organisms that destroy the branching coral colonies in Lakshadweep.

The assessment of damage caused to the stalk portion of branching coral is based on *Acropora* sp. collected from Kalpeni. The stalk portion of this colony has an average diameter of 5 cm and the various boring organisms occupying the cut end of the stalk were identified incidence-wise. Sponge infection could be noted at 8 places, polychaete at 6 places, mollusc at 5 places and sipunculid at 3 places. Species-wise Incidence of sponge indicates that *C. ensifera* has the maximum incidence (3 numbers) followed by *C. celata* and C. *vastifica* (with 2 each). However, the incidence noted in the case of C. *mucronata* is the minimum (one).

Data collected from massive coral, from Kavaratti, show that boring sponges form by far, the most dominant group causing biological

erosion here also. Only one species of sponge (*C. celata*) could be collected and this species occupied three different locations inside the coral. The other groups noted were polychaetes, molluscs, crustaceans, sipunculids and algae; polychaetes were noted at two different spots while the others at one spot each, In an area-wise analysis, *C. celata* ranked first.

From pooled data obtained from the above three samples it may be concluded that among the boring organisms, the sponge ranks first followed by polychaetes and sipunculids in Lakshadweep reefs.

Activity factor relationship : The factors influencing the activity of boring sponge in the reef envivonment are many. Rutzler (1975) has experimentally proved that when a coral piece infested by boring asponge is cut into two it will stimulate the boring activity in the resultant bits considerably. Cutting channels across the reef will produce a similar effect and the chipping will go on at an accelerated rate atleast along the cut edges of the channel. Illumination also plays an important role in the accelerated activity of boring sponges (Rutzler, 1975). The clarity of water in the lagoons of the various islands surveyed is rather exceptional and hence this may be cited as an important factor that affect boring in a positive way.

In conclusion, it may be stated that the damage caused to corals by boring sponges is rather widespread in all the morphozones of the reefs investigated. In many cases it was noted that the infestation may kill the corals partly or fully. Localised death of a colony may not produce any far reaching results unless considerable damage occurs to the stalk portion. In any branching colony that occupies the reef front zone, a dead or disintegrated stalk can result in the sliding away of the entire colony into ddeper waters where it will be buried by sediments But, branching colony which occupies level bottom will never experience such a fate since ihe interlocking of the branches of adjacent colonies will keep it in position, even after the total disintegration of the stalk.

Molluscs :

Appukuttan (per. comm.) informs that the mytilid *Lithophage nigra* and *gracilis* making deep and massive burrows at the base of ramose corals are present in most of the reefs of the Archipelago. These molluscs are more common on the reef habitat than in the lagoon. Another mytilid *Botula cinnamomea* which makes shallow burrows was recorded from Minicoy. Its occurrence in other atolls awaits confirmation. Yet another group that burrows into limestone is the venerid *Petricola lithophaga* and *P. divergens*. Both these species were collected from Minicoy reefs. Two spicies of gastrochaenid, viz. *Gastrochaena gigantea* and *G. impressa* also make burrows into corals. The former is widespread while the latter is recorded only from Minicoy. While *Lithophaga* bores the coralline material by chemical action, the gastrochaenids act mechanically to make burrows 1.5 to 3 cm deep. *Jouannetia cumingii* is found throughout Lakshadweep and this species makes deep burrows on massive corals; the siphon of this species project 2 to 3 cm from the burrow. This is also an effective mechanical borer.

A few wood boring bivalves such as *Teredothyra, Uperotus, Teredo, Lyrodus, Bankia, Pholas* and *Martesia* were also recorded from the Lakshadweep waters that cause damage to wooden structures and timber (Nair and Dharmaraja, 1983.

Holothurians:

The role of the holothurians in the lagoon sand formation has to be commented here. Several species of holothurians like *Holothuria (Ludwigothuria) atra, H. (Microthele) nobils* and *H. (Mertensiothuria) leucospilota* feed on the calcareous alga *Halimeda* sp. and convert the same into largoon sand (Fig. 4). In some places 500 to 1000 tonnes of sand is known to pass through the holothurians in an year. This will have a direct bearing on the filling up of the lagoon. In some places liKe Kiltan the holothurian *Holothuria (Ludwigothuria) atra* is thickly distributed with 5-7 specimens in one sq. m. The role of holothurians in filling up the lagoon with sand in such places will be significant.

POPULATION AND ATOLL ENVIRONMENT

Human activities on coral atolls is an important aspect that needs a detailed study in Lakshadweep; for the effect of changing environment on population needs careful assessment for future planning. As pointed out

by Weins, (1971) the availability of percapita land, fresh water, reef area and lagoon for population are criteria for estimating the population pressure in restricted geographical areas like small atolls. Though reliable statistical data on these aspects from the inhabitated atolls of Lakshadweep are still required, it may be assumed that due to improved medical supplies, education, sanitation, nutrient food supply, and recreational facilities in the recent decades the population pressure in the atolls is gradually increasing.

CONSEQUENCES OF ENVIRONMENTAL DAMAGE

Mortality to corals set chain actions and interactions bringing out visible changes in the ecosystems. The loss of live corals directly brings out a depletion of associated organisms as well as an advancement of algae and animals that thrive on dead corals. Pillai (1983, 1986) and Pillai and Madan Mohan (1986) have described the adverse impact of mass mortality to corals in Minicoy atoll (Fig. 19). As already pointed out by Endean (1973) the coral skeleton, on death, display a whitish colour due to loss of living matter and many remain so, for a few weeks or month. Soon, they get coated by green filamentous algae and assume a dark green colour. Subsequently, coralline algae make an over coat. Dead corals are more vulnerable to the attack of borers and bioerosion of the colonies starts at a faster rate. Sponges, sipunculids, molluscs and echinoderms start attacking the colonies and the resulting calcareous sediments cause more sedimentation in the reef habitats. When ramose corals die and remain *insitu* they act as effective sediment trappers in between the branches and thus effect filling of the lagoon, ultimately the corals themselves get burried.

Coral associated or coral haunting fishes such as chaetodons, some humbugs (eg. *Dascyllus aruanus* as seen in Minicoy) and rock cod may remain associated with corals when the latter die but may disappear as the algal coating on dead skeletons increases (Endean, 1973). Most of the live coral associates, including fishes, abandon the coral colonies. What is found mostly are borers and a few crustaceans and molluscs.

The death of corals in the Minicoy lagoon was found to have a direct inverse impact on the coral associated fishes and tuna fishery as explained in detail by Pillai (1983). Pillai and Madan Mohan (1986) have noted the microhabitat selection of many coral associated fishes in Minicoy. For example *Chromis caeruleus* the blue puller, which is an important tuna live-bait in Lakshadweep was found to be predominantly associated with arborescent corals like *Acropora intermedia, A. formosa, A. teres* and *A. aspera* (Fig. 18) which were very common in lagoon. The species is also found along with *Pocillopora* spp. and *Stylophora pistillata*. However, recently Pillai has observed their presence among large colonies of *Heliopora caerulea* at Chetlat. As pointed out by Pillai and Madan Mohan (in press) this species coexists with *Dascyllus aruanus*. It was observed that mass mortality to the arborescent corals in the traditional fishing areas of Minicoy coupled with over exploitation have caused a marked dwindling of *C. caeruleus*. It is not successful with dead corals though *D. aruanus* gets adapted to dead corals in the absence of sufficient living habitat of live corals (Pillai and Madan Mohan in press[2]). The resident fishes such as *Archamia* sp , *Apogon* spp; *Pristiapogon* and *Spratelloides japonicus* on corymbose corals are also found not able to adapt to dead corals. The overall result is that death of corals causes a dwindling of many important reef fishes that are used as live-baits in Lakshadweep. Mass mortality to corals and dwindling of resident live-baits may affect the traditional tuna fishery by pole and line, for they form a steady sources for baits, while the availability of migrant forms is unpredictable.

RECOLONISATION OF CORALS AND ECOSYSTEM IMPROVEMENT

Recolonisation of reefs and lagoon habitats by hard corals depends on many factors including the magnitude of the destruction, modification of the habitat, availability of planulae, nature of water current to favour the inflow of planulae; recurrent damage to habitat and the like. When a reef is damaged by catastrophic events (both natural and man-made) there should be some hard bottom still left so that settlement of planulae can take place. As far as one could judge, in some of the lagoon of Lakshadweep as in Minicoy, Kavaratti and

Kiltan, the interference of sedimentation is of high magnitude and there is great sediment transport in the lagoon. Few new settlements of colonies were seen in both Kiltan and Minicoy though over growth of fresh living layers are seen on many dead and intact coral colonies. Reefs subjected to human activities appear to have lost capactty to re-generate since the impact is long lasting (Wells, 1984). Based on a study of the south Indian reefs, Pillai (1975) felt that within a period of 20 to 25 years reasonable recolonisation of *Acropora* will take place provided the conditions for recolonisation are favourable. As far as Lakshadweep atolls are concerned even if any recolonisation on the lagoon is to take place absolutely no further interference should be there. Dredging has to be abandoned. Effective measures to check sea-erosion have to be taken up. Destruction to live corals has to be avoided. It is rather difficult at this stage to say whether active re-growth of corals in the lagoon habitat will take place in future, where significant damages have already taken place.

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20. UNDERWATER OBSERVATIONS IN THE LAGOONS

A. C. C. Victor, A Chellam and K. Ramadoss

INTRODUCTION

The paper deals with the results of the underwater observations carried out on the faunistic and topographical features by direct underwater observations at selected localities covering the entire length and breadth of the lagoons of Minicoy, Suheli paar, Kalpeni, Kavaratti Androth, Agatti, Bangaram, Amini, Kadmat, Kiltan, Bitra and Chetlat between January and April 1987. In each island a week long survey was carried out by means of diving The scope of this report is limited and by no means exhaustive It enables us to provide first hand information on the nature of substratum, disposition of coral reefs, fauna and flora of the lagoon.

For the purpose of mapping the distribution pattern of different species of marine fauna and flora, if was felt convenient to divide each island into different sectors (Figs 1&2) and observations by diving were made on a transect line commencing from the low water mark to the outer reef crest. In each transect line 4 to 6 stations were selected for observation taking care to include the shoreward lagoon, mid lagoon, outer lagoon, reef flat and reef.

MINICOY

Sector I: This sector commences from the middle of the southern portion of the eastern shore and extends upto the southern end. The intertidal region is sandy intermittent with coral boulders. Along the shoreward portion of the lagoon, the substratum is mostly sandy.

Massive corals (*Porites* sp) are widely distributed in this region. Silt deposition is high in this region and due to this effect huge shoals of corals lie buried into the sand. On the mid portion, the lagoon's bottom is sandy. Here too, heavy silting is observed, Molluscs and holothurians appear to be absent. The branching acroporans are the dominant corals in this region, of which the commonest and the most characteristic one is *Acropora formosa*. *Porites* sp is also seen in certain locations. The reef flat is coralline, intermingled with coral sand. *Tridacna maxima* occurs in stray numbers.

Sector II : This sector commences from the middle of the island and extends upto the commencing point of sector 1. The intertidal region of the sand/ shore possesses a dense population of the clam belonging to the genus *Mesodesma*. Along the shoreward portion of the lagoon, the substratum is sandy where dense settlement of the clam belonging to the genus *Lucina* is observed The maximum density of clam recorded is over 1000/m². The coral community is sparse in this region. Silt deposition is high. The mid portion of the lagoon floor is formed mainly of coral sand. Majority of corals found in this region are dead ones. However patches of branching acroporans are seen here and there. Silt deposition is high in this region. Corals found fo be dominant in the reef flat include several species of *Acropora* and *Porites*.

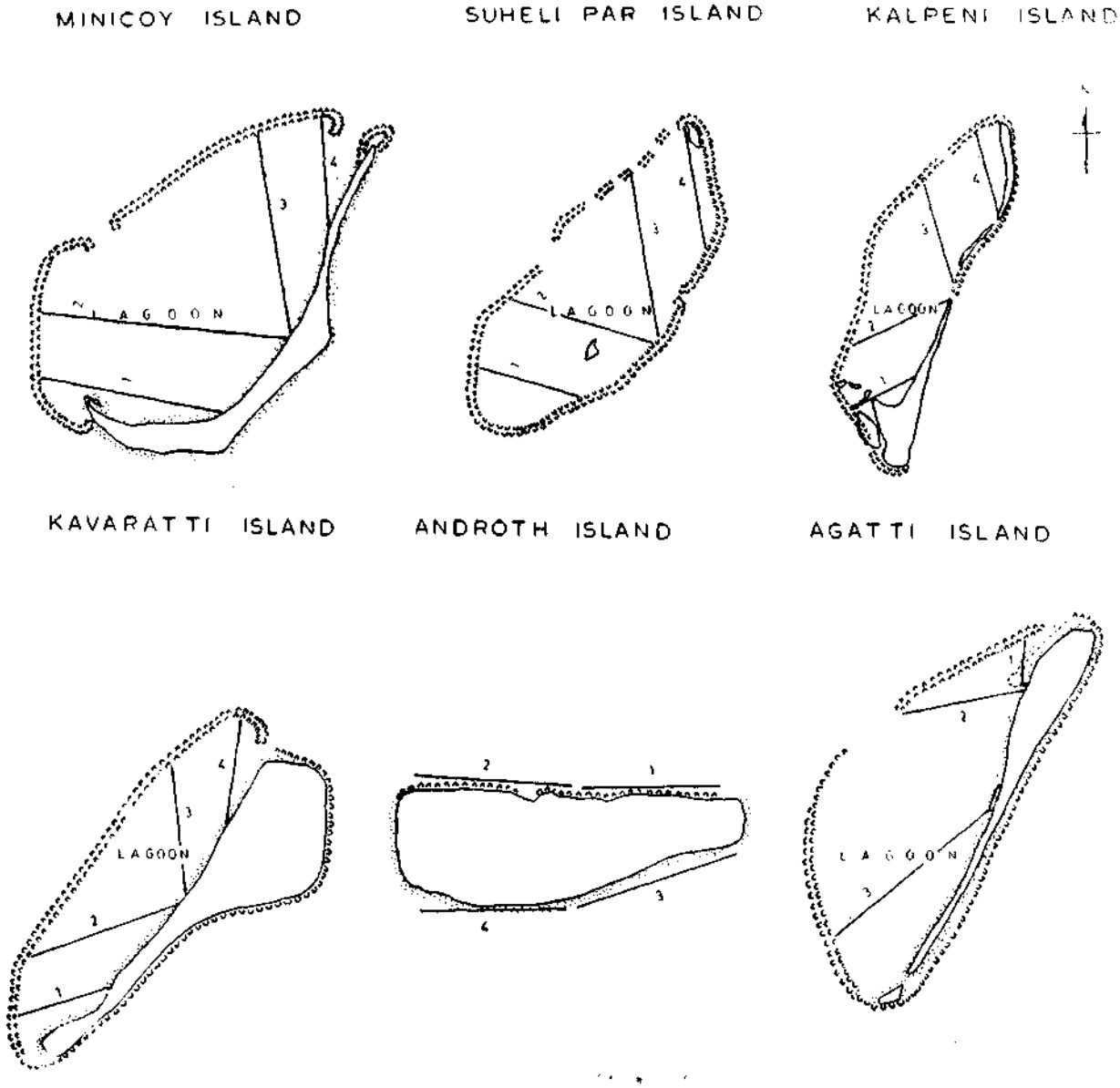

Fig. 20 Figure showing different sectors of the lagoons where under water observations were made

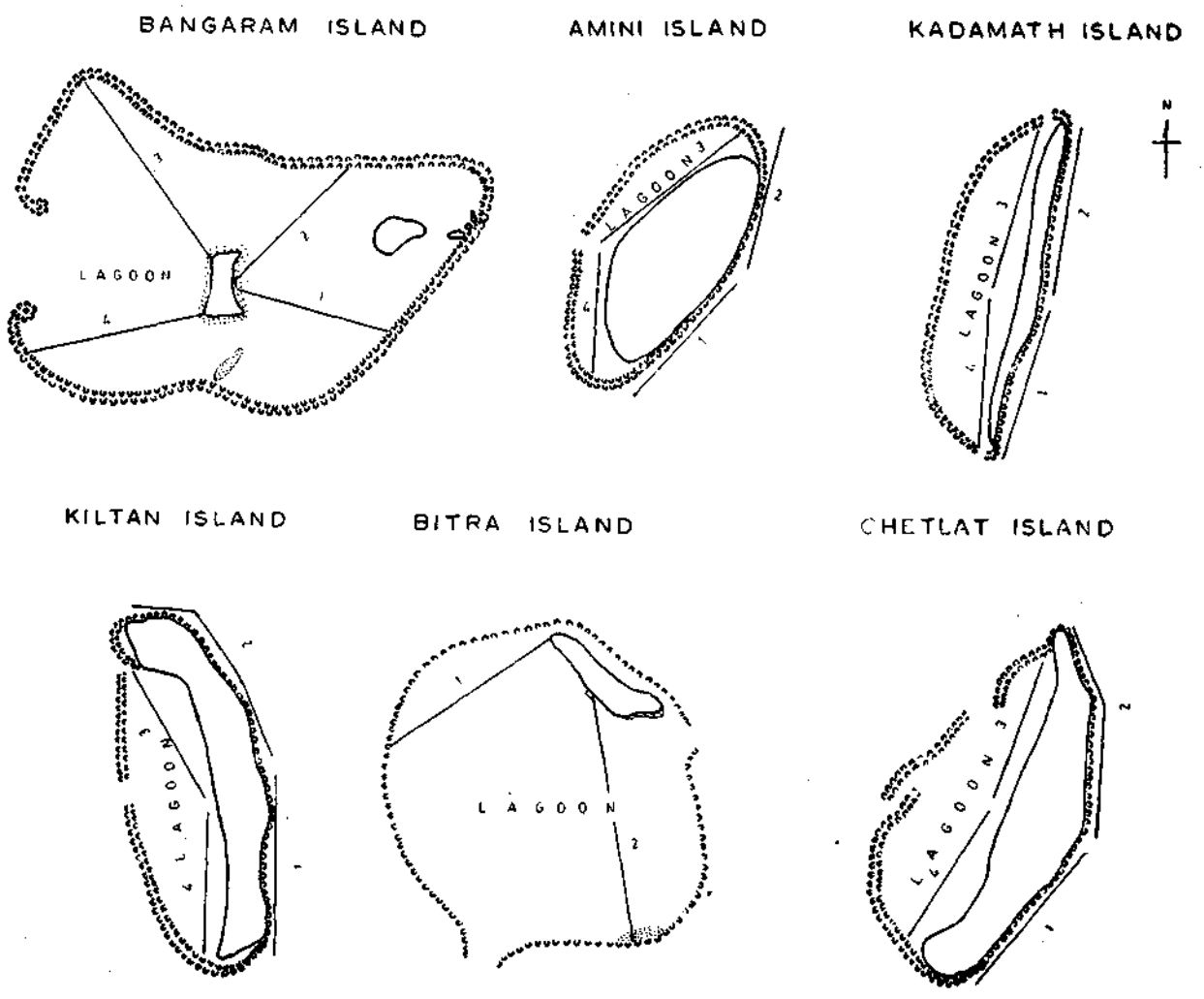

Fig. 2. *Figure showing different sectors of the lagoons where underwater observations were made*

Sector III : This sector commences from the mid point of the island and extends upto the point of commencement of sector IV. The intertidal region is sandy. Along the shoreward portion, the lagoon bottom is sandy intermittent with corals where dense settlement of clam *Lucina* sp is observed. The sea grass *Cymodocea* is abundant over wide areas. Sedimentation is observed to be high in few numbers. The fauna and flora of the mid portion of the lagoon are similar to those that occur in the sector II. The reef flat is formed mainly of coral boulders on sand. Several species of branching acroporan and *Porites* corals occur in this region. Molluscan fauna is sparse in this region.

Sector IV: This sector commences from the middle portion of the northern side and extends upto the northern end. The fauna and flora of this region are almost identical to those of sector II and III.

SUHELI PAAR

The Suheli paar lagoon is very extensive and deep in certain localities. Inside the lagoon two islets are located. One is Valiakara which is located on the northern end of the lagoon and the other is Cheriyakara which is located on the southern end.

Sector I : This sector commences from the middle of the southern portion and extends upto the southern end. On the eastern side of the lagoon, the reef flat is submerged in water. The reef flat is constituted mainly of coral boulders with intermittent coral bits. The coral reef in this region comprised mainly of *Acropora* spp. Besides this, the other forms noticed are the pearl oysters (*Pinctada sugillata*) and sea weeds (*Halimeda* sp, *Padina* sp. and *Turbinaria* sp.). Below this region is the shoreward portion of the lagoon where the floor is constituted

mainly of sand with occasional corals. The depth varies between 1m and 3m. This zone supports a variety of fauna and flora. These include the common corals (*Acropora* spp and *Fungia* sp), molluscs (*Tridacna maxima* and *Conus* spp) and the sea weeds (*Chaetomorpha* sp, *Halimeda sp*, *Sargassum* sp and *Padina* sp.) In the mid portion the bottom components constituted mainly of sand with decayed corals. The depth in this zone ranges between 3 and 5 m. Corals like *Acropora* spp and *Heliopora* sp. are very common. Fishes inhabiting the corals are *Ostorhynchus* sp., *Labroides dimidiatus*, *Dascyllus* sp and *Acanthurus* sp. Two pelecypod molluscs namely *Pinctada sugillata* and *Tridacna maxima* are frequently seen. Noteworthy among the sea weeds growing here are *Chaetomorpha* sp., *Halimeda* spp, *Turbinaria* sp and *Sargassum* sp. The reef flat is submerged in water and the depth range is between 0.5 and 2.0 m. The substratum is firm with dead coral boulders. Frequenting the rocky bottom, fishes like *Ostorhynchus* sp and *Rhinecanthus* sp and *Labroides dimidiatus* are very common. The molluscan fauna is sparse except for the occurrence of *Lambis* sp, *Conus* spp and *Tridacna maxima*. The density of algal vegetation is very thin.

Sector II: The sector commences from the middle of the southern portion and extends upto the mid portion of the lagoon. On the outer reef flat of the eastern side, the substratum is hard with stretches of coral rocks where the depth ranges between 0.5 and 2.0 m. The slope from the lagoon reef to the lagoon floor is gradual and the floor itself is covered thickly with sand and coral bits. The fauna and flora of these 2 regions are similar to those found in the same zones of secfor I. In between the mid and shoreward portion of lagoon, Cheriyakara is located. The intertidal region of sandy shore possesses dense population of the clam belonging to the genus *Mesodesma*. Besides this, the other forms include polychaete worms siphunculid worms and *Emerita* sp. The mid portion of the lagoon bottom component constituted mainly of sand with live and dead corals. The area is poor in animal life but covered by patches of algae such as *Halimeda* sp. *Turbinaria* sp and *Padina* sp. The reef flat on the western side of the lagoon is submerged in water. The substratum is hard with dead coral bits and coral boulders. The coral communities of this region include *Acropora* sp and *Porites* sp.

Sector III: This sector lies in between the mid point and the middle of the northern portion of the lagoon. In this sector too, the outer reef flat of the eastern side is formed mainly of coral boulders. The massive coral *Porites* spp are seen in abundance. The giant clam *Tridacna* sp is seen in some part of the reef flat. On the shoreward portion of the lagoon corals belonging to the genera *Porites* and *Acropora* are moderately abundant. The gaint calm *Tridacna maxima* is occasionally noticed. Patches of *Turbinaria* sp and *Cymodocea* sp are seen in some parts of the lagoon. The mid portion of lagoon floor is covered mainly with sand and dead corals. The depths here varies between 3 and 5 m. Branching acroporan coral and the solitary coral *Fungia* sp. are abundant. The reef flat is submerged in water and the fauna and flora are identical to those that occur in the same zone of sector I & II.

Sector IV: This zone commences from the middle of the northern portion of the lagoon and extends upto the northern end. The islet Valiakara is located in this sector. The eastern side reef flat is composed mainly of coral boulders. The shoreward portion of the lagoon's floor is sandy with coral rocks where the depth varies between 1 and 3 m. The giant clam *Tridacna maxima* is the most abundant mollusc in this region. The coral communities and algal vegetation are less abundant. The middle of the lagoon floor is sandy where the depth range is between 3 and 5 m. Molluscs and holothurians are not observed in this region. The area supports a wide variety of acroporan and *Porites* corals. The reef flat is composed mainly of reef rocks and dead corals. The molluscs, *Tridacna* sp and *Lambis* sp are generally abundant and larger in size. The area supports a thick growth of algae such as *Halimeda* sp, *Padina* sp and *Laurencia* sp.

KALPENI

Unlike the topography of other Lakshadweep islands, Kalpeni has an extensive lagoon in which 3 pitties and 2 Thilagams are located on the southern portion of the lagoon. On the northern porton of the lagoon, an islet called Cheriyam and a sand dune called Kodithala are located.

Sector I : This sector commences from the middle portion of the lagoon's western shore and extends upto the southern end. All along the south west region of the island, the intertidal expanse is shallow and broad (100 m). The length is about 500 m. The substratum is formed mainly of coral sand. Dense population of the clam belonging to the species *Tellina idae* occur in this region. The shoreward portion of the lagoon is heavily silted. The corals lie buried in the sand. Among molluscs. *Tridacna maxima* and *Pinctada sugillata* are the common ones. Among the echinoderms, *Acanthaster planci* and *Linckia* sp predominate. Among sea weeds, *Gracilaria edulis* is abundant over wide areas. In the mid portion, 3 pitties and 2 Thilagams are located. The shore area of these pitties and Thilagams consists mainly of coral sand and coral stones. Few dead shells of *Codakia* sp are also observed. Over the remaining portion of the lagoon's floor, dead corals were found strewn in abundance. Algal growth is poor in this area. Parts of the reef flat are often exposed during low tide. Coral growth is not observed in this zone. The characteristic mollusc of this region is the giant clam *Tridacna maxima*. Algal vegetation is seen to be poor.

Sector II : This sector commences from the mid point of the island and extends upto the northern end of the island. The intertidal region is sandy intermittent with coral bits. Animal life inhabiting the beach sand is very poor. The shoreward portion of the lagoon is shallow and the substratum is formed mainly of coral rocks and sand. This area supports a few species of echinoderms (*Bohadschia* sp and *Actinopyga* sp) and molluscs *(Tridacna maxima)*. The sea weed *Gracilaria edulis* and the sea grass *Cymodocea* sp are common. However, the coral growth seems to be poor in this region. Heavy silting is observed in this zone. On the mid portion of the lagoon the floor is sandy with dead and live coral patches. The depth varies between 3 and 6 m. The sandy areas between the coral patches support a wide variety of organisms. Among corals, species of *Heliopora, Acropora, Porites* and *Fungia* predominate. *Alcyonarians* are seen in this region. *Tridacna maxima* is the chracteristic mollusc of this region. The echinoderms *Linckia laevigata* lie on the coral sand. Sea weeds such as *Halimeda* sp, *Caulerpa* sp and *Gracilaria eduils* are seen in some parts of lagoon. The reef flat is formed mainly on coral boulders where the depth ranges between 1 and 2 m. Among corals, species of *Acropora* and *Porites* predominate. The less important genus is *Fungia*. This region supports a small association of molluscs such as *Tridacna* sp., *Cypree* sp and *Trochus* sp. Among sea weeds, *Halimeda* sp and *Gelidium* sp are the most common ones.

Sector III : This sector lies in between the northern end of island and the southern end of the islet 'Cheriyam'. The eastern side of the reef flat is formed mainly of coral boulders where the cowrie *Cyprea* sp is very common. The algal vegetation is very sparse. The shoreward portion of the lagoon's substratum is formed mainly of sand. The most characteristic molluscs of this region are *Tridacna* sp and *Pinctada sugillata*. Two species of echinoderms namely *Actinopyga* and *Linckia* sp occur in this region. Among corals, species of *Acropora* and *Porites* are found spread on the bed. Among sea weeds, *Turbinaria* sp predominate. The lagoon's depth at mid portion varies between 3 and 6 m. The lagoon floor is mostly sand with occasional corals. The fauna and flora that occur in this region are similar to those which occur in the same zone in sector II. The reef flat is formed mainly of coral boulders where the range of depth is between 1 and 2 m. Molluscan and echinoderm fauna are generally absent. Among corals, species of *Acropora* and *Porites* predominate. Small patches of algal vegetation are seen here and there.

Sector IV : This commences from the southern end of the islet Cheriyam and extends upto the northern end of the lagoon. The intertidal zone is sandy and the fauna and flora inhabiting this zone is very sparse. The shoreward portion of the lagoon is sandy intermingled with corals and debris. The coral community is represented by species of *Acropora* and *Porites*. Several species of coral associated fishes occur in this region. The echinoderm and molluscan fauna are sparse. Several species of sea weeds namely *Enteromorpha* sp, *Cheaetomorpha* sp, *Turbinaria* sp, and *Laurencia* sp occur in this region. On the mid portion of the lagoon, the substratum is sandy with live and dead corals. The depth varies between 3 and 5 m. In most areas, the upper part of coral shoals shows profound

growth whereas the lower portion seems to be in a decayed condition. Silt deposition is very high in this region and due to this effect huge shoals of coral lie buried into the sand. The echinoderms and molluscs are sparse in this region. The common sea weed which occur in this region are *Halimeda* sp, *Caulerpa* sp, and *Turbinaria* sp. On the reef flat, the bottom constituents consists mainly of coral boulders and sand. The coral community is represented by species of *Acropora* and *Porites*. Except *Tridacna maxima*, no other mollusc observed in this zone and *Turbinaria* sp are common.

KAVARATTI

Sector I: This sector commences from the southern portion of the lagoon's western shore and extends upto the southern end. The intertidal zone is composed mainly of coral sand with intermittent coral bits. Among the shoreward portion of the lagoon, the substratum is sandy with large shoals of live and dead corals distributed equally. The depth in this zone ranges between 2 and 3 m. On the mid portion, the lagoon floor is mostly sandy. Corals are the dominant organisms on the lagoon's floor. These include *Acropora formosa*, *A. teres* and *A. aspera*. The most characteristic molluscan fauna of this region is the giant clam *Tridacna maxima* These clams are found attached to or buried in corals and are firmly attached to substrate by means of byssus. *Holothuria atra* is the only echinoderm occurring in this region. The lower portion down to the middle zone is occupied by *Tridacna maxima*, *Holothuria atra*, *Acropora formosa*, *A. teres*, *Porites lutea* and *P. solida* Beyond this region is the reef flat, which is composed mainly of reef rocks and dead corals. The depth of the water ranges between 1 and 2 m. *Tridacna maxima*, *Cyprea* spp and *Conus* spp are the main molluscs of this region. The sea weeds encountered in this region are *Gelidiella acerosa*, *Gracilaria edulis* and *Turbinaria* sp. The sea grass *Cymodocea serrulata* also occur here and there in this region. The surface living holothurians are sparse.

Sector II: This zone starts from the middle of the island and extends upto the commencing point of sector I. The molluscan fauna is very sparse. The shoreward portion of the lagoon is shallow and the depth ranges between 2 and 3 m. The floor is sandy intermittent with live and dead corals. (*Acropora formosa*, *A. teres* and *A. hyacinthus*). The algal vegetation is sparse in this region. However, two species of holothurians namely *Holothuria atra* and *H. cineracens* are very common. In this zone, the giant clam *Tridacna maxima* is the only mollusc to predominate. The mid portion of the lagoon's floor is formed mainly of calcareous rocks where the depth ranges between 2 and 3 m, Molluscs and holothurians appear to be absent. However many species of corals namely *Acropora teres*, *Porites lutea*, *P. solida* and *Fungia* sp are very common. The sea weeds (*Gelidiella acerosa*, *Turbinaria* spp and *Padina* sp) and the sea grass *Cymodocea* sp are abundant over wide areas forming rich green tufts. The reef flat is partially exposed in this region. Corals are the dominant organisms of the reef flat. These include *Acropora teres* and *Porites* spp. Among molluscs, *Tridacna maxima* is generally abundant in this region. In some areas, the weeds *Gelidium* sp, *Turbinaria* sp and *Padina* sp are abundant.

Sector III: This sector commences from the middle portion of the island and extends upto the point of commencement of sector IV. Along the intertidal region, the clams belonging to the genus *Mesodesma* and the mole crab, *Emerita* sp occur in stray numbers. On the shoreward portion of the lagoon, the substratum is sandy, The substratum is perhaps unsuitable for many molluscs and corals. The echinoderm fauna is mostly represented by *Holothuria cineracens* and *H. atra*. They live mostly on the sandy bottom and a few live ones under rocky crevices. Sea weeds and sea grass are well represented; the important species being those of *Gelidium*, *Padina*, *Turbinaria* and *Cymodocea*. Compared to the shoreward portion of the lagoon, the mid portion is richer in fauna and flora qualitatively and quantitatively. The lagoon floor consits mainly of calcareous sand inrermittent with broken corals and live and dead corals. The clarity of water is good and the depth ranges between 2 and 5 m. This zone is characterized by thick assemblage of various coral communities namely *Acropora teres*, *A. formosa*, *A. aspera* and *Fungia* sp. The corals provide ideal habitat for many species of lagoon fishes. *Octopus macropus* is the only cephalopod noticed in this region in pits and crevices. Two

species of holothurians viz: *Holothuria atra* and *H. cineracens* are very common. Fishes in vivid colours and various sizes inhabit this zone Besides these organisms, this zone is characterised by a dense growth of sea weeds such as *Gracilaria edulis*, *Padina* sp and *Turbinaria* sp. The occurrence of massive corals and boulders is the most characteristic feature of the reef flat The organisms found in this zone include the gastropods (*Turbo* spp, *Trochus* spp and *Cyprea* spp).

Sector IV : This sector begins from the middle of the northern part of the lagoon and extends upto the northern end. The intertidal region is composed mainly of coral sand intermittent with coral rocks and debris. The shoreward portion of the lagoon is sandy and shallow and the environment is dominated by thick growth of coral *Acropora* and *Porites*. The corals harbour many lagoon fishes. The characteristic sea weeds noticed here are *Gelidium* sp and *Turbinaria* sp. Below the shoreward region is the mid portion of the lagoon. The depth ranges between 2 and 4 m. The substratum is hard with live and dead corals evenly distributed. *Acropora formosa*, *A. teres*, *Porites* sp and *Fungia* sp with associated fishes characterised this zone. Over the lagoon's floor, patches of algae such as *Laurencia* sp, *Caulerpa* sp and *Sargassum* sp. could be seen. The reef flat gets exposed during low tide. This region supports very poor animal life The molluscan fauna is dominated by *Lambis truncata*, *Tridacna maxima*, *Cyprea* spp and *Trochus* spp. The sea weed flora consists of predominantly *Halimeda* sp and *Gelidium sp.*

ANDROTH

Androth has no lagoon and therefore the the survey had to be carried out on the open sea.

Sector I : This sector commences from the middle of the northern side of the island and extends upto the eastern end. The intertidal region is sandy but a little farther the substratum is hard where the depth is about 1 m. In this zone, thick growth of *Modiolus* sp was seen over the substratum underneath luxuriant growth of sea weeds. Spat of the pearl oyster *Pinctada sugillata* also occur along with *Modiolus*. Large type boulder corals (*Porites* sp) and branching corals mostly of *Acropora* spp are seen in many spots. Two species of echinoderms namely *Ophiocoma* sp and *Echinometra mathaei* occur in this region. The sea weeds *Gelidium* sp and *Trubinaria* sp are seen near the eastern end. The zone that lie about 100 to 200 m beyond the intertidal region constitute mainly of coral rocks intermittent with sand patches. The depth at this zone ranges from 5 to 7 m. Corals are the dominant organisms on the sea floor. These include species of *Acropora*, *Porites* and *Fungia*. Among echinoderms, *Echinothrix* sp occur in stray numbers. The gastropod, *Lambis* sp are distributed here and there.

Sector II : This sector commences from the middle of the northern side and extends upto the western end. The intertidal zone is mainly sandy but becomes hard deeper down. Dense settlement of *Modiolus* sp is noticed along with the pearl oyster spat *Pinctada sugillate*. Two species of echinoderms namely *Echinothrix diadoma* and *E. calamris* occur in this region. Live and dead corals mostly branching (*Acropora* sp) and masive (*Porites*) are seen in this region. Good growth of sea weeds *Gelidium* sp and *Turbinaria* sp is noticed in this zone. The zone that lies about 100 to 200 m beyond the intertidal region has depth ranging between 5 and 7 m. The substratum is hard and the composition of the fauna and flora which occur in this region are identical to those that occur in the same zone in sector 1.

Sector III : This sector begins from the middle of the southern side of the island and extends upto the eastern end. The bottom of this zone is hard with coral boulders distributed here and there. Species of *Acropora* and *Porites* corals predominate in this region. The algal vegetation is poor. The zone that lies about 100 to 200 m beyond this zone is deeper where the depth ranges between 6 and 8 m. The substratum is hard with a film of coral sand. There is a very heavy underwater current here. Deep channel like structures filled with sand are evident in several localities. Different species of *Acropora* and *porites* corals are common. Molluscan fauna is not observed in this zone. *Turbinaria* sp and *Padina* sp are the most abundant sea weed occuring in this zone. The soft alcyonarians are seen on certain localities.

Sector IV: This sector commences from the middle of the southern side of the island and

extends upto the western end. The substratum is hard. About 50 m width of this zone get exposed during low tide. During low tide the *Modiolus* beds are completely exposed. Sparse settlement of *Pinctada sugillata* is also noticed on the substratum. The entire bed is covered by a thick mat of sea weeds. The coral community is sparse in this region. The zone that lies about 100 to 200 m beyond the intertidal region has a depth which varies from 6 to 8. m. Both live and dead corals of *Acropora* sp and *Porites* sp are abundantly seen. Bivalve molluscs are not seen in this zone.

AGATTI

Sector I: This sector commences from the northern point of the island's tip and extends upto the passenger jetty. The lagoon's main entrance is located at the northern end and the passage of all the mechanised fishing vessels are effected from this point only. The bottom of the lagoon is entirely of dead corals belonging to both branching and massive types spread all over this region, Silt deposition is heavy on the dead corals and the associated sea weeds perhaps due to human interference. As a result of this, the sea weeds growth is retarded. *Gracilaria* sp and *Turbinaria* sp are found along the northern side of lagoon. Among gastropods, *Lambis* spp and *Conus* spp are found in large numbers. Holothurian; sea urchins, star fishes and brittle stars are also represented in few numbers. Sea anemones with their associated fishes are in abundance in the northern part of the lagoon. The mid lagoon towards the south is mainly sandy. The lagoon side of the reef flat is mostly with live growth of massive corals towards the northern portion. Towards the south it is discontinuous in some places. Holothurians, *Cyprea* spp, *Lambis* spp and *Conus* spp are widely distributed on the lagoon side of the reef flat. Sea weeds are few in numbers, *Octopus* is present in good numbers in the shallow coralline crevices. This area, particularly the northern lagoon abound with many species of ornamental fishes like *Chaetodon, Amphiprion, Blennids, Acanthurus, Apogon, Platax, Callyodon, Chromis* etc.

Sector II: This sector starts from the passenger jetty in the north and extends upto the highly eroded portion of the island, about 300 m away from the southern end of the island. The beach is sandy. In the intertidal region, dead coral beds are found exposed during low tide along the southern region of the sector. The sea grass *Cymadocea* grows profusely in some part of the lagoon towards the shore. The middle lagoon and the regions towards the shore is sandy. Patchy growth of sea grass is found here and there in the middle lagoon. No fauna could be observed on the sandy bottom. The reef flat of this sector is discontinuous in some parts and the substratum is sandy mixed rock bits. On the lagoon side of the reef flat, fresh growth of corals could be seen. Branching corals are sparse. The solitary corals *Fungia* sp and the giant clam *Tridacna maxima* are abundant on the coral mounts.

Sector III: This sector commences from the highly eroded portion of the island on the north and extends upto the southern tip of the Kalpitti Island. The beach is sandy throughout excepting the Kalpitti island where large quantities of dead coral bits are seen washed ashore. The beach as well as the intertidal area of the Kalpitti Island is only with dead corals and coral flats throughout. A small creek intercept the two islands, the bottom of which is sandy. The mid lagoon is mostly sandy with boulders and mounts of corals mostly massive and branching type, The solitary coral *Fungia* sp and the giant clam *Tridacna* sp are found in good numbers. *Lambis* spp, *Cyprea* spp and *Conus* spp are also found in fair numbers. The sea anemones and their associated fishes *Grammistes, Upeneus, Chaetodon, Amphiprion, Acanthurus, Canthigaster, Blennids, Chromis, Apogon, Platax, Abudefduf, Balistes* and *Callyodon* are the other fishes found in good numbers in this area.

BANGARAM

Sector I: This sector extends from the passenger jetty situated in the middle of the northern side of the island to the northeast corner of the island. All along the sea shore the beach is sandy. The bottom of the lagoon is mostly sandy. Broken pieces of branching corals are found spread on the sandy bottom. The fauna and flora are sparse in this region. Patchy growths of *Turbinaria* sp and *Gracilaria* sp on dead coral pieces are found in small quantities. Holothurians, star fishes, *Conus* spp, *Lambis* sp and *Tridacna* sp are seen at random on the sandy bottom.

Sector II: This sector extends from the passenger jetty on the south to the north eastern corner of the islands. The beach is sandy. The lagoon bottom is mostly sandy. The mid lagoon is very deep. Massive blocks of corals rising from the deep and reaching 1-2 m below the water level are seen here and there. Faunistic richness of the area is evident here. Solitary corals *Fungia* sp, *Lambis* spp, *Conus* spp, *Cyprea* spp, *Tridacna* sp, holothurians and star fishes are seen in good numbers on the mounts. Sea weeds are totally absent.

In between sector I and II, Tinnakara and Parali islets are situated. The northern sides of these islets are facing lagoon and mostly sandy while the southern side is either covered by dead coral blocks of massive type or the reef commences from the beach head. There appears to be paucity of fauna and flora in the islet zones.

Sector III: This sector extends from the north eastern corner of the island to the south western corner. The beach of the island in this sector is hard with coral debris spread throughout the beach and also on the intertidal regions. It is devoid of any notable animal life. The lagoon adjacent to the beach is shallow covered with a wash of dead coral pieces. Some portions of the lagoon towards the reef is deep with coral mounts reaching 1-2 m below the water surface. *Lambis* sp, *Conus* spp, *Cyprea* spp, *Tridacna* sp and *Fungia* are found on the mounts. The reef flat on the lagoon side having the characteristic fauna such as *Cyprea* spp, *Tridacna* sp, *Conus* spp, *Drupa* sp and *Chama* sp. *Octopus* sp is also found in good numbers in the crevices of the dead corals.

Sector IV: This sector extends from the north-east corner of the island to the south west corner. The beach is sandy towards the south-west and of dead corals mixed towards the northwest beach. The mid lagoon is sandy. A sand mount is located off this sector in the mid lagoon where sea weeds such as *Gelidiella* spp, *Gracilaria* sp, *Turbinaria* sp are found in heaps having been washed ashore amidst broken bits of branching corals. Sea gulls in hundreds are found resting on the sand mount. *Lambis* sp is found in good numbers in the sandy lagoon. Large numbers of the sea turtle *Erytmochelys imbricata* in group of 5-7 are found moving about in the lagoon on the eastern side of the islands. Fishes such as *Zanclus cornutus, Holocentrus* sp, *Callyodon* sp, Gobids. *Apogon* sp' *Platex* sp, *Amphiprion* sp, *Chaetodon* spp, *Epinephelus* sp, *Chromis* sp are found hovering around coral growths in the northern part of the lagoon.

AMINI

Sector I: This sector starting on the middle of the eastern shore extends upto the southern tip of the island. The entire beach is sandy in nature. The reef flat in this zone is more of rocky bottom with broken dead coral bits. At the extreme south eastern side of this zone, the depth of water is 2 m during low tide when the reef edge is exposed. The bottom is more sandy in nature with good growth of sea grass. Here a good population of echinoderms belonging to the species *Holothuria (microthele) noblis* are observed. On the other areas the entire reef flat is exposed during low tide. The reef edge lies at about 200 m from shore line and is steep.

Sector II: This sector covers the central point of the eastern shore to northern most tip of this island. The shore line is generally rocky in nature except on extreme north. The extent of reef flat is 10 m from the shore and during low tide about 25 cm of water is retained. The bottom of the reef flat constituted mainly of dead coral bits and reef edge is composed of big dead coral boulders. The observations made during low tide in this area revealed the presence of mostliy intertidal molluscs such as *Conus chaldaeus*, C. *zonatus*, *Lambis truncatus Vasum ceramicus* and *Tricardium magnum*.

Sector III: This sector starts from the western side of the jetty and extends upto the southern tip of island. This area occupies half of the lagoon. At the jetty the depth of the water is about 3 m. The bottom is mostly sandy and in some places it is hard. Damage done to the fauna and flora due to dredging is evident in this area. On the southern side, the shore is sandy and the lagoon is partly exposed during low tide. The reef flat lies about 500 m away from shore line and constituted mainly of small dead coral stones. During high tide the lagoon retains 2 m of water and in some places big coral blocks of 1 m height were seen alive. Branching corals are few in numbers. The fishermen here have constructed the fish aggregating device and they catch fishes during low tide.

The bottom is mainly sandy and in some places it is firm.

Sector IV : This sector begins from the jetty and extends upto the northern end of the island The beach is mainly sandy and in the lowest low tide mark level of the extreme north the bottom is composed of hard sand stone. The sand deposition is high inside the lagoon and during low tide substratum gets fully exposed. Water retention is noticed in exposed areas where coral fishes and intertidal molluscs occur in few numbers. The giant clam *Tridacna* sp occurs sparsely in this region. At the northern most point the bottom of the lagoon is sandy. It is 3 m deep during low tide. At the bottom line block corals belonging to the genus *Porites* have grown to a height of 50 cm and branching corals to a height of 20 cm. A rich growth of sea grass is seen in this region harbouring quite a good number of holothurians.

KADMAT

Sector I : This sector starts from the middle region of the eastern shore and extends upto the southern end. The entire shoreline is sandy. Sea erosion is noticed at some places. The bottom of the reef flat is hard, interspersed with dead coral stones. At the reef edge huge dead coral stones are seen. At the extreme southern point of the island's eastern shore, the reef flat extends to a distance of about 500 m from the shore line. The depth of the water during low tide is 2m. New colonisation of corals was evident on the sandy bottom. The water pool occupies an area 300 X 400 m. sq.

Sector II : This sector commences from the middle region of the eastern side and extends upto the northern end of the island. The reef flat possess a hard substratum and about 20 cm of water is retained during low tide. The bottom components consisted mainly of dead coral bits and thick growth of algae are seen on these coral bits. Pearl oyster spat are found attached on the algae (4/ m^2). *Conus* sp, *Strombus* sp and *Littorina* sp are predominantly seen. The extreme northern end of the island is made up of coral boulders and exposed during low tide.

Sector III : This sector extends on the western shore from the jetty to northern end of the island. At the jetty, lagoon is 2 m deep during low tide. The bottom is sandy. At the northern side of the lagoon the depth is about 2 m where huge block corals are found. At a point just west to the jetty area many species of branching corals occur. Pearl oyster spat are found attached to dead corals. Different species of algae are observed. The giant clam *Tridacna* sp are found attached in block corals

Sector IV : This sector begins from the jetty and extends upto the end of the southern side. The depth of the lagoon is 1 m during low tide The bottom is sandy and a few patches of live branching corals are seen in this region. Large shoals of bait fishes are common. At the extreme southern end of this lagoon live block corals are found. The gastropods are well represented by *Conus* sp and *Strombus* sp. Holothurians occur in moderate numbers.

KILTAN

Sector I : This sector starts on the middle of the eastern shore of the island and extends upto the southern end. Generally the beach is sandy and the reef flat rocky. Since no water is retained during low tide no molluscs could be seen. At the extreme southern end accumulation of dead corals are seen along the shore line.

Sector II : This sector is from the eastern shore's middle point to the northern end of the island. The entire shoreline is made up of dead coral bits. The reef flat extends for about 10 m from shore line. Water is not retained during low tide and hence no important molluscs are seen in this area. At the reef edge profuse growth of algae are observed and beyond the ridge the depth is more than 10 m.

Sector III : This area extends from the jetty of the northern end of the island on western shore. Generally the shore line is sandy and at the extreme northern end the shore is rocky which is formed of sand stones. The lagoon extends 0.5 km from the shore line and the bottom is sandy. The water is very clear. In this region the gastropod molluscs and echinoderms are very common.

Sector IV : This sector extends from the jetty area towards the southern end of the island's western shore. The shore line is generally sandy and the lagoon begins at the extreme south.

The bottom of the lagoon is very hard. Live block corals, holothurians and echinoderms are the main occupants of this area. Small sized *Tridacna* sp (less than 20 mm) are also present. Small sized *Conus* sp and *Cyprea* sp are also seen.

BITRA

Sector I: This sector commences from the north west tip of the island where the beach and the intertidal regions are strewn with bits of broken corals and shingles to the passenger jetty which is situated in the middle of the island, The beach is sandy throughout. The intertidal region is also sandy but intermingled with pieces of dead corals. The lagoon is shallow and sandy towards the shore but becomes deeper in the middle. Here and there mounts of dead corals are seen projecting from deep waters. Dead corals and broken pieces of corals are found spread over the bottom of the mid lagoon, wherever it is shallow. Fresh coral growths are seen on the coral flat and also on the dead coral beds towards the reef flat The most characteristic fauna found on the coral formations are holothurians, *Fungia* sp, *Lambis* sp *Drupa*, *Conus* spp, *Cyprea* spp, *Trochus* spp and *Tridacna* sp. Moderate growth of sea weed like *Turbinaria* sp is noticed in these regions. Fishes such as *Acanthurus* sp, *Epinephelus* sp, scarids, Anemone fishes, *Holocentrus* sp, *Chaetodon* spp upeneids, *Chromis* spp, *Amphiprion* spp, leather jacket, *Abudefduf*, *Platax* sp, sharks, *Caranx* spp and *Lethrinus* spp are found inhabiting the shallow areas towards the lagoon side of the reef flat.

Sector II: This sector commences from the passenger jetty in the north to the heavily eroded southern tip. The beach is sandy and the lagoon towards the shore is shallow with pieces of dead corals spread through the breadth of the shallow bottom. As in sector 1, the middle lagoon is deep with projecting coral mounts. Holothurians star fishes, *Fungia* sp *Haliotis* sp, *Conus* spp, *Tridacna* sp and a few pearl oysters are collected from the coral mounts and the shallow coralline beds. Almost all the fishes present in sector 1 are also characteristic of this region.

A sand mount exposed during low tide is seen on the southern border of the lagoon very close to the reef flat with sea gulls in hundreds resting on it.

CHETLAT

Of all the lagoons of the islands surveyed the Chetlat lagoon with rich fauna and flora is undisturbed.

Sector I: This sector extends from middle shore to southern end on the eastern side of the island. The extent of reef flat is about 8-10 m along the shore. The sandy shore has a gentle slope which is periodically exposed during low tide. *Littorina* sp and *Nasa* sp are abundant in some places on the shore, At the extreme southern end the shore line is made up of dead corals and hard sand rocks which acts as a natural barrier and prevents sea erosion.

Sector II: This sector spreads from middle shore to northern end of the island. The entire shore is sandy except the middle point where some hard sand rocks are found intermittently. The intertidal reef flat possess populations of algae and gastropods. The near shore at the northern end is sandy with dead coral bits. The fauna are less here due to periodic exposure during low tide.

Sector III: This sector lies on the western side extending from the middle shore to the northern end of the island. The shore line is entirely sandy. Profuse growth of live corals are seen all along 2 m depth towards the lagoon side. Occurrence of pearl oysters of the size range 10-15 mm are seen on dead corals at a density of 1/10 m^2 and *Tridacna* sp at a density of 1/20 m^2. Numerous echinoderms are also recorded in this sector.

Sector IV: The extension of the sector is between the middle point and the southern end in the western side. The nature of bottom is sandy but on the southern end it is hard with dead corals. Sea grass are seen throughout the sector along with gastropods such as *Cyprea* sp, *Conus* sp, *Nasa*, sp and *Vasum* sp. Echinoderms are seen in good numbers. The width of the southern most part of the island is about 10 m and lies in close proximity to deep open sea. The reef flat with dead coral boulders extends upto a width of 15 m along the shore and is exposed during low tide. On the western side the beach shows gentle slope and within a a distance of 10 m a depth of about 15 m is reached. The bottom is rocky and it consists of live and dead coral blocks.

REMARKS

Although the present underwater observation in the lagoon areas of Lakshadweep islands are by no means exhaustive, the studies have brought out a few interesting features. A perusal of the catalogue of different species of marine life collected and documented in Tables 1 to 12 would indicate the diversity of the species composition of fishes, molluscs, and corals. Many of these species are commercially valuable from the point of view of ornamental fish trade, conchologist collection and industrial purpose. The scope for a national policy of exploitation appears bright. But one disturbing aspect witnessed in different sectors of the lagoon areas of the islands visited is the scenario of heaps of dead coral bits, decaying coral reef portions and the sand-silt accumulation of considerable extent. The observations on the faunistic feature of Lakshadweep islands published by Gardiner (1903-1906) do not indicate any silt accumulation in the reef area. Perhaps this happening may be of recent origin.

TABLE 1

Distribution af important fruna and flora in the lagoon of Minicoy.

Name of fauna and flora	Sector I	II	III	IV
Echinoderms				
Holothuria sp.	—	—	x	—
Molluscs				
Lucina sp.	—			—
Tridacna sp.	x	—	x	x
Corals				
Acroporra spp.	x	x	x	x
A. Formosa sp.	x	x	—	x
Porites spp.	x	x	x	x
Algae				
Cymodocea sp.	—	—		

– Abundant
8 – Common
x – Present
– – Nil

TABLE 2

Distrubution of important fauna and flora in the legoon of Kalpeni.

Name af Fauna and Flora	Sector I	II	III	IV
Echinoderms				
Linckia sp.	—	x	x	—
Acanthaster planci	x	—	—	—
Ophiocoma sp.	x	—	—	—
Bohadschia sp.	—	x	—	—
Actinopyga sp.	—	0	x	x
Molluscs:				
Pinctada sugillata	x	—	x	—
Tridacna sp.	0	0	0	0
Tellina idae	8	—	—	—
Trochus sp.	—	x	—	—
Cyprea sp	—	x	0	—
Corals:				
Acropora spp.	x	0	0	0
Fungia sp	—	x	—	—
Porites spp.	x	0	0	0
Helopora sp.	—	x	—	—
Algae:				
Enteromorpha sp.	x	—	—	0
Halimeda sp.	x	x	x	x
Codium sp.	x	—	—	0
Caulerpa sp.	x	0	—	0
Turbinaria sp.	x	—	0	0
Gracilaria sp.	0	x	x	x
Gelidium sp.	—	x	x	—
Cymodocea sp.	x	x	x	0

8 – Abundant
0 – Common
x – Present
– – Nil

Table: 3

Distribution of important fauna and flora in the lagoon of Suheli paar.

Name of Faunaand Flora	Sector I	II	III	IV
Echinoderms				
Holothuria sp.	x	—	—	—
Molluscs				
Pinctada sugillata	x	—	—	—
Tridacna sp.	0	0	0	0
Mesodesma sp.	8	8	—	—

Conus spp.	x	—	—	—
Lambis sp.	x	—	—	—
Corals				
Acropora spp.	0	0	0	0
Porites spp.	0	0	0	0
Fungia sp.	x	—	x	—
Heliopora sp.	x	—	—	—
Algae				
Chaetomorpha sp.	x	—	—	—
Halimeda sp.	x	—	—	—
Caulerpa sp.	x	x	x	x
Turbinaria sp.	x	0	x	x
Sargassum sp.	x	—	—	—
Padina sp.	x	x	x	x
Fishes				
Ostorhynchus sp.	x	—	—	—
Rhinecanthus sp.	x	—	—	—
Dascyllus sp.	x	—	—	—
Labroides dimidiatus	x	x	—	—
Acanthurus sp.	x	—	—	—

8 - Abundant
0 - Common
x - Present
- - Nil

Table 4

Distribution of Important fauna and flora in the lagoon of Kavaratti.

	Sector			
Name of Fauna and Flora	I	II	III	IV
Echinoderm				
Holothuria cineracens	—	x	x	—
Holothuria atra	x	x	x	—
Molluscs				
Tridacna sp.	0	x	—	x
Mesodesma sp.	—	—	x	—
Conus sp.	x	—	—	—
Lambis truncate	—	—	—	—
Trochus sp.	—	—	x	—
Turbo spp.	—	—	x	x
Cyprea spp.	x	—	x	x
Octopus sp.	—	—	x	—
Corals				
Acropora formosa	x	0	0	x
Acropora aspera	—	—	x	—
Acropora teres	x	x	x	x
Acropora hyacinthus	—	x	—	—
Porites spp.	0	x	x	x
Fuugia sp.	—	—	x	x
Algae				
Halimeda sp.	—	—	—	x
Caulerpa sp.	—	—	—	x
Trubinaria sp.	x	x	x	
Sargassum sp.	—	—	—	x
Padina sp.	—	x	x	—
Gracilaria edulis	x	—	x	—
Laurencia sp	—	—	—	x
Gelidella acerosa	x	x	x	x
Cymodocea sp.	x	x	—	—

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 5

Distribution of important fauna and flora occurring around Androth.

	Sector			
Name of fauna and flora	I	II	III	IV
Echinoderms:				
Ophiocoma spp.	x	—	—	—
Echinothrix calamaris	x	—	—	—
Echinothrix diodema	—	x	—	—
Echinometra sp.	—	x	—	—
Molluscs:				
Modiolus sp.	x	x	—	x
Pinctada sugillata	x	x	—	x
Lambis sp.	x	—	—	—
Corals:				
Acropora spp.	0	0	0	0
Porites spp.	0	0	0	0
Fungia sp.	x	x	—	—
Algae:				
Padina sp.	—	—	x	—
Turbinaria sp.	x	x	x	—
Gelidium sp.	x	x	—	—

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 6

Distribution of important fauna and flora in the lagoon of Agathi

	Sector		
Name of Fauna and Flora	I	II	III
Echinoderms			
Holothuria sp.	8	—	x

Star fish	0	—	—
Brittle star	x	—	—
Sea urchin	x	—	—
Molluscs			
Tridacna sp.	0	8	8
Lambis spp.	8	—	x
Conus spp.	8	—	x
Cyprea spp.	0	—	x
Octopus sp.	x	—	x
Coelenterates (Corals)			
Sea anemone	x	—	x
Acropora spp.	0	0	0
Fungia	—	8	0
Porites sp.	0	8	8
Algae			
Turbinaria sp.	x	—	—
Gracilaria sp.	x	—	—
Cymodocea sp.	—	8	—
Fishes			
Grammistes sp.	—	—	x
Upeneus sp.	—	—	x
Chaetodon sp.	x	—	x
Amphiprion sp.	x	—	x
Blennids	x	—	x
Acanthurus sp.	x	—	x
Canthigastor sp.	x	—	x
Chromis sp.	x	—	x
Platax sp.	x	—	x
Apogon sp.	x	—	x
Abudefduf sp.	—	—	x
Balistes sp.	—	—	x
Callyodon sp.	x	—	x

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 7

Distribution of important fauna and flora in the lagoon of Bangaram.

	Sector			
Name of Fauna and Flora	I	II	III	IV
Echinoderms				
Holothurian	x	x	—	—
Star fish	x	x	—	—
Mollusc				
Chama sp.	—	—	x	—
Tridacna	x	x	x	—
Conus spp.	x	x	x	—
Lambis spp.	x	x	x	0
Cypree spp.	—	x	x	—
Drupa sp.	—	—	0	—
Octopus sp.	—	—	0	—
Corals				
Acropora sp.	—	x	x	—
Porites	—	x	x	—
Algae				
Turbinaria sp.	x	—	—	x
Gracilaria sp.	x	—	—	x
Gelidiella sp.	—	—	—	—
Fishes				
Chaetodon sp.	—	—	—	x
Amphiprion sp.	—	—	—	x
Gobids	—	—	—	x
Chromis sp.	—	—	—	x
Platex sp.	—	—	—	x
Apogon sp.	—	—	—	x
Callyodon sp.	—	—	—	x
Zanclus sp.	—	—	—	x
Holocentrus sp.	—	—	—	x
Ehinephelus sp.	—	—	—	x

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 8

Distribution of important fauna and flora in the lagoon of Amini.

	Sector			
Name of Fauna and Flora	I	II	III	IV
Echinoderm				
Holothuria atra	8	x	x	0
Holothuria sp.	x	x	x	0
Molluscs				
Pinctada sp.	—	—	—	—
Crassostrea sp.	—	—	x	—
Tridacna sp.	—	x	x	x
Mesodesma sp.	x	—	x	x
Conus spp.	x	x	0	x
Lambis sp.	x	x	x	
Trochus sp.		—	x	—
Cyprea sp.	—	—	0	x
Nasa sp.	x		0	x
Vasum sp,	x	x	0	
Octopus sp.	x	x	0	
Corals				
Acropora spp.	—	x	x	—
Acropora formosa	—	x	x	—
Actopora aspira	—	—	x	—
Fungia sp.	x	—	x	x
Porites spp.	x	x	x	x

Algae				
Halimeda sp.	x	x	x	x
Caulerpa sp.	x	—	x	x
Turbinaria sp.	—	—	—	—
Sargassum sp.	x	—	x	x
Padina sp.	x	x	x	x
Gracilaria sp.	—	—	x	x

8 – Abnudant
0 – Common
x – Present
– – Nil

TABLE: 9

Distribution of important fauna and flora in the lagoon of Kadmat.

Name of Fauna and flora	Sector I	II	III	IV
Echinoderms				
Holothuria sp.	x	x	x	x
Holothuria atra	—	x	x	x
Molluscs				
Pinctada sp.	—	x	x	x
Crassostrea sp.	x	x	x	x
Tridacna sp.	—	x	x	x
Mesodesma sp.	—	—	x	—
Conus spp.	x	x	0	0
Lambis sp.	x	x	0	0
Trochus sp.	—	x	x	—
Cyprea spp.	x	x	x	x
Nasa sp.	x	x	0	x
Vasum sp.	0	0	0	x
Octopus sp.	x	x	x	x
Corals				
Acropora sp	—	x	x	—
Acropora formosa	—	—	x	x
Acropora aspira	—	x	—	—
Fungia	x	x	x	x
Porites spp.	x	x	0	x
Algae				
Halimeda sp.	x	x	—	—
Caulerpa sp.	x	—	0	—
Turbinaria sp.	—	—	x	—
Sargassum sp.	x	—	—	—
Padina sp.	x	x	0	x
Gracilaria sp.	—	—	0	x

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 10

Distribution of important fauna and flora in the lagoon of Kiltan.

Name of fauna and flora	Sector I	II	III	IV
Echinoderms				
Holothuria spp.	x	x	0	0
Holothuria atra	—	x	0	x
Molluscs				
Pinctada sp.	x	x	x	—
Crassostrea sp.	x	—	x	—
Tridacna sp.	—	x	x	x
Mesodesma sp.	—	x	0	x
Conus spp.	0	x	0	x
Lambis sp.	x	0	0	x
Trochus sp.	x	—	0	—
Cyprea spp.	x	x	0	x
Nasa sp.	0	0	x	0
Vasum sp.	0	0	x	x
Octopus sp.	x	x	x	x
Corals				
Acropora spp.	—	x	x	—
Acropora formosa	—	x	x	x
Acropora aspera	—	x	x	x
Porites sp.	0	0	0	x
Fungia sp.	x	—	x	x
Algae				
Halimeda sp.	—	x	—	—
Caulerpa sp.	x	x	0	x
Turbinaria sp.	0	x	x	—
Saragassum sp.	0	—	—	—
Padina sp.	0	x	x	x
Gracillaria sp.	—	—	0	x

8 - Abundant
0 - Common
x - Present
- - Nil

TABLE: 11

Distribution o important fauna and flora in the lagoon of Bitra

Name of fauna and flora	Sector I	II
Echinoderms		
Holothurian	x	x
Star fish	x	x
Molluscs		
Pearl ovsters	—	x

Tridacna sp.	x	x
Conus spp.	x	x
Lambis sp.	x	x
Trochus spp.	x	x
Cyprea spp	x	x
Drupa sp.	x	x
Haliotis sp.	—	x
Coelenterates/Corals		
Sea anemones	x	—
Acropora spp.	x	x
Fungia sp.	x	x
Porites sp.	x	x
Algae		
Turbinaria sp.	x	—
Fishes		
Upeneus sp.	x	x
Chaetadon sp.	x	x
Amphiprion sp.	x	x
Acanthurus sp.	x	x
Chromis sp.	x	x
Platax sp.	x	x
Abudefdul sp.	x	x
Balistis sp.	x	x
Holocentrus rp.	x	x
Ephinephelus sp.	x	x
Lethrinus sp.	x	x
Caranx sp.	x	x
Scads	x	x
Anemone fishes	x	x
Sharks	x	x

8 - Abundant
0 - Common
x - Present
– - Nil

TABLE: 12

Distribution of important fauna and flora in the lagoon of Chetlet.

Name of fauna and flora	Sector I	II	III	IV
Echinoderms				
Holothuria sp.	x	—	0	0
Holothuria atra	—	—	0	0
Molluscs				
Pinctada sp.	—	—	x	x
Crossostrea sp.	—	—	x	x
Tridacna sp.	—	—	0	0
Mesodesma sp.	x	—	0	x
Conus spp.	x	x	0	0
Lambis sp.	x	x	x	0
Trochus sp.	—	—	0	0
Cyprea sp.	x	x	0	x
Nasa sp.	x	x	0	0
Vasum sp.	x	x	x	0
Octopus sp.	x	0	x	x
Corals				
Acropora spp.	x	—	0	x
Acropora formosa	—	—	x	x
Acropora aspera	—	—	0	x
Fungia sp.	x	x	0	0
Porites sp.	x	x	0	0
Algae				
Halimeda sp.	—	—	x	x
Caulerpa sp.	x	—	x	0
Turbinaria sp.	—	x	x	0
Sargassum sp.	—	x	x	x
Padina sp.	x	x	0	x
Gracilaria sp.	x	—	x	x

8 - Abundant
0 - Common
x - Preset
– - Nil

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21. MARICULTURE PROTENTIALS

R. S. Lal Mohan, D. B. James and Kalimuthu

INTRODUCTION

The protected bays and lagoons of the island provide suitable sites for mariculture. Further there are many potential candidates for mariculture - food fishes, bait fishes, ornamental fishes, holothurians, turtles and sea weeds. Apart from the indigenous varieties of culturable species, fry of fast growing fishes and prawns can be transported from the mainland and cultured. But so far no serious attempts have been made to utilise the mariculture potentials of islands.

CULTURE SITES

The lagoons serve as an ideal site for culture of fishes and other organisms. The coral reefs protect the lagoons preventing the heavy breakers.

Fish pens can be located in the lagoon with the aid of nylon webbings supported by poles. The foot rope of the webbing can be burried in the sand, with the aid of stones as sinkers. The organisms can be stocked during September and harvested in March. Fast growing fishes, prawns and holothurians can be reared in it.

Floating cages also can be suspended in the lagoons. There can be a battery of small cages. The cages can be made of nylon webbings, or velon screens as the case may be. Carnivorous fishes like *Serranus* spp, *Lutianus* spp, and *Caranx* spp, can be cultured in the system. The stock has to be fed artificially.

The low lying areas can be converted into fish farms. Though there are not many such areas in the islands, a few places are identified in Minicoy and Kalpeni.

At Minicoy the fish farm near the helipad in the Southern part of the island can be renovated. It has sluice gate and partly damaged bunds. The accumulation of decaying sea grass has to be removed from the farm. The water flows out during lowtide. This farm can be used by deepening it and strengthening the bunds.

Apart from these areas, the lagoons can be utilised for culture of mussels in the rafts and the seaweeds in the coir net frames.

Candidates for culture :

Fish culture :- Making use of the recent technology evolved for culture, food fishes, bait fishes and ornamental fishes can be cultured in the island. There are many species of food fishes, bait fishes and ornamental fishes that can be cultured in the islands.

Culture of food fishes :- Food fishes like *Mugil* sp. *Caranx* sp. can be cultured in the fish pens. The tuna-waste available in large quantities during fishing season can serve as food for the carnivorous fishes. Seeds of fishes like chanos can be transported from the mainland and cultured in the lagoons in fish pens, feeding them artificially.

Bait fish culture :- The culture of bait fishes has attained importance due to the demand for it in the pole and line fishing for tuna. The *Spratelloides delicatulus* and *Spratelloides japonicus*, are the two species which are in the great demand. Culture of other bait fishes can also be tried. Due to the specific habitat of these fishes and due to their sensitive nature culturing them may require the infrastructural facilities like aquarium, suitable feed and other ecological requirements.

Culture of ornamental fishes : Lakshadweep lagoons are rich in ornamental fishes. The ornamental fishes have acquired importance due to its export potentials. Many species of ornamental fishes occur in the islands (Please refer to the chapter on ornamental fishes of this volume). But they may not withstand commercial exploitation from the natural habitat. Supply of ornamental fishes from the island will be possible only if it can be cultured in large numbers. Here also due to the specialised habitat and food habits it will be difficult to culture them without proper infrastructral facilities. But survival of the ornamental fishes

in the Kavarati aquarium indicates the feasibility of rearing them, It will be possible to develop a hatchery for the ornamental fishes by creating the necessary infrastructural facilities like running water, aeration, storage facilities, filtration and feeding Seeds of ornamental fishes are found during the months of March and April. They can be collected by using specially made nets.

Prawn culture : The nonavailability of prawn seeds in the lagoon is the major constraints for developing prawn culture in the island. Nevertheless due to the availability of proper site for culture the fast growing species of prawns can be grown in the lagoons of the islands. Intensive culture of prawns can be tried in the floating cages made up of nylon webbing. The seeds of *P. indicus* can be transported from the main land.

The low laying areas also can be utilised for prawn culture. The fish farm at the southern end of Minicoy island can be converted into a prawn farm after making necesssary alteration.

Culture of holothurians :

Large scale culture of holothurians, *Stichopus* sp. is being carried out in the main land of China with considerable success (Anon. 1983). James, (1983) conducted preliminary trials on the culture of *Holothuria scabra* at Port Blair in Andaman islands and obtained promising resulls. There is a great demand for *beche-de-mer* in South eastern countries. Hongkong and Singapore alone require about 500 tonnes of *beche-de-mer* annually. But the demand outstrips the production. Further the natural resources of holothurian will not withstand commercial exploitation as the holothurian beds in the lagoons are not very extensive. Its exploitation may also affect the ecology of fhe lagoons. Hence culture of holothurians will be a means of increasing the production of holothurians in large number without depleting the natural stock.

Holothuria nobilis, H. scabrea, Actinopyga mauritiana, Thelenota ananas and *Stichopus chloronotus* are some of the *beche-de-mer* yielding holothurians found in Lakshadweep. Of the above species *Holothuria scabra* and *Stichopus* sp can be cultured. The other species like *Thelenota ananas* and *Actinopyga mauritiana* may also prove to be potential candidates for culture. But we have no information on the food, growth, reproduction, survival and recruitment potential of these holothurians.

The culture of holothurians can be taken up in two ways. The juveniles can be collected in large numbers and stocked in the pens with nylon webbing. It can be fed with the calcarious algae like *Halmida* spp., the favoured food of holothurians, found abundantly in the lagoons.

For any large scale culture, hatchery system has to be developed. Mortensen (1937, 1938) reported spawning of the holothurian, *Actinopyga mauritiana* in the Egyptian Coast. The auricularia larvae can be produced by keeping a number of specimens in a large tank. The depth of the tank should be more than 1 metre, (Mortensen, 1921). The auricularia larvae are planktonic and have to be fed with microalgae. The plankonic phase of the larvae being short, soon they are transformed into doliolaria larva and settle on the bottom. At this stage it feeds on fine mud and sand deriving the nutrients from the organic matter present in them. The calcarious algae, *Halimeda* spp also can be provided as food. *Holothuria scabra* was found to grow from 65 to 160 mm, to 190 mm to 290 mm, during 5 months, February 1978 to July 1978 indicating fast growth in Port Blair, (James, 1983). The advantage of the holothurian culture is the very low inputs in its farming. The expenses involved in the maintanances of the farm, feed making and other infrastructural facilities are very low. But the returns from the culture is very high. The low grade *beche-de-mer* from *Holothuria scabra* costs Rs. 140/kg. at Hongkong market. The cost of high grade *beche-de-mer* from other holothurians like *Holothuria nobilis* and A. *mauritiana* is much higher (about Rs. 900/kg.). The post harvest technology of processing and preparation of *beche-de-mer* is also not costly.

The southern parts of Kalpeni, Kavaratti, Amini and Kadmat lagoons are suitable for holothurian farms. These lagoons have a natural population of holothurians and the holothurian farms can be established in these islands.

4. *Molluscan Culture*:-

a) *Pearl Culture*:- The experiments conducted at the Bangaram lagoon in culturing pearl oyster

(*Pinctada vulgaris*) demonstrated the possibility of pearl culture in the island. It has been reported that the pearl oyster transported from the mainland of India has established well. During the survey a few stray numbers of *Pinctada fucata* were also collected. Culture of Pearl oysters can be tried in other island also.

b) *Mussel culture*:- It has been demonstrated that very high production can be obtained from culturing the mussels, *Perna viridis* (green mussel) and *Perna indica* (brown mussel) in floating rafts in open sea along the South West Coast of India (Kuriakose, 1980, Appukuttan *et al.*, 1981). The lagoons offer suitable sites for floating mussel culture rafts. Seedling can be transported from mainland and grown in the mussel culture rafts on coir ropes. The seedlings also can be produced by establishing a hatchery in the islands to meet the seed requirement.

Turtle farming :

There are large turtle farms in the Grand-cayman island in Carribean which began its operation in 1968. Turtle farms are found in Torres strait in Australia, in Seychelles, South Yenam, Malayasia, Philippines, Indonesia Surinam and other places. (Dodd, 1981). Farming is carried out with different views of protecting the natural nesting populations getting supply of high source of protein and other products, salvaging the eggs that are doomed to be destroyed and to augment research. (Reiger, 1975; Hendricksoe, 1976).

A small turtle farm can be established in Suheli Valiyakara with an annual stocking of 200 neo-nates of *Chelonia mydas*.

Lakshadweep is one of the few places in the Indian Ocean where the green turtles *Chelonia mydas* nest. It has been observed that about 30 green turtles nest in Suheli Valiyakara (Kar and Bhaskar, 1982). Usually these turtles nest three times in season depositing about 100-130 eggs at each nesting About 9000 eggs are laid in Suheli Valiyakara during each season. If removal of 5% of the eggs is considered to be safe, it will be possible to collect about 200 neo-nates, for rearing without affecting the population.

The low lying areas near the northern end of the Suheli lagoon can be converted into a Turtle pen. Suheli lagoon also has a good growth of seagrass and seaweeds on which the turtles feed. These seaweeds also can be fed to the turtles in addition to the seaweeds available from the natural bed.

Culture of Seaweeds:

Mariculture of economic seaweeds has been practised successfully in countries such as Japan, China, Korea, Philippines and Taiwan. The Central Marine Fisherieries Research Institute and Central Salt & Marine Chemicals Research Institute have made attempts to cultivate *G. acerosa* (Krishnamurthy *et al.*, 1975; Subbaramaiah *et al.*, 1975;) and *G. edulis* (Raju and Thomas, 1971; Rao, 1973 and 1974; Krishnamurthy *et al.*, 1975; Chennubhotla *et al.*, 1978; Anon, 1983) using different techniques. The suitable methods for cultivation of *G. edulis* and *G. acerosa* were found to be coir rope net method and coral stone method respectively.

The survey indicated the availability of culturable agarophytes, alginophytes, edible seaweeds and the seaweeds used for cattle feed and fertilisers, in the island. But due to the small size of the lagoon the prospects of harvest of the seaweeds from the natural bed for commercial use is limited. Hence seaweeds have to be cultured if large scale production is required. The common culturable agarophytes found in the island are *Gelidiella acerosa* and *Gracilaria edulis*, The alginophytes available in the island are *Sargassum* spp. and *Turbinaria* spp. The edible seaweeds observed in the lagoon are *Hypnea* spp. and *Acanthophora* spp. Though the demand for edible species of seaweed is very low, agarophytes and alginophytes are in great demand. The availability of natural stock of seedling, suitable site for farm, highly productive lagoons and clear water devoid of sediments are great assets for sea weed culture.

It has been demonstrated that 5m x 2m. coir net frame yield 30 kg of wet sea weeds *(Gracilaria edulis)* in about 60 days in Gulf of Mannar. (Ramalingam and Selvaraj, 1979.) Though we have a wealth of information on the seaweeds of mainland of India (Rao, 1971),

we have no information on the culture of seaweeds in Lakshadweep. However there is high potentials for the culture of seaweeds in the islands.

Cultivation of *G. acerosa* is successful by coral stone method. In this method, the fragments of *G. acerosa* were tied to nylon twines at regular intervals and the seeded twines were then wound round the nails erected on coral stones. Seed material is available in all islands except Bitra.

Almost all the lagoon where the water level is about 1-2 m can be utilised for seaweed culture. Wooden frames of 5 x 2 m with coir net can be seeded with fragments of seaweeds like *G. edulis*. The coir rafts can be harvested after two months. As the fair season of the islands extends from September to March it will be able to make atleast 3 harvest in a year.

The main constraint in the seaweed culture is that the islanders are not familiar with the seaweeds and its culture. As it is a new area for them the work has to be demonstrated and the benefits explained to them. The culture sites should not be of any hindrance to the fishing operations or to the boat traffic in the lagoon. It will be possible to establish a small agar-agar cottage industry based on the seaweed cultured in the island.

SUGGESTIONS

1. The mariculture is new to the islanders' hence experimental farms should be started sponsored by the public sector to demonstrate its feasibilities and benefits.

2, We have no information on the culture of various species available in the island. Hence for a better scientific base more research inputs are required. For instance, many species of culturable holothurians are available in the island. But we have no information on its rate of growth, reproductive parameters, survival, etc. The same thing can be said about bait fishes, ornamental fishes and seaweeds.

3. The lagoons are small hence proper care should be taken so that the ecology of the lagoon is not disturbed resulting in the damage to the eco-system. The interaction of the culture system and the natural population has to be monitored carefully. This aspect requires more attention when transplantation of culturable species is attempted.

4. Literacy rates in the island is very high. Hence it will not be difficult to motivate the local people and impart training to them. The mariculture activities like seaweed culture, holothurian culture and ornamental fish culture can be taken up with proper initiative and financial assistance from the grovernment agencies. involvement of the local people in these activities is very essential for its success.

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22. SUGGESTIONS FOR ESTABLISHING A NATIONAL MARINE PARK IN LAKSHADWEEP

P. S. B. R. James and C. S. Gopinadha Pillai

INTRODUCTION

A marine park is a reserve and should be managed along sound ecological principles and should serve many relevant purposes such as habitat and species preservation, scientific research, recreation and financial gains (Ray, 1975). The deteriorating coastal and marine habitats due to many natural and man-made factors have generated a tremendous awareness among developing and developed countries in nature conservation and ecodevelopment. The marine and coastal habitats of India are also facing environmental crisis (Pillai, 1983, 1985) from many aspects and the worst affected habitat in this country seems to be coral reefs and reef resources. Proposals are in vouge to establish marine parks and preserves along the coast of India such as Gulf of Mannar (Silas *et al.*, 1985) and Malvan, Vengurla coast of Maharashtra (Quasim, 1980). First Marine National Park in Inida came into existence in Gulf of Kutch in 1980 (Rashid, 1985). Silas *et al.* (1985) have discussed in detail some theoretical aspects of selection and management of large marine preserves and parks. In this short communication some of the problems and prospects for establishing some coral reef reserves in Lakshadweep to generate scientific interest, additional income as well as conserving the endangered habitats (Pillai, 1985) are discussed.

Background: The Lakshadweep is mainly of coral origin and constitute 11 major islands (Kavaratti, Kalpeni, Agatti, Androth, Amini, Kadmat, Kiltan, Chetlat, Bitra, Bangaram and Minicoy) and a few submerged banks and reefs such as Veliyapani, Cheriyapani Pitty (Bird Island) Pitti 1 and Pitti 2 and Suheli. Coconut and tunas form the mainstay of the economy of these islands. In addition the minor and ancillary resources from the reefs are also exploited. Mining of calcareous sand which amounts to several thousand tonnes in the lagoon for starting small scale industry has been suggested. Since the islands have no infrastructure and raw material for starting any major or minor industry the greatest potential for additional income generation for Lakshadweep is the development of tourism (Anon, 1986). The islands with their palm fringed sandy shores, the crystal clear logoon with corals and coral fishes, the cultural heritage and the blue-waters around are potential paradise for tourists. These islands have been rightly known as Coral Paradise of India. However, development of tourism to a large scale in Lakshadweep is a matter to be decided on national policy. The establishment of marine parks in some of the islands can certainly serve the cause of tourism.

NEED FOR A MARINE PARK IN LAKSHADWEEP

All Lakshadweep islands are of coral origin and some of them like Minicoy, Kalpeni, Kadmat, Kiltan and Chetlat are typical atolls. The corals and associated fauna and flora form the most dominant marine benthic community in these islands. As already pointed out by Pillai (1985) and also discussed elsewhere in this publication the reefs and reef associated organisms of Lakshadweep in general are fast deteriorating due to natural and man-made causes. In many atolls like Minicoy, Kavaratti and Kiltan, mass mortality of corals due to human interference is severe. The terrestrial habitats have also undergone drastic changes due to total destruction of natural vegetation, mining of lime stones and sand stones for the preparation of lime and construction of houses; all natural corollary of expanding settlement and population pressure. The overall result is that the terrestrial and marine habitats of Lakshadweep are fast changing. It is imperative that conservation measures have to be urgently implemented in some of these

islands to preserve and protect these critical habitats for scientific, cultural and economic purposes. Selection of coral preserves and establishment of parks in and around some of the islands may serve this purpose. Lakshadweep can still boast of being the richest coral growing area around the Indian subcontinent, but it needs protection urgently. Establishment of marine parks and reserves can generate an additional income to the territory, if and when further development of tourism is effected.

Basic requirements for Marine Parks and preserves

Ray (1975) discussed in details the criteria to be observed in site selection, some of which are presented below and an attempt is made to evaluate the existing conditions in some of the islands in Lakshadweep.

a) Since a marine park basically should serve both recreation and education, the site selected should have existing or potential for infrastructure development.

b) The area should be deep enough to facilitate SCUBA and skin diving and should be safe for auch activities.

c) The benthic communities should be rich and varied for observation.

d) The climatic condition should be suitable for operation during a large part of the year.

e) The area should be "ecologically stable" in the sense that drastic natural changes though unpredictable should not bring forth cataclysmic changes in the ecosystem.

f) The area available should be sufficient enough and should be accessible for surveillance and eco-development, if necessary.

Suitability of Islands

Since most of the islands are relatively small and now thickly populated the land is scarce for any major development. This can, to a certain extent, put constraints on living quarters and tourist resorts. The marine habitat should be rich and varied. Inspite of these basic difficulties there may be more than one island in the archipelago to establish a marine park or national reserve. It may not be possible to apply the various criteria for selection with equal priority to all islands, since the priority will shift according to the purpose and function of the proposed park.

During the recent (January-March 1987) marine living resources survey of the islands by the CMFRI, Scientists paid some attention to examine some of these aspects in the various islands based on which the following islands were identified.

Minicoy: Minicoy has a vast and relatively deep lagoon The northern tip of the island is uninhabited and very narrow where once the Leper colony existed. The tuna fishery by traditional pole and line with live-bait is famous. Minicoy lagoon once had a luxurient growth of corals but today there is mass mortality due to human interference (Pillai, 1983). The lagoon looks barren since corals are very few. Further, imposing conservation measures on lagoon fishery and other minor resources will tell upon the tuna fishery. This is a place where user-conservationist conflict can reflect. Social and cultural problems are peculiar to Minicoy when compared to other Lakshadweep islands.

The adjacent Wiringili Island on the leeward reef flat is uninhabited and is a panoramic site with vast sandy lagoon stretching infront. However the present paucity of marine fauna in the lagoon as well as practical problems that may crop up in imposing conservation measures may be a major constraint for Minicoy.

Kavaratti: It is the Headquarters of the Union Territory and as such has got more credence. But recent survey has shown that the lagoon is mostly depopulated of corals. Land and other aminities may not be available. Existing tourist accommodation facilities include family huts and bathing huts. Further, shipping service to Kavaratti is more often than to other islands. The Headquarters of the local fisheries department at Kavaratti can get involved in the development and management of the Park. But the deteriorating environment and

anticipated developmental activities in tuna with other developments in the lagoon may not improve the natural condition of the lagoon.

Chetlat Island: In the northern Lakshadweep, Chetlat Island is one which still preserves the natural habitat to an extent in the lagoon. Exploitation of fishes and other marine organisms is limited. The lagoon has a luxuriant growth of corals. But the major problem is the shallow nature of the lagoon which gets partially exposed at low tide. Diving and swimming facilities are limited. Further' the island needs many more infrastructural facilities for tourists.

Kadmat: The beach is sandy. It is a typical atoll. The lagoon is deep enough for diving and swimming. The growth of corals is relatively profuse. Already family huts, honeymoon huts and youth hostels are available for the tourists. This island has many amenities that can be developed. Exploitation of living resources is not very severe. Regular tuna live-bait fishery is absent except when fishermen from Amini come to collect a few. Kadmat has potential and infrastructure that merit consideration for the establishment of a Marine Park.

Kalpeni: This island also is a typical atoll with relatively rich lagoon. The growth of coral is very good. At present there exists little living facilities for tourists. The advantage with Kalpeni is that it can serve as a central place from where conducted tours to nearby uninhabited Tilakkam, Pitti, Cheriyam and other places could be arranged. The area-wise coverage for the marine park and reserve will be much more in this island. The entire island along with the nearby uninhabited banks and islets can be declared as a marine sanctuary or park with the administrative nucleus at Kalpeni. It is also understood that the interference from local people in the lagoon habitat is not of a severe magnitude.

The above facts indicate that each of the islands considered has certain merits and demerits and priority should be given only after due consideration of administrative and practical aspects.

CONSTRAINTS AND PROSPECTS

User - conservationist conflict: The reefs and reef resources of Lakhadweep are the mainstay of local people for construction material, fish and other food items. It is true that the local administration has banned the exploitation of corals and lime stones for construction work in these islands. Live corals are also not permitted to be removed except for scientific purposes. The local people seem to have traditional rights of exploitation of live-baits from the lagoon. The traditional tuna fishery of Lakshadweep chiefly thrives on the availability of live-baits which are caught from the lagoon. Imposing restrictions on the live-bait fishery can trigger user conflict and hence needs a critical study, especially in islands like Minicoy. A high level committee including the representatives of the local people should examine this traditional rights of exploitation before a park is established in any of the inhabited islands.

Demarkation of zones for fishing, exploitation, diving, scientific studies and replenishment without disturbance is likely to confront practical difficulties since the area available in each island is small. However, in a national marine park and preserves such demarkation of zones is a must for its successful management. These aspect needs careful consideration before proposals are made for the establishment of a marine park.

Priority on criteria for selection of sites: The physiography, fauna and flora, environmental condition, infrastructure available, developmental feasibility, economic viability and socio-economic conditions of the island should be given due emphasis in the final choice of the park.

Scientific value: Since the corals and coral associated fauna of most of the Indian waters are fast deteriorating due to many reasons it is imperative that we should carefully preserve some areas in Lakshadeep for scientific research

and protection of the habitats. The economic viability and gains alone should not be criteria.

MANGEMENT ASPECTS

Ecodevelopment : All efforts should be made to protect and propagate the natural atoll vegetation which is fast disappearing from almost all atolls It is worth trying planting of trees like *Calophyllum inophyllum*, wild betham, *Thespesia populnea*, bread fruit (*Artocarpus incissa*) and screw-pines along the beaches that may provide shore protection to an extent, rather than introducing further exotic plants from the mainland.

It was observed that introduction of sea grass from Kavaratti to Chetlat lagoon was very successful by a local man. The introduced grass has established well in many square meters. This should be tried in places where there is a lack of seagrass bed in the lagoon. It will enhance productivity and, will form excellent forage ground for lagoon fishes and turtles. Further, they act as effective sediment trappers and prevent silt transportation upstream by erosion of the shore by wave action into the lagoon.

Restoration of the deteriorating and micro- and micro-habitats in the lagoon and reefs should be attempted. Enrichment of lagoon corals may be possible if hard substratum is provided at sites where there is least interference from silt. This will favour the settlement of planula larvae.

Even in small islands, total preserves of several square meters of area should be selected upstream and left totally undisturbed which should help in the propagation of species by natural ways. There should not be any involvement of wanton ecological disturbance at the selected zones. Since establishment and management of Marine Parks and reserves in this country is a new concept few persons may be trained abroad for the effective management.

Display stones, markings etc. should be effectively displayed. Strict surveillance should be observed to assess the research needs and modifications required.

Financing should be from the central authorities and Lakshadweep Administration can manage it.

The Tourism Development Corporation should have an active role in this.

Regulations : Effective implementations of certain regulations will become necessary in the effective scientific management of a marine park and reserves. Dredging in the lagoons should be avoided as far as possible. If dredged the soil at any cost should not be deposited in the lagoon or on reef flats (eg. Minicoy, Kiltan where this has resulted in death of corals in large areas). Blasting of the reef flats should be stopped.

Collection of corals and other reef organisms from the reserves should be restricted and certain zones may totally be banned (Regulations already effected by Administration). Sport fishing should be banned in the lagoon habitat and explosives and use of poisons should never be allowed. Sport fishing by tourists on a minimum level may be allowed in reef front only. Anchorage damage, diver damage, reef walking, turning of corals boulders etc. that can cause damage to marine denizens in the park should be minimised. At any cost collection of aquarium fishes and bait fishes for economic purposes should not be allowed in the reserved zones. All efforts should be made to protect the lagoon shores from sea erosion and subsequent sediment interference (already effective). Introduction of animals of economic importance and aesthetic value in the habitat may be done after careful assessment of the species interaction.

Construction activities along the near shore areas and lagoon in the reserves should be minimised.

The most important problem in all the Lakshadweep islands is the lack of hygiene on the beaches. Clean beach is a *sine qua-non* for the development of tourism. Sanitary conditions should improve and a public

awareness has to be created among the local people against polluting beaches.

Preparation of Red data book on endangered species as well as threatened species in the habitat should be done and strict surveillance against their exploitation made.

Only some general guidelines are presented above and the *Modus operandi* and functional viability of the various aspects need careful assessment and implementation.

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23. DEVELOPMENT OF FISHERIES IN LAKSHADWEEP — RECOMMENDATIONS

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INTRODUCTION

Investigations conducted by the Central Marine Fisheries Research Institute have indicated the possibilities of exploitation of the potential marine resources especially tunas and other commercially important fishes around Lakshadweep. Realising the need for the increased exploitation of the marine fishery resources, emphasis has been given to the biology and assessment of the resources of tunas, fishery and biology of tuna live-bait fishes and the environmental factors affecting their distribution and abundance. Of the various developmental schemes proposed to be implemented in Lakshadweep in recent years, exploitation of fishery resources has been given considerable importance by researchers and planners alike. As the land area being limited, the scope for the development of land based industries is very meagre and hence any major development programme envisaged has to be centred on the exploitation of marine fish resources.

PRESENT STATUS OF FISHING

The present average annual yield of 4949 tonnes (for 1983-86) of marine fishes from the islands is only a small fraction of the reported potential of the Sea around Lakshadweep which is as high as 90,000 tonnes (Jones and Banerji, 1973). Pole and line fishing for tuna practised in an organised manner only in Minicoy was adopted with the introduction of mechanised boats in the other islands of Lakshadweep after 1960 based on the suggestion made by Jones and Kumaran (1959). This has considerably enhanced the landings of tunas' especially the oceanic skipjack, the production of which has reached an annual average of 3983 tonnes during 1983-86' thereby bringing prosperity to the islands. However, a reasonable estimate of the exploitation potential of tunas around Lakshadweep is 50,000 tonnes (George *et al.*, 1977). The use of mechanised boats for pole and line fishing has resulted in considerable increase in the catch per boat The other fish resources which constitute about a fourth of the total production are mainly exploited by traditional gears like hook and line, harpooning, surface trolling, drag nets and cast nets. The important resources other than tunas are *Acanthocybium solandri*, *Elagatis bipinnulatus*, *Coryphaena hippurus*, perches, sharks and rays. As the traditional methods of capture of fishes other than tunas have not undergone any change, landings of other fishes are more or less at a stand still when compared to the increasing trend in tuna landings by pole and line. The magnitude of the landings of other fishes depends on the fluctuation in the availability of tuna shoals around the islands.

IMPROVEMENTS SUGGESTED

Various suggestions have been made by different authors for the exploitation and utilization of the resources of tunas, bill fishes sharks and other fishes (James *et al.*, 1986, James and Pillai, 1987; Kumaran and Gopakumar, 1986; Mannadiar, 1973; Nair, 1986; Silas and Pillai, 1982; Silas *et al.*, 1986). As the tuna fishermen are not able to go far out in small mechanised boats to scout for tuna shoals, Silas and Pillai (1982) suggested the introduction of large pole and line boats to increase the area of operations. The use of navigational aids and adequate storage facilities for enabling prolonged fishing operations beyond the traditional fishing grounds by pole and line and improving the operational techniques and post-harvest technology and marketing were proposed by James *et al*, (1986). The prospects of acquiring and utilising vessels, equipment and expertise from technologically advanced countries were also considered (James and Pillai, 1987). Diversification of fishing effort for exploitation of fishery resources other than tunas and practiisng cheaper preser-

vation methods and effective marketing have been suggested by Kumaran and Gopakumar (1986).

IMPORTANCE OF LIVE-BAIT

Live-baits are of paramount importance for the success of pole and line operations for skipjack. Shortage of live-baits at times is found to be a constraint for pole and line operations in the islands especially after mechanisation. Seasonal changes in the availability of bait fish in the lagoon have been observed and their scarcity sometimes affects skipjack fishing operations. However, observations made at Minicoy have shown that the total catch of live-baits is only increasing year after year from 1981-82 season and that the catch per unit effort fluctuates in different years. The fluctuations in the seasonal recruitment to the populations of migrant live-baits like *Spratelloides delicatulus, S. japonicus, Lepidozygus tapeinosoma, Caesio* spp. etc , environmental deterioration and the demand exceeding the available live-bait stocks are the main reasons attributed to the apparent shortage of live-baits (Pillai *et al.*, 1986). The increase in the number of pole and line units consequent on mechanisation of boats has resulted in the progressive increase in the tuna catch and hence the demand for live-baits also has increased, while the area of collection of live-bait remains the same. Pillai and Madan Mohan (1986) are of the opinion that adverse changes brought about in the environment by human interference are responsible for the declining trend in live-bait. Excessive erosion and siltation of the lagoons by the fury of nature, blasting of reefs and dredging to deepen the boat channels and removal of coral stones for construction purposes damage the ecosystem causing mortality of corals and associated fauna including live-baits (Pillai and Madan Mohan, 1986). Tilapia *Sarotheroden mossambicus)* was introduced in Minicoy as an alternate for live-baits. Though the species has established there, now in all the freshwater ponds, wells and tidal pools, it has failed as an alternative to other live-baits.

RECOMMENDATION

Development of tuna fisheries

Most of the earlier workers on the resource potential of the islands are of the view that tuna stocks are at present under exploited and that the production can be increased considerably. The pole and line fishery for tuna is the main fishing operation of the islands and hence developmental efforts should be directed towards the adoption of improved techniques. Indigenous manufacture of lure-hooks, fibre reinforced plastic poles, introduction of fishing boats with large holds for bait fish are worth the attempt to improve the tuna catch. The use of larger pole and line vessels will definitely be of advantage to increase the area of fishing operations and enable better catches. Drift gill netting and long lining from larger fishing vessels will yield large species of tunas. Fish aggregating devices could be set up around all submerged banks and isolated reefs in the archipelago for attracting tuna and other large fishes and thereby enable the fishermen to increase the landings.

Development of bait fishery

As the availability of live-bait is important for the development of pole and line fishing for skipjack, suggestions have been made already for the proper management of bait fishery, preservation of the ecosystem, identification of new varieties of bait fishes, locating fishing grounds so far remaining unexploited, culture of bait fishes and adopting improved methods of stocking live-bait tanks. However, concerted efforts have not yet been made on the above aspects so far. It has been observed that the requirement of bait fishes for pole and line fishery often outstrips the supply resulting from acute shortage of conventional species of bait fishes. As there is greater demand for live-baits than in the past due to the expansion of the pole and line fishery, the use of artificial baits could be tried. The availability of bait fish in regions of submerged reefs and around isolated islands have to be explored using better methods of capture which will definitely relieve to a great extent

the pressure on conventional species of bait fishes caught from the lagoon at present. Over stocking of the bait tanks and also the storage tanks floated in the lagoon results in mortality. Optimum requirement of live bait for a day's fishing operation as well as the maximum storage capacity of the tanks for retaining baits in captivity for long durations have to be estimated to avoid wastage. Preservation of the ecology of the lagoons and reefs is of considerable importance for the maintenance of flora and fauna. For sustaining the populations of coral associated live-bait resources, the coral reef ecosystem has to be conserved as far as possible. The possibilities of culture of *Chromis caeruleus, Chromis ternatensis Lepidozygus tapeinosoma* and atherinds which are hardy and forming a good percentage in the live bait catches during certain seasons can be explored.

Development of other fish resources

About one fourth of the total fish production of the islands consists of crangids, perches, wahoo, dolphin fish, rainbow runner, sharks, rays etc. As the capture of other fishes is inversely related to the availability of tuna shoals in close proximity to the islands, and the annual landings of other fishes are declining year after year consequent on the highly remunerative pole and line fishing, diversification of fishing gears will definitely increase the catches of other fishes. Drift gillnetting, surface trolling and long lining in the open sea are suitable propositions for the capture of larger fishes. Rays could be captured in good numbers by harpooning. Diversification will also generate employment opportunities for the youth of the islands. Surveys aimed at locating productive fishing areas and finding out the suitability of different gears have to be carried out. Experienced fisherman of the south-west coast of the mainland who are adept in trolling and long lining can be engaged in Lakshadweep for the capture of sharks and larger fishes. Immediate development of the shark fishery can boost the fish catches and lead to export of a number of products from this resource.

Improvement in fishery products

The local demand for tuna being limited, adequate attention has to be given for the storage, processing and marketing of the catches. 'Masmin', the smoked and dried product of tuna has good shelf life but deteriorates on keeping for several months by infestation by beetles. Steps have to be taken to improve the quality depending on the market preferences on the mainland and elsewhere. Large quantity of firewood is consumed for the preparation of 'masmin' and shortage of firewood is already felt in some of the islands. Alternate source of energy has to be used to remedy the situation. The production capacity of the tuna canning plant has to be increased to cope up with the increased tuna landings. Transportation and marketing the tuna in the mainland after freezing can also be done to dispose of the catches. The head and entrails of tuna are thrown while cutting tuna for the preparation of 'masmin'. These wastes can be converted into good quality manure or chicken feed.

Export of ornamental fishes

A good number of species in the lagoon and reefs of Lakshadweep are valuable ornamental fishes. Export of ornamental fishes on a limited scale can be attempted with suitable arrangements for storage, transportation and marketing. However, the impact of exploitation of ornamental fishes have to be carefully studied to obviate depopulation of the region.

Other minor resources

Crustaceans, holothurians, seaweeds, turtles and molluscs are some of the resources that are available to a limited extent. The exploitation of holothurians, seaweeds and crustaceans will not be an economical of proposition and at the same time bring about deterioration in the ecosystem. Octopus in the reefs and squids in the open ocean which are likely to occur in good concentrations could be exploited on a limited scale. Attempts have to be made to assess the potentialities of the resources of squids around Lakshadweep.

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