

ECOLOGY OF INTERTIDAL ECHINODERMS OF THE INDIAN SEAS*

D. B. JAMES**

Central Marine Fisheries Research Institute, Cochin-682031

ABSTRACT

Echinoderms are common and conspicuous organisms of the intertidal region. Their body structure is modified to live on different substrata such as rocky shores, sandy beaches, muddy flats, algal beds and coral reefs. Their concentration in the coral reefs is maximum. The author during the past twenty years has collected and studied echinoderms from various places along the Indian Coast and also from the coral reefs of the Gulf of Mannar and Palk Bay, Andaman and Nicobar Islands and the Lakshadweep Islands. More than one hundred species belonging to all the five classes have been collected from the intertidal region of India. In this paper their adaptations, habits and their distribution in the intertidal region is discussed.

INTRODUCTION

DURING the past twenty years the author has made extensive collections of echinoderms along the mainland coast of India from Jamnagar, Bombay, Ratnagiri, Karwar, Cochin, Vizhinjam, Tuticorin, Mandapam and neighbouring Islands in the Gulf of Mannar and Palk Bay, Madras, Machilipatnam, Kakinada and Waltair. Also extensive collections were made from the various Islands of the Andaman and Nicobar. Very good collections were also examined from all the Islands of Lakshadweep Islands. More than 160 species of echinoderms have been collected of which 105 come from the intertidal region.

Although there are a number of papers on the taxonomy of intertidal echinoderms from India hardly there is any publication on their ecology. This paper is presented to fill this gap in our knowledge of echinoderms. Special emphasis is made to study the habits of the animals *in situ* by using a mask and a snorkel.

* Paper presented at the Second National Seminar on Marine Intertidal Ecology organised by the University Grants Commission and the Andhra University, Waltair during February 14-16, 1985.

**Present address: Madras Research Centre of CMFRI, 29 Commander-in-chief Road, Madras 600 105.

The author is grateful to Dr. S. Jones, former Director of Central Marine Fisheries Research Institute for kindly introducing him to the study of these interesting animals and also for his encouragement and guidance. He is also thankful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute for providing him opportunities to study the echinoderms and also for his kind interest in the work.

MATERIAL AND METHODS

Various methods were used to collect the specimens living in different habitats. The most common and regular method of collection is to search for them in the intertidal region during the low tide. Small stones were turned over to collect small asteroids, ophiuroids and holothuroids. Since most of them are cryptic in their habits, sand stones and dead coral stones were broken into smaller pieces to collect specimens which live inside the crevices. Since most of them are nocturnal in habits collections were made during the night with the help of a petromax lamp. Muddy flats were surveyed during low tide to collect burrowing forms. The presence of the animal inside mud is often indicated by a characteristic mark on the surface of the mud. Coral reefs which surround the various Islands were well explored. Careful

search was made for specimens which live inside the crevices of the corals and collected by chipping off pieces of corals. Sand dwelling ophiuroids were collected by sieving the sand. Sea weeds and algae were washed in the laboratory to collect small ophiuroids and holothuroids which live attached to them. Rock boring sea urchins were collected by chiselling the rock to small bits. Holothurians were narcotised before preserving them in rectified spirit. Other groups of animals were killed in fresh water and preserved in 5% formalin.

Echinoderms collected from different habitats are described below.

CORAL REEFS

Coral reefs are by far the best habitat for echinoderms since they afford excellent protection to them. Many fugitive forms live in this habitat. Some of the starfishes like *Acanthaster planci* and *Culcita schmideliana* live on the polyps of corals. More than half the number of intertidal echinoderms are collected from this habitat. Starfishes like *Linckia laevigata* and *L. multifora* live in the crevices of corals in the young stages. Coral reefs are favourite haunts for brittle stars. Members of the family Ophiocomidae live gregariously in coral reefs (Pl. I). *Ophiocoma pica* is associated with live coral *Pocillopora meandrina* var. *noblis*. Large ophiuroids like *Ophiomastix annulosa* and *Ophiocoma erinaceus* live near the low water mark among the corals. Among sea urchins species of *Diadema setosum* (Pl. II) and *Echinothrix calamaris* are characteristic of coral reef fauna. Among holothurians many fugitive forms like *Holothuria hilla*, *H. pardalis*, *H. arenicola* and *H. impatiens* live among the branches of dead coral reef. A. M. Clark (1976 a) has given an account of the echinoderms of coral reefs.

ROCKY COASTS

Next to coral reefs rocky coasts are important habitats for the echinoderms particularly for the sea urchins. Some of the sea urchins like *Echinometra mathaei* and *E. mathaei* var. *oblonga* bore into rocks and live in the tunnels made by them. It is impossible for the animal to come out of the tunnel and it has to depend on the food brought by the high tide. In places where there is heavy surf action the sea urchin *Stomopneustes variolaris* bores into the rock and lives in a cup-like depression. The same sea urchin in places like Mandapam where there is no surf action simply lives by attaching to the rock by the tubefeet. Sometimes it is even seen on sea grass beds in calm water. Considerable massing of the tubefeet takes place on the flattened oral side to assist anchorage. This is well seen in the limpet-like sea urchin *Colobocentrotus atratus* with its extremely short, stout, polygonal, upper spines fitting closely together to form a smooth mosaic-like surface. The flattened basal spines form a marginal fringe and the tube feet are massed below so that the animal can hold fast on wave beaten rocky shores. *Echinostrephus molaris* makes cylindrical pits deep enough for the whole animal with its tuft of long vertically directed upper spines to drop completely out of sight from its usually feeding perch at the top of burrow at the slightest disturbance. Sea urchins like *Salmacis virgulata*, *S. bicolor*, *Salmaciella dussumieri* and *Temnopleurus torematicus* simply attach to the rock by tube feet. Some of the holothurians notably small dendrochirots like *Hemithyone semperi*, *Afrocucumis africana* and *Actinocucumis typicus* live by attaching to the underside of stones. *Afrocucumis africana* is somewhat gregarious and often seen living in rock crevices even in the supra-littoral zone. Other holothurians like *Holothuria rigida*, *H. mobei*, *H. cinerascens* live under stones attached to stones. In such species the tube feet

on the ventral side are well developed appearing like a sole, *Holothuria pyxis* is always found under large stones which are well fixed to the ground. The long and narrow anterior end is kept out and is seen in constant movement like a snake. It is impossible to pull out the animal without damaging the specimen. On lifting the stone it is found to have a bulged posterior end. Among star fishes members of the family Asterinidae which are small are found to live under stones by attaching to them by tube feet. Often two or three specimens of *Asterina burtoni*, *Patriella pseudoexigua* are found to live under the same rock. Among ophiuroids *Amphipholis squamata* lives under stones found on sand. Often three or four specimens were found to live under the same stone. Members belonging to the family Ophiotrichidae *Macrophiothrix aspidota*, *M. variabilis*, *M. longipeda* live under stones. They hold on to the rock by their serrated spines. Feather stars attach to stones by the cirri.

SANDY SHORES

Species which live in sandy shores have the ability to bury themselves in sand with the help of tube feet. Starfishes like *Astropecten indicus* and *A. polyacanthus* have pointed tube feet which enable them to bury quickly into sand. *Archaster typicus* which is gregarious at Andamans comes up from sand when the tide recedes, in order to reach water. A sort of copulation is noticed where the male which is smaller sits over the female with its rays alternating with that of the female. Among ophiuroids no sand dwelling ones could be collected from the intertidal region. Among sea urchins *Laganum depressum* and *Arachnoides placenta* were found to live in sand in the intertidal region. Their presence is indicated by the characteristic mark on the sand. Among sea cucumbers *Labidodemas rugosum* lives buried deep in sand under coral stones. The tube feet are long and slender which enables the animals

to bury quickly. It is found distributed from the midlittoral to low water mark. Some of the dendrochirotidids like *Phyrella fragilis* are good sand burrowing forms. It is found distributed from the supralittoral to midlittoral zone. The animals are always found under stones completely buried in coarse sand. On lifting the stone the presence of the animal is indicated by a jet of water ejecting from the cloaca. As soon as it is dug out from the sand it becomes like a ball by contraction. On the surface of the body small pieces of shell, coral bits and big sand particles are attached. It immediately eviscerates on collection. The apodus holothurian *Patinapta ooplax* is found to be distributed in the supralittoral zone. It is found to be loosely buried in the sand under stones. On lifting the stones the animal slowly withdraws its body into sand. It is easily overlooked in collection due to its small size, colour and habitat. *Holothuria atra* is one of the most common holothurians of the Indian region. It is always found fully exposed on sandy bottoms. Specimens collected from the outside of the reef are large (400 mm) and found to have the alga *Halmida* in the alimentary canals. Often sand forms as a coat on the body. *Holothuria leucospilota* which lives on sandy bottoms has a peculiar habit of tucking its posterior end under a rock and when disturbed it ejects cuvierian tubules. *Stichopus variegatus* lives exposed on sandy reef flats. Smaller forms are encountered near the low water mark.

MUDDY FLATS

Some of the holothurians are characteristic of muddy flats. *Holothurian erinaceus* lives in mud in the supra-littoral zone. In the marine area at Andamans where there is lot of mud 3-5 specimens were distributed in a square metre area. On walking over the mud due to the pressure caused on the surrounding area a jet of water is ejected by nearby specimens. In

some places it is truly gregarious. When the tide recedes they come out of mud and keep a small portion of the anterior end (about 30 mm length) outside with the tentacles spread out. *Polychera rufescens* is a common inhabitant of the muddy flats at Andamans. It is found to be distributed in the supralittoral zone. It is chiefly a burrowing species living in burrows located under stones. Often under the same stone three or four individuals may be found. On disturbing the stones over the burrows the holothurians slowly withdraw by contracting their body and at the same time letting out water which flows at the entrance without force. In order to collect the specimens one has to dig deep into the mud. *Holothuria scabra* which is used in the preparation of *Beche-de-mer* is characteristic of muddy flats. During low tide time a number of them can be seen in half buried condition. When they are buried the posterior end of the body is always kept outside. Small specimens (50 mm to 90 mm) were seen to be lying freely on the muddy grounds during low tide. At some places there are about ten specimens distributed in an area of 25 square metres. *Acaudina molpadiodes* is characteristic of muddy flats at Kakinada. The whole animal lies buried in loose and fine mud.

ALGAL BEDS

Only a few species of echinoderms are characteristic of the algal beds. *Synaptula recta* was found to live on algae in the intertidal region. When it occurs it is gregarious. They were found to crawl on the algae with the help of tentacles and anchors which stick to the algal branches. *Stichopus naso* were seen to occur on the eel grass beds in an exposed manner. On the same eel grass beds the starfish *Pentaceraster regulus* was also collected. This species is also collected on the sand flats. The ophiuroid *Ophiocomella sexradia* was found to be associated with the alga *Caulerpa* sp. When branches of algae were washed several

specimens which live at the basal portion of the alga come out. In addition to the above species some of the species living on the sandy flats are also found in the algal beds.

EPIZOIC HABITAT

In the intertidal region some of the echinoderms lead an epizoic life. Many of them belong to the Family Ophiotrichidae. The long arms and the serrated spines and hooks enable them to get a firm hold on the host. *Ophiomaza cacaotica* which lives on the sea feather *Tropometra carinata* leads even a parasitic life A. M. Clark (1976 b). The five arms of the ophiuroid are coiled round the dorsal side of the sea feather. The brittle star is of the same colour as the sea feather being chocolate brown. The ophiuroids get shelter and also share the food of the sea feather. Another ophiuroid *Ophiogymna elegans* lives on Alcyonarians. The colour of the ophiuroid strikingly matches with that of the host being red and white. They live in the grooves of the colony by firmly attaching themselves. The small brittle star *Ophiothela danae* lives on Gorgonians by firmly coiling their small arms. Here again the colour matches well with the colour of the host. It therefore appears that epizoic forms exhibit protective colouration.

There are some echinoderms which live inside the canals of sponges. *Ophiactis savignyi* lives in the canals of the sponge *Spirastrella inconstans*. Specimens of different sizes live gregariously inside the sponge. Most of the young forms have six or seven arms. *Ophiactis modesta* also lives inside canals of sponges in a more gregarious manner. A few specimens of the holothurian *Afroccumis africana* are also collected from inside of sponges.

The ophiuroid *Ophiothrix exigua* exhibits remarkable colour adaptation for specimens collected from the body surface of the holothurian *Holothuria atra* are black in colour and

those collected from the surface of red sponges are red and those from the surface of white sponges are white in colour. It is found to live on *Prostylylla foetida callospongia diffusa* and *oceanopia* sp.

The brittle star *Ophiocomella sexradia* was found to be associated with the alga *Culerpa* sp. This was collected from the low water mark.

Echinometra mathaei var. *oblonga*. As stated above majority of the intertidal echinoderms live in the mid-littoral zone. Characteristic forms of the infra-littoral zone are *Acanthaster planci*, *Calcita schmideliana*, *Ophiocoma pica*, *Stomopneustes variolaris*, *Microthele nobilis*, *Theloneta ananas*, *Holothuria edulis*, *Stichopus chloronotus*, *Holothuria spinifera* and *Pentacta quadrangularis*.

TABLE 1. Distribution of the echinoderms in the intertidal region in the Indian seas

Supralittoral Zone	Midlittoral Zone	Infralittoral Zone
<i>Ophiocoma scolopendrina</i>	<i>Asterina coronata</i> , <i>A. burtoni</i> , <i>A. sarasini</i>	<i>Tropiometra carinata</i>
<i>Ophiocoma brevipes</i> , <i>O. dentata</i>	<i>Patriella pseudoexigua</i> , <i>Tegulaster ceylanica</i>	<i>Lamprometra palmata</i>
<i>Ophiarachnella septemspinosa</i>	<i>Pentaceraster regulus</i> , <i>Archaster typicus</i>	<i>Acanthaster planci</i>
<i>Ophiolepis cincta</i>	<i>Astropecten polyacanthus</i> , <i>A. indicus</i>	<i>Calcita schmideliana</i>
<i>Echinometra mathaei</i>	<i>Linckia laevigata</i> , <i>L. multifora</i> , <i>L. guildingi</i>	<i>Ophiocoma erinaceus</i>
<i>Echinometra mathaei</i> var. <i>oblonga</i>	<i>Amphipholis squamata</i> , <i>Ophiarthrum elegans</i>	<i>Ophiocoma anaglyptica</i>
<i>H. erinaceus</i>	<i>Macrophiothrix aspidota</i> , <i>M. variabilis</i>	<i>Ophiomastix annulosa</i>
<i>Afrocucumis africana</i>	<i>Ophiarachnella gorgonia</i> , <i>Ophionereis porrecta</i>	<i>Ophiocoma pica</i>
<i>Phyrella fragilis</i>	<i>Salmacis bicolor</i> , <i>S. virgulata</i> , <i>S. dussumieri</i>	<i>Stomopneustes variolaris</i>
<i>Patinapta ooplax</i>	<i>Temnopleurus toreumatcus</i> , <i>Diadema setosum</i>	<i>Colobocentrus atratus</i>
<i>Polycheira rufescens</i>	<i>Echinothrix calamaris</i> , <i>E. diadema</i>	<i>Microthele nobilis</i>
	<i>Tripneustes gratilla</i> , <i>Breynia vredenburgi</i>	<i>Toxopneustes pileolus</i>
	<i>Archnoides placenta</i> , <i>Laganum depressum</i>	<i>Theloneta ananas</i>
	<i>Holothuria pyxis</i> , <i>H. rigida</i> , <i>H. hilla</i> , <i>H. pardalis</i>	<i>H. edulis</i>
	<i>H. arenicola</i> , <i>H. impatiens</i> , <i>H. scabra</i> , <i>H. atra</i>	<i>Stichopus chloronotus</i>
	<i>H. leucospilota</i> , <i>Actinopyga mauritiana</i> , <i>A. miliaris</i>	<i>Holothuria spinifera</i>
	<i>A. lecanora</i> , <i>A. echinites</i> , <i>Bohaschia marmorata</i>	<i>Stolus buccalis</i>
	<i>Labidodemas rugosum</i> , <i>Actinocucumis typicus</i>	<i>Pentacta quadrangularis</i>
	<i>Ophiodesma grisea</i> , <i>Synapta maculata</i>	<i>Pseudocolochirus violaceus</i>
	<i>Synaptula recta</i> , <i>Euapta godeffroyi</i>	<i>Synaptula striata</i>
	<i>Memithyone semperi</i>	<i>Havelockia versicolor</i>
		<i>Holothuria moebi</i>

ZONATION OF ECHINODERMS IN INTERTIDAL REGION

The distribution of the echinoderms in the intertidal region is presented in Table 1. From the Table it is seen that majority of the echinoderms are found to live in the mid littoral zone (60%). In the infralittoral zone 25% of them live and in supralittoral zone only 15% were found to live. The forms which live in the supralittoral zone should be in a position to withstand exposure during low tide. Notable members of this zone are *Patinapta ooplax*, *Polycheira rufescens*, *Afrocucumis africana*, *Phyrella fragilis*, *Holothuria erinaceus*, *Ophiolepis cincta* and the rock borers *Echinometra mathaei* and

HABITAT DESTRUCTION

One of the serious problems faced by the intertidal organisms is their habitat destruction and the other is marine pollution. Coral quarrying has been going on for a long time, but in recent years it has assumed alarming proportions since coral forms the raw material for several industries including cement. According to Silas *et al.* (1985) annually 25,000 tonnes of coral is removed from early fifties. This not only removes the habitat, but brings in lot of suspended matter which kills the animals. In recent years large quantities of algae are removed for some chemical industries. Also lot of eel grass is removed in recent years to be used as

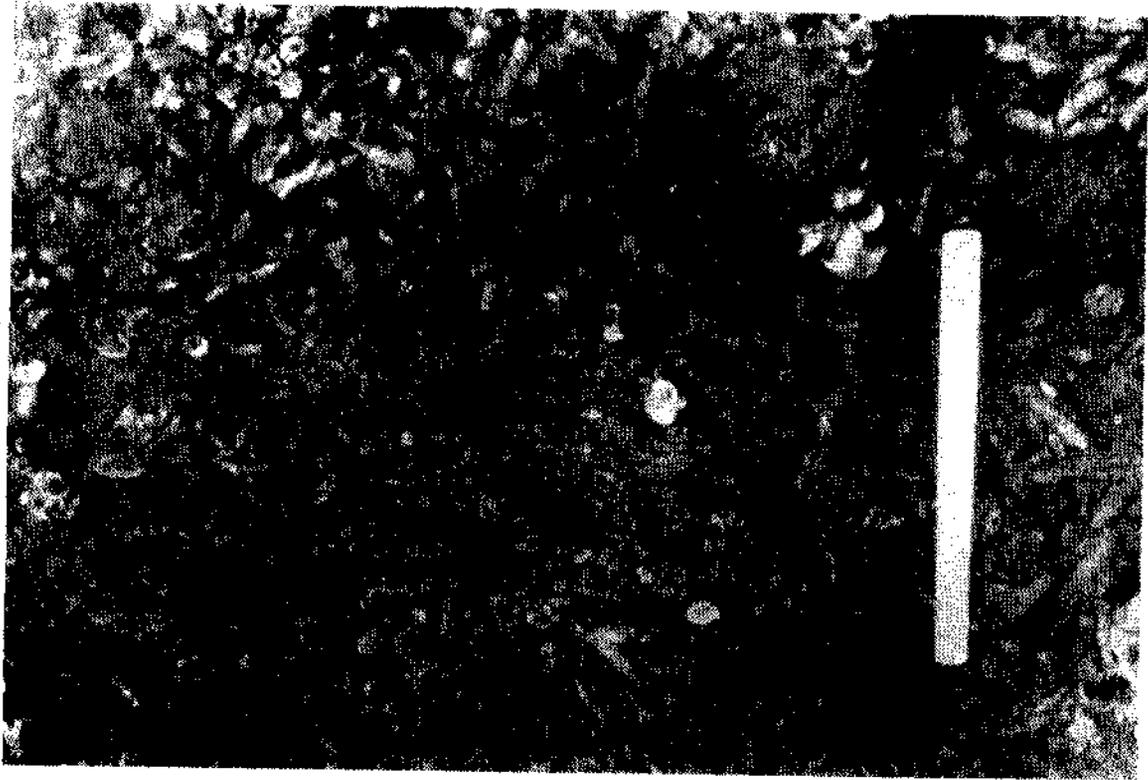


PLATE I. Coral reef flat during low tide showing *Ophiocoma scolopendrina* at Port Blair.

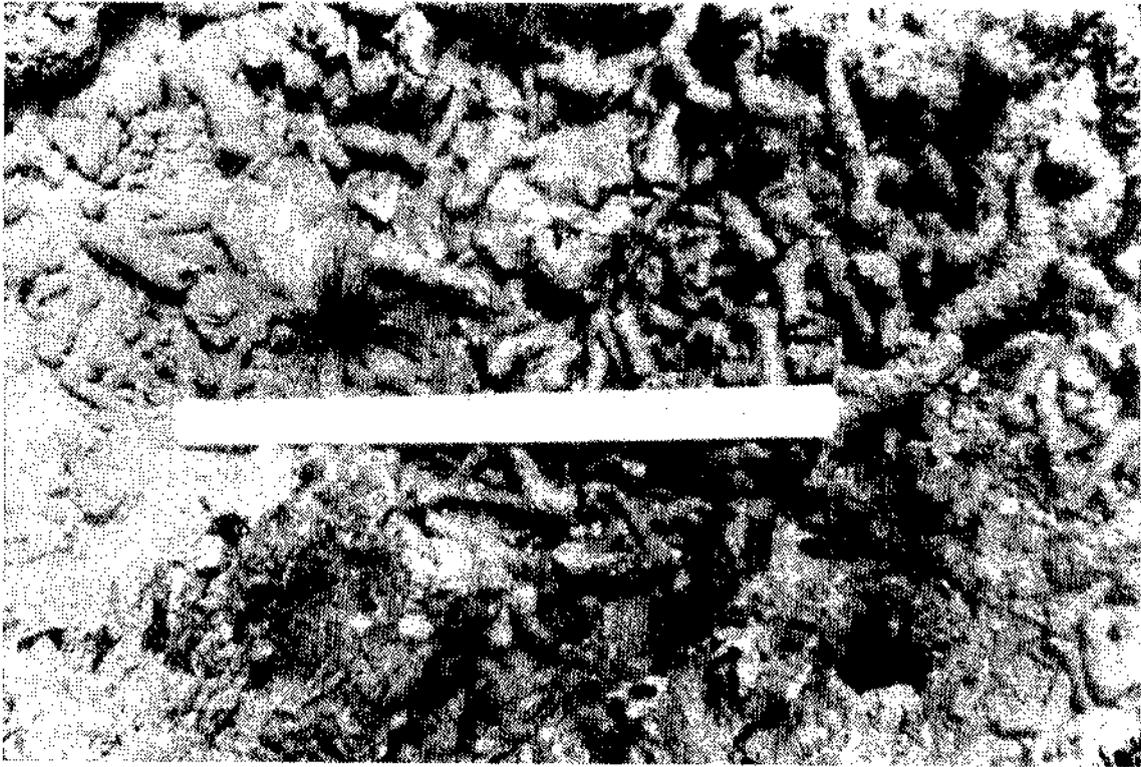


PLATE II. Coral reef flat during low tide showing *Dalmanella serotina* at Port Blair.

manure for coconut plantations. These activities have to be checked to save the intertidal organisms. Another important step to be taken is to check marine pollution. Already some of the industries are located on the banks of the proposed National Marine Park in the Gulf of Mannar. Their activities have to be carefully watched and monitored.

It is sad to note that already some of the coral loving forms have disappeared from the Gulf of Mannar and Palk Bay. Thurston (1884) mentioned about *Ophiocoma erinaceus* and other forms which are absent to-day. Also Gravely

(1927) recorded *Ophiocoma scolopendrina* from the Gulf of Mannar. Species of *Ophiocoma* when they occur they occur gregariously, but an intensive search for over seven years on all the coral reefs showed that they are absent today. Also Gravely (1927) mentions about hundreds of specimens of *Stichopus chloronotus* at Rameswaram in 1927, but to-day not single specimen is to be seen anywhere. The above facts clearly show that something has happened to the reefs irrecoverably and we should take timely action to save further damage.

REFERENCES

CLARK, A. M. 1976 a. Echinoderms of Coral Reefs. In: O. A. Jones and R. Endean (Ed.) *Biology and Geology of Coral Reefs*. Academic Press, New York, 3 (2): 95-123.

----- 1976 b. Tropical epizoic echinoderms and their distribution. *Micronesica*, 12 (1): 111-117.

GRAVELY, F. H. 1927. The littoral fauna of Krusadai Island in the Gulf of Mannar: Echinodermata. *Bull. Madras Govt. Mus. (Nat. Hist.)*, 1 (1): 163-173.

SILAS, E. G., S. MAHADEVAN AND K. NAGAPPAN NAYAR 1985. Existing and proposed marine parks and reserves in India - A review. Paper submitted for the Symposium on endangered marine animals and marine parks. Vol. 3, paper No. 36: 1-28. Organised by the Marine Biological Association of India.

THURSTON, E. 1894. *Rameswaram Island and fauna of the Gulf of Mannar*. *Madras Government Museum Sci. Ser.*, 1: 78-138.