FAUNA OF CONSERVATION AREAS : 4

# A GENERAL ACCOUNT OF THE MANGROVE FAUNA OF ANDAMAN AND NICOBAR ISLANDS

A. K. DAS AND M. K. DEV ROY

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## A GENERAL ACCOUNT OF THE MANGROVE FAUNA OF ANDAMAN AND NICOBAR ISLANDS, INDIA

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# EDITOR'S PREFACE

Mangroves represent a very specialised forest ecosystem dominated by some unique halophytes which grow at land-sea interface and border sheltered sea coasts and estuaries of the tropical and subtropical regions of the globe. This forest ecosystem is a vital resource in terms of wood and wood products, nursery bed and feeding ground of many commercially important animals. Mangroves are also ecologically significant for their role in shore line protection and as important reservoirs of large number of animal species, both terrestrial and aquatic. Destruction of the mangroves can, therefore, lead to a major change in shore ecology with subsequent dislocation of food chain accompanied by inevitable depletion of organisms within the chain and decline of commercial fishing.

Despite these economical and ecological values there has been relatively little research on the faunal components of the Indian mangroves and their ecological implications. Studies made so far in this regard are restricted either to planktonic organisms or to benthic and boring animals of the intertidal area of the mangroves, leaving a vast terrestrial components which utilise mangroves for feeding, roosting, transit and nesting.

In this context the authors of the present communication studied the mangrove fauna of Andaman and Nicobar islands in details during their tenure in the Andaman and Nicobar Regional Station of the Zoological Survey of India at Port Blair from 1978 to 1983. The communication deals with both marine and terrestrial fauna of the mangroves of the Bay islands, which cover an area of about 100,000 hectres and constitute 28 per cent of the total Indian mangales. An account of mangrove borers and galls, faunal zonations in the mangroves and results of quantitative studies of some mangrove inhabiting crabs of South Andaman islands are also given. The communication is well illustrated with good number of plates and figures and I am sure that it would be of much interest to the specialists and research workers of mangrove and marine biology.

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Director
Zoological Survey of India.

# FAUNA OF CONSERVATION AREAS :

## A GENERAL ACCOUNT OF THE MANGROVE FAUNA OF ANDAMAN AND NICOBAR ISLANDS, INDIA

# ZOOLOGICAL SURVEY OF INDIA

CONTENTS

# INTRODUCTION

The fascinating and fairly important discipline, mangrove biology, has attracted the attention of many workers in recent years especially after the initiation of MAB Programme on tropical ecosystems. This attention continues to increase because of better understanding of the importance of mangroves in relation to their associated productivity.

In India, a large amount of scientific literature is now available dealing with different aspects of the mangrove ecosystem. Even then, while floral aspects of this ecosystem are relatively well studied, the faunal elements and their ecological implications are rather disparately presented. Barring a single publication of Mukherjee (1975) who has given a brief account of the Sundarban biota, as a whole, works on the mangrove fauna of India pertain to one or a few faunal groups. In most of the cases either planktons or macrobenthic fauna of the intertidal area of the mangroves have been presented. Interestingly, terrestrial faunal elements of the Indian mangroves are practically neglected for study. Keeping this in mind, the present authors during their tenure in the Andaman and Nicobar Regional Station of the Zoological Survey of India at Port Blair during the years, 1978-1983 have collected and studied large number of animal taxa from different mangrove areas of these Bay islands, which include both terrestrial and intertidal fauna. These are being dealt with in the present communication with a view to giving an over all picture of the faunal components available in the mangroves of these Bay islands.

During the present investigation much emphasis has been given to study the borers (both insect and marine) and galls as well as crabs of the mangales of these Bay islands. Therefore, those categories of mangrove fauna have been dealt with in the present communication in much detail compared to other faunal components of this ecosystem.

Majority of the fauna dealt with in this paper have been collected/ observed by the present authors. The specific identification of these animal taxa has been done mainly by the concerned experts of the Zoological Survey of India, Calcutta.

## EARLIER WORKS

Work on the faunal elements of the mangrove ecosystem of Andaman and Nicobar islands is practically unattended till date. In recent years, Das (1985), Das and Dev Roy (1980, 1981, 1982, 1984a, b), Das, Dev Roy and Mitra (*in press*), Dev Roy and Das (1985), Dev Roy, Das and Mitra (1984 and *in press*) and Tiwari *et al.*(1980) have studied the mangrove borers and Sharma *et al.*(1983, 1984, 1985) have dealt with the mangrove galls of these islands.

## PHYSIOGRAPHY AND STUDY AREAS

### General :

Andaman and Nicobar islands are the summits of a submarine mountain range having a continuation with the Arakan Yomas of Burma in the north and the island fastoons of Sumatra in the south. These islands are situated between 6°45′ N and 13°30′ N latitudes and 90°20′ E and 93°56′ E longitudes covering an area of 8293 km$^2$ as per 1981 census. The tropical, hot and humid climate with abundant rains has resulted in the formation of very luxuriant and rich vegetation in these islands. The mangrove forests of these islands have developed along the tidal creeks, inland channels and in shores (bays) protected by coral reefs, which receive tidal inundation and are protected from high waves, wind and monsoons. The substratum as a rule consists of muds of varying depths (at places about knee deep) containing sandy particles in variable proportions. The consistency of the substratum varies from semi fluid mud to hard substratum depending upon the period of tidal inundations. Whenever the mangroves extend seaward small boulders, pebbles and medium sized rocks are found at the edges of these forests, rendering the substratum firmer and plant species which develops in this type of substratum becomes dwarf in nature. Water logging of the substratum with saline water is not an uncommon feature.

### Climate :

As in other tropical islands on the same latitude the climate of the Bay islands is warm and humid. The features of the climate of these islands are summarised in Figs. 1 & 2. The mean temperature near the sea level during the years 1980-1982 ranged from 20.8°C to 32.8°C and the maximum diurnal range was 10.8°C. The relative humidity varied from 66% to 93%. The average minimum and maximum rain fall during the said three years were zero and 633.4 mm respectively, the maximum rain fall being

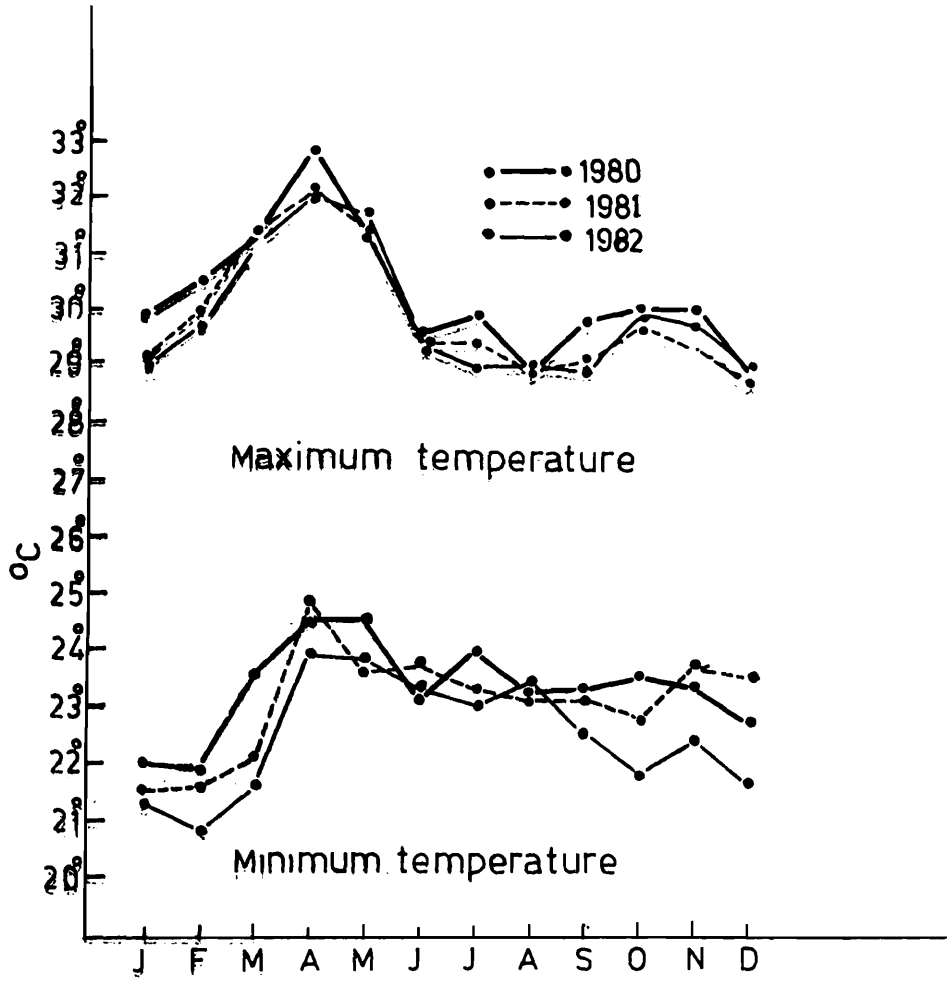



**Fig. 1.** Maximum and minimum temperatures for 1980 to 1982 at Port Blair, South Andaman.

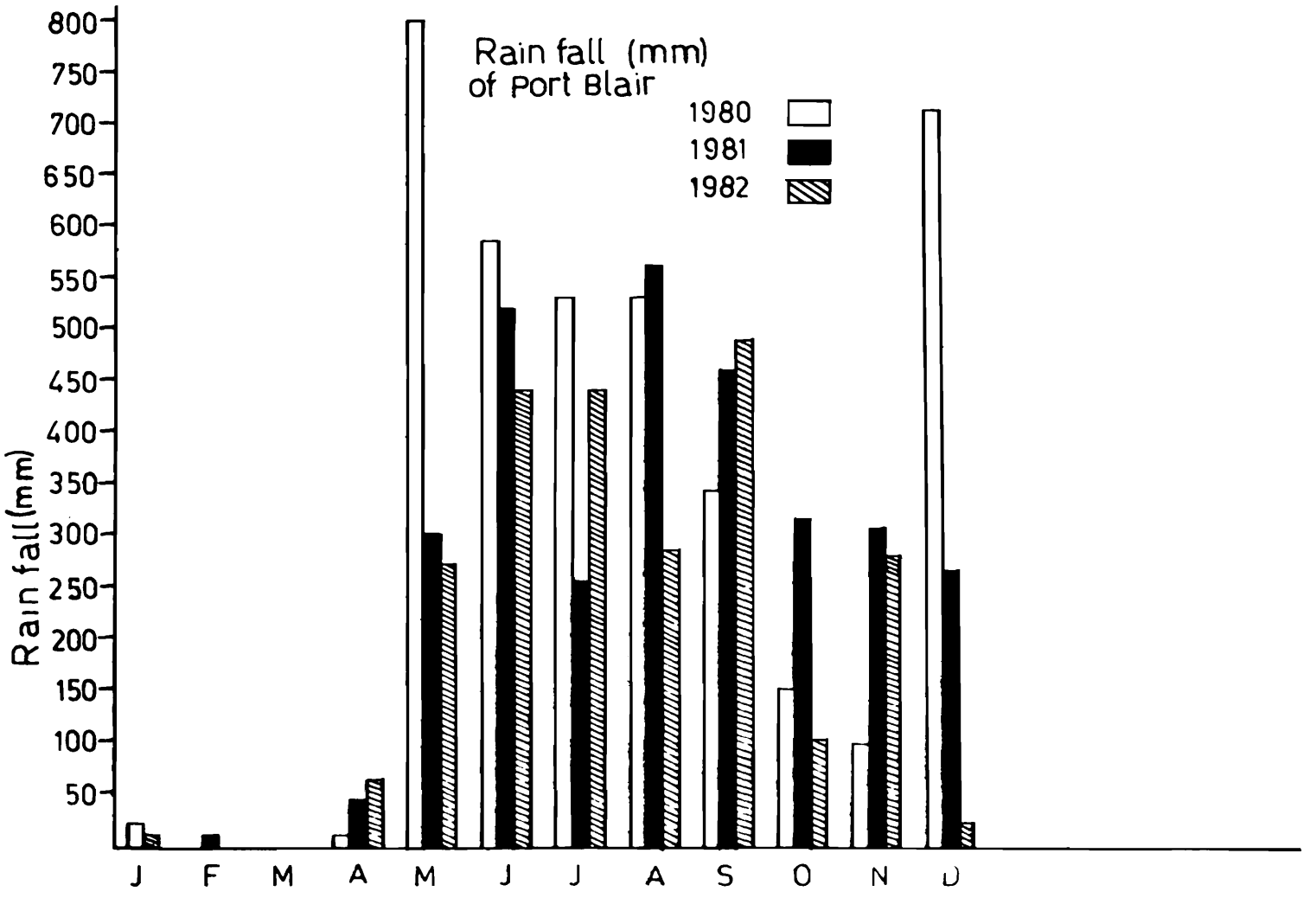



Fig. 2. Rain fall at Port Blair for 1980 to 1982.

798.3 mm during 1980. January and April were the dry months. The most striking feature of the weather during these three years was that in 1980 north-east monsoon brought heavy rain fall (715 mm) during the month of December.

Both south-west (May to September) and north-east (October to December) monsoons influence the rain fall in these islands. During the south-west monsoon winds are moderate but by its retreat typhoons affect the area. Some of these may develop into cyclonic storms accompanied by heavy rain. Cyclones are very rare.

**Mangrove flora :**

This archipelago in the Bay of Bengal comprises more than 300 islands or islets (Tikader and Das, 1985; Annual General Report, 1980-81 of Andaman Administration) which are, in most of the cases, separated from each other by narrow but deep creeks. These creeks are fringed with abundant mangroves. According to an estimate of Blasco (1977) mangroves of Andaman and Nicobar islands cover an area of about 100,000 hectares. So far as the Indian mangroves are concerned this area is next only to the Gangetic delta of West Bengal where mangroves occupy 200,000 hectares. Again, considering that total area of Indian mangale is about 356,500 hectares (Blasco, *op. cit.*), 28 per cent of Indian mangales are confined to these Bay islands. However, Andaman group of islands contain most of the mangroves while the Nicobars are having very little. As per Sahany's report (1957) mangrove forests of these islands occupy about 20 per cent and 2 per cent of the total land area of the Andamans and the Nicobars respectively.

The mangrove flora of these bay islands have been studied by Chengappa (1944), Banerji (1954, 1958), Sahany (1957) and of late by Mall *et al.*(1985) and Vasudeva Rao (1986). Mall *et al.*(*op. cit.*) have listed 26 exclusive mangrove species and 10 non-exclusive mangrove species. But perusal of literature including the work of Vasudeva Rao (*op. cit.*), consultation with the Botanical Survey of India, Port Blair Circle and personal observation in different mangrove areas of these islands reveal the presence of 37 species of mangroves and their associated vegetation.

The mangroves of the Bay islands are noteworthy for their gregariousness and nearly uniform degree of dominance by the fewer number of species unlike on the mainland (Krishnamurthy, 1985). Two categories of mangroves, namely, core mangroves and associated and peripheral vegetation are also recognised. Among the Andaman mangroves, *Rhizophora*

Fig. 3. Mouth of a creek at Corbyn's Cove (South Andaman) fringed with mangroves, *Rhizophora* sp.

Fig. 4. Creek (interior portion) fringed with very thick mangrove in Havelock island.

Fig. 5 Mangrove forest in Neil island; showing ***Sonneratia alba*** with characteristic pneumatophores and cable roots and *Rhizophora* sp with stilt roots.

Fig. 6. Mangrove forest in Havelock island, showing *Bruguiera gymnorhiza* with characteristic knee roots.

Fig. 7. Mangrove forest at Sippighat (South Andaman), with *Acanthus ilicifolius, Nypa fruticans* and *Bruguiera gymnorhiza*.

*mucronata* and *R. apiculata* are most dominant and grow on the outer seaward fringe of the swamp (Figs. 3 & 4). Sometimes open mudflats, and rocky and coral reef flats are occupied by *Sonneratia alba* (Fig. 5), *S. apetala* and *Avicennia marina*. In the tidal creeks, *Bruguiera gymnorhiza* and *B. parviflora* are abundant (Fig. 6), of which tallest trees grow as high as 25 metres. In the tidal swamps, *Avicennia officinalis, Ceriops tagal, Kandelia candel, Xylocarpus granatum, X. moluccensis, Lumnitzera racemosa, L. littorea, Excoecaria agallocha* and *Aegiceras corniculatum* are found to grow. *Acanthus ilicifolius* forms a dense prickly undergrowth generally near the creek. *Heritiera littoralis, Scyphiphora hydrophyllacea, Brownlowia lanceolata* and *Cynometra ramiflora* grow towards the landward fringe. Sometimes fern, *Acrostichum* spp and palms, *Nypa fruticans* and *Phoenix paludosa* are quite common in this zone (Fig. 7). In the supra-littoral zone of the disturbed mangrove forests *Acanthus ilicifolius* and *Acrostichum aureum* are sometimes very frequent as in Sippighat area, South Andaman.

In both Andaman and Nicobar islands, membrs of the family Rhizophoraceae are pioneers in mangrove formation and are the guardian of soil builders. These forests along with their peculiar root system develop gregariously fringing the coasts or at the mouth of the creeks. Once *Rhizophora* colony becomes established other species grow gradually behind them. Mention may be made here that *Rhizophora* and its allied species have become rare or tended to be disappeared in other parts of India except in Cauvery delta and in the Andaman islands due to strong biotic pressure.

Ecological distribution of the mangrove plant-species and their associated vegetation is presented below according to Watson's (1928) inundation classes.

| Family & Species | Habit | Distribution according to Watson's inundation classes 1 2 3 4 5 | Adjacent and inland vegetation |
|---|---|---|---|
| Family Acanthaceae | | | |
| 1. *Acanthus ebracteatus** | S | | — |
| 2. *Acanthus ilicifolius** | S | | — |
| 3. *Acanthus volubilis** | C | | — |

| Family & Species | Habit | Distribution according to Watson's inundation classes 1 2 3 4 5 | Adjacent and inland vegetation |
|---|---|---|---|
| **Family Apocynaceae** | | | |
| 4. *Cerbera manghas*** | T | | — |
| 5. *Cerbera odollam*** | T | | — |
| 6. *Cerbera floribunda*** | T | | — |
| **Family Combretaceae** | | | |
| 7. *Lumnitzera littorea** | ST/T | — | |
| 8. *Lumnitzera racemosa** | ST/T | — | |
| **Family Euphorbiaceae** | | | |
| 9. *Excoecaria agallocha** | ST/T | — | |
| **Family Meliaceae** | | | |
| 10. *Xylocarpus granatum** | T | — | |
| 11. *Xylocarpus moluccensis** | T | — | |
| **Family Myrsinaceae** | | | |
| 12. *Aegiceras corniculatum** | T | — | |
| **Family Palmae** | | | |
| 13. *Nypa fruticans** | T | — | |
| 14. *Phoenix paludosa** | T | — | |
| **Family Papilionaceae** | | | |
| 15. *Derris heptaphylla*** | C | | — |
| 16. *Derris scandens*** | C | | — |
| **Family Pteridaceae** | | | |
| 17. *Acrostichum aureum** | S | — | |
| 18. *Acrostichum speciosum** | S | — | |
| **Family Rhizophoraceae** | | | |
| 19. *Bruguiera cylindrica** | T | — | |
| 20. *Bruguiera gymnorhiza** | T | — | |
| 21. *Bruguiera parviflora** | T | — | |
| 22. *Bruguiera sexangula** | T | — | |
| 23. *Ceriops tagal** | T | — | |
| 24. *Kandelia candel** | T | — | |
| 25. *Rhizophora apiculata** | T | — | |
| 26. *Rhizophora mucronata** | T | — | |

| | | 1 2 3 4 5 |
|---|---|---|
| 27. *Rhizophora stylosa** | T | ——— |
| **Family Rubiaceae** | | |
| 28. *Scyphiphora hydrophyllacea** | ST | ——— |
| **Family Sonneratiaceae** | | |
| 29. *Sonneratia alba** | T | ——— |
| 30. *Sonneratia caseolaris** | T | ——— |
| 31. *Sonneratia apetala** | T | ——— |
| Family Sterculiaceae | | |
| 32. *Heritiera littoralis** | T | ——— |
| Family Tiliaceae | | |
| 33. *Brownlowia lanceolata*** | ST/T | ——— |
| Family Verbinaceae | | |
| 34. *Avicennia alba** | T | ——— |
| 35. *Avicennia marina** | T | ——— |
| 36. *Avicennia officinalis** | T | ——— |
| 37. *Clerodendrum inerme* | S | ——— |

* Absolute bound to salt or brackish water (core mangrove species);

** Belonging to littoral vegetation and/or inland vegetation, making their appearance in back mangroves (mangrove associated vegetation).

S : Shrub; T : Tree; ST : Shruby tree; C : Climber.

1 : inundated by all tides; 2 : inundated by medium high tides; 3 : inundated by normal high tides; 4 : inundated by spring tides; 5 : occasionally inundated by exceptional tides.

## Hydrology :

During the present investigation four environmental parameters, namely, temperature, salinity, dissolved oxygen and pH of the study areas were measured during the field work (Figs. 8-10).

Atmospheric temperature varied from 23.4°C to 31°C, surface (soil) temperature from 27.8° to 35.3°C and temperature of surf water from 27.5° to 34.5°C. The important feature of these temperature readings was that surface (soil) temperature was always higher than atmospheric temperature during the field work. Further, in some mangrove areas of South Andaman (*viz.* Corbyn's Cove, Guptapara and Chidyatapu) burrow temperature of some fiddler crabs at about 10 cm depth was also recorded through the year round. Those burrow temperature varied from 28.1° to 31.5°C. The most

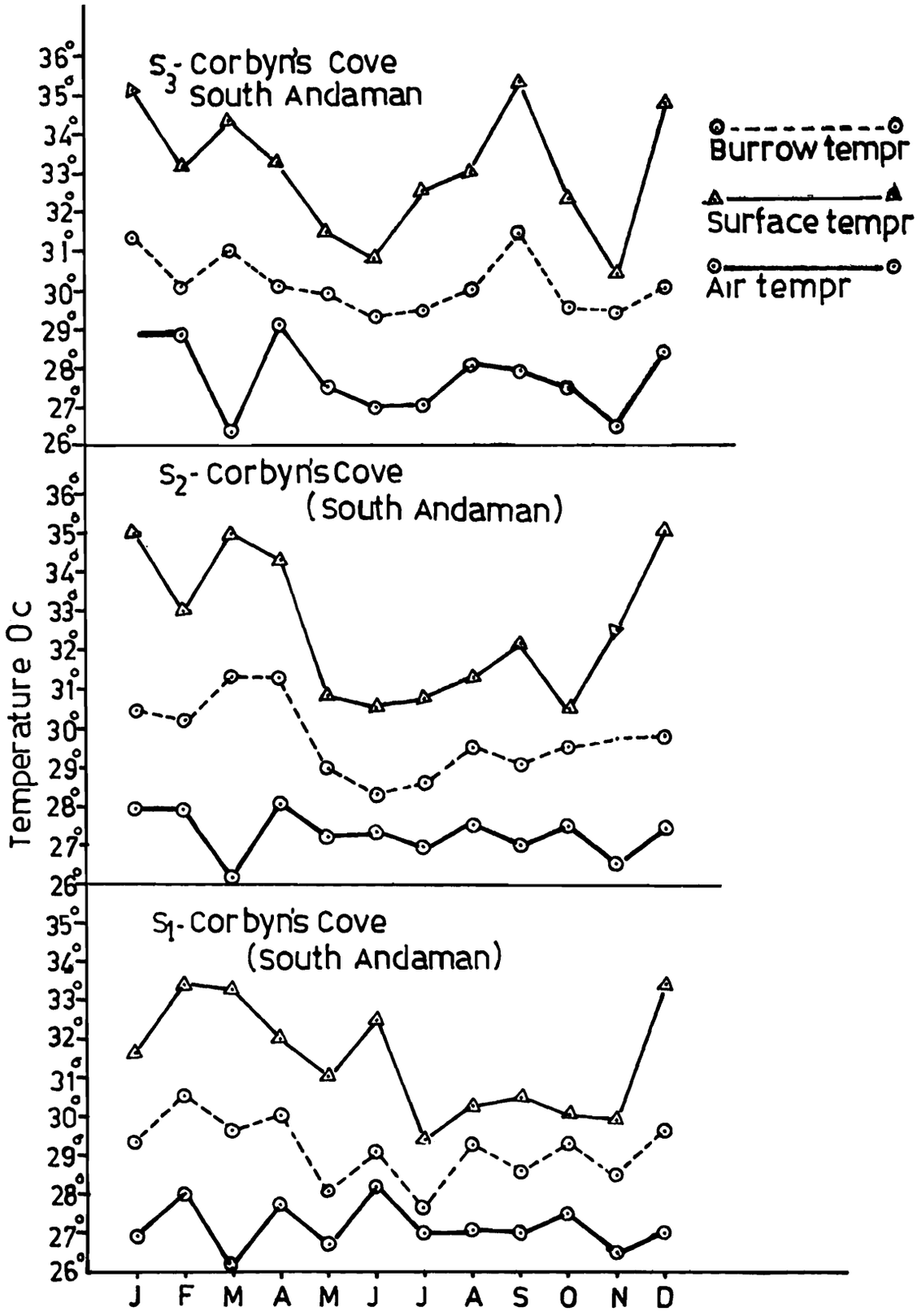



**Fig. 8.** Air, surface (soil) and burrow temperatures for 1982 in the three stations ($S_1$, $S_2$ & $S_3$) at Corbyn's Cove, South Andaman.

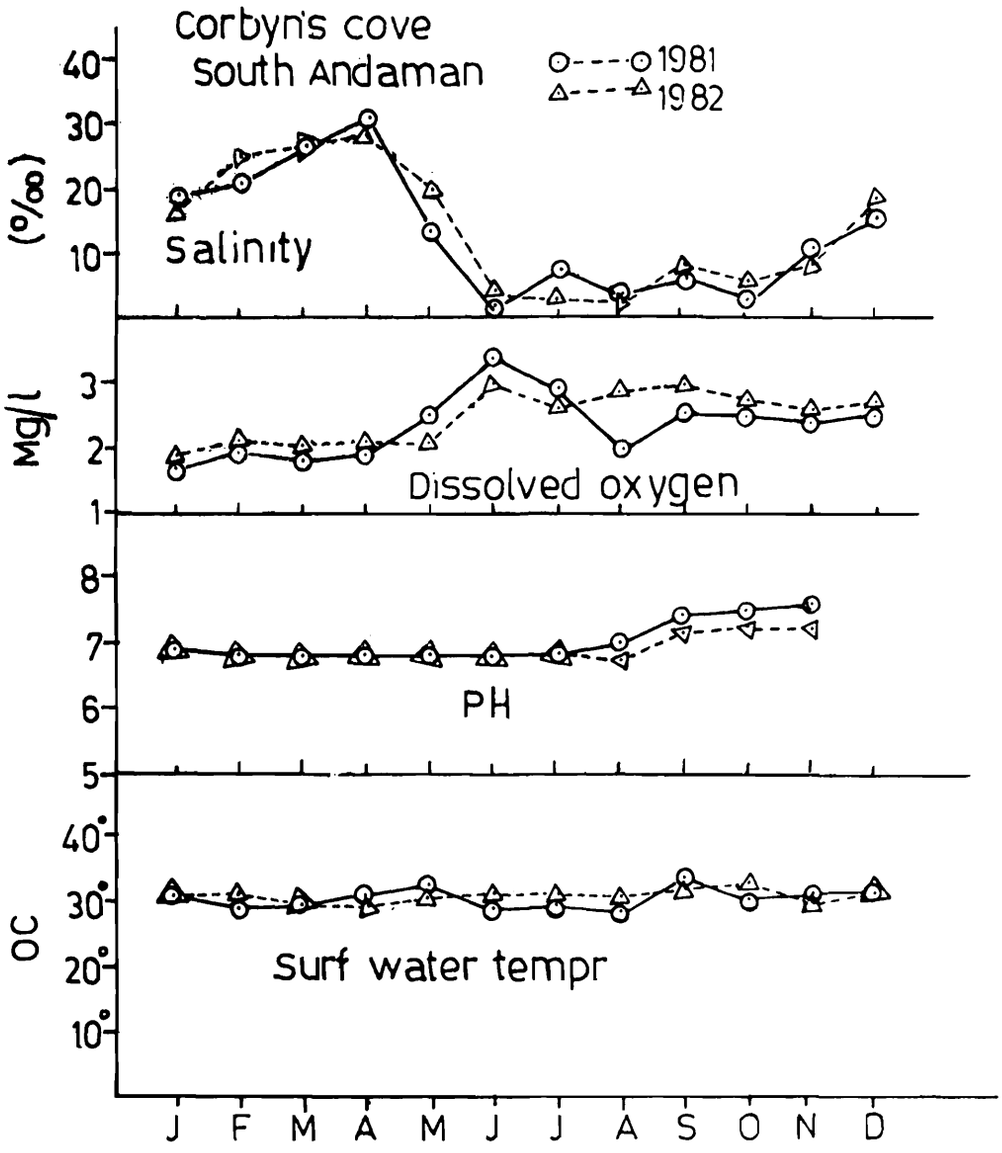



**Fig. 9.** **Surf water temperature, pH, dissolved oxygen and salinity for 1981 and 1982 at Corbyn's Cove, South Andaman.**

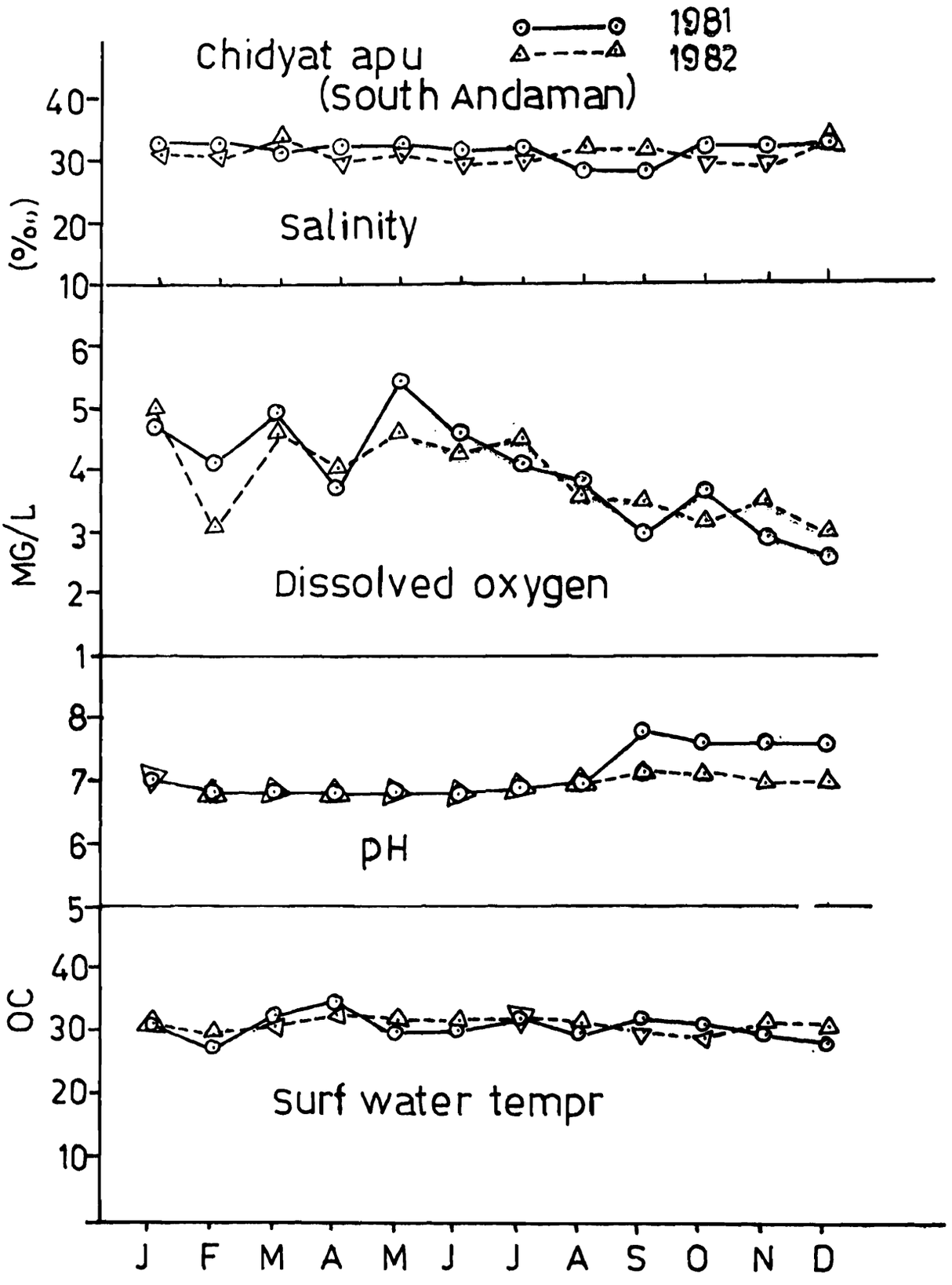



Fig. 10. Surf water temperature, pH, dissolved oxygen and salinity for 1981 and 1982 at Chydiatapu, South Andaman.

notable feature of the burrow temperature was that although it was lower than the surface (soil) temperature, still in most cases it was higher than prevailing atmospheric temperature.

Salinity of the estuarine areas of mangrove showed considerable fluctuation, ranging from 1.8°/oo to 31.8°/oo and that of the bays fringed with mangroves varied from 28.6°/oo to 33°/oo, showing very little fluctuation. Dissolved oxygen of the mangrove areas was very low, ranging from 1.70 mg/l to 5.40 mg/l in marine condition. Throughout the present investigation pH was found to fluctuate from 6.8 to 7.6 in estuarine condition and 6.8 to 7.8 in marine condition. All the data on hydrological parameters of the mangrove areas are featured in Figs. 9 & 10.

## MATERIAL AND METHODS

In all, 60 localities in the mangrove areas of both Andaman and Nicobar islands have been surveyed for the collection and study of mangrove fauna, particularly macrobenthos. The samplings were made from June 1978 to April, 1983. For qualitative analysis, studies were conducted in a transect on either side of the islands, covering three biotopes, 25 from mangrove biotopes, 10 from mangrove fringed creeks and 25 from mud flats, and rocky areas and coral reef flats adjacent to mangroves. A $1/10^2$ quadrat frame was forced into the mud to a depth of 15 cm (approx.) and the quadrat mud was sieved through 0.6 mm mesh screen. All the animals retained on the screen were sorted out and preserved in alcohol. Sometimes buffered formaldehyde was also used in the field.

The hydrological samples were collected from January, 1981 to December, 1982. The temperature was recorded by using Celsius thermometer; the salinity and dissolved oxygen of the samples were estimated by Mohr-Kundsen method and modified Winkler's method respectively. In the field, pH was measured by pH colour comparator disc using phenyl red screen and subsequently, in the laboratory by BIOCHEM digital pH metre. The two readings were found to be nearly concurrent. Rain fall and temperature data were collected from the meterological unit at Port Blair.

Infested mangrove logs and fruits procured from different mangrove areas of South Andaman islands were brought to the laboratory of the Zoological Survey of India at Port Blair for insectary studies. Some of the larvae and pupae were preserved in Pampel's fluid for further studies. The pattern of gallery formation by the larval forms was also noted. Infested logs

were kept inside galvanised iron chambers (70 cm × 37 cm × 37 cm) with one glass bottle on the top. Infested fruits were kept in glass jars (30 cm × 28 cm × 26 cm) with tops covered with mulmul and were examined daily at regular interval. Similar materials from places other than South Andaman were initially kept in the field laboratory, subsequently brought to Port Blair and then above mentioned procedure was followed.

## MANGROVE FAUNA

Mangrove ecosystem comprises the intertidal land area dominated by mangroves together with contiguous water courses, mudflats, rocky and coral reef flats (particularly in case of these Bay islands), backwater areas and their associated plant and animal species. Different schemes have been proposed for the description of the zonation of the mangroves and their associated fauna — some based on the physical features of the environment, namely, frequency of inundation or salinity with tidal flooding; others based on dominant mangrove genus (namely, *Rhizophora*- zone, *Bruguiera*-zone, *Avicennia*-zone, etc.) and some others on some 'key' biological types, (namely, Polychaete-zone, *Uca*-zone, Barnacle-Oyster-zone, etc.). Again, mangrove fauna, both qualitative and quantitative, can conveniently be studied by considering their horizontal distribution from land towards the sea using tidal height as primary parameter and vertical distribution from tree tops down to the soil.

Whether horizontally or vertically some zones are constantly or frequently inundated by tidal water. Whereas, some other zones, namely, supralittoral zone and the portion of the trees above the highest high water marks (generally upper portion of the trunk and canopy of tall mangroves) are never inundated. Therefore, one can demarcate the faunal communities in the mangrove formation broadly into aquatic, semi-aquatic and terrestrial types. Essentially being an intertidal area mangrove habitat is subjected to lack of vigorous water motion, active sedimentation of particles and a relatively sheltered location with high detritus content. It is a stressful habitat which makes the biota either to adopt to the wide range of environmental variations or else evolve a mode of life that will minimise the adverse effects (Perulekar, 1984).

The animals that are associated with the mangale, span a wide range invertebrates and vertebrates which, as pointed out earlier, include two major components — terrestrial and, aquatic and semi-aquatic. The

terrestrial faunal components mainly consist of mammals, birds, reptiles, insects and a few other groups which may either be resident or visitor. Aquatic and semi-aquatic faunal components, on the other hand, comprise planktons, and benthonic and necktonic animals which exploit the mangroves as habitat, nursery ground and source of food.

**Aquatic and semi-aquatic components :**

Planktons of Andaman mangrove areas are completely unattended. Only the fauna of the intertidal area of this ecosystem has been studied in some detail during the course of our present investigation.

The intertidal area and the floor of the mangrove fringed creeks provide diversified habitats for large number of organisms which collectively constitute benthos. These organisms can be categorised under three broad subheads — the micro-, meio- and macro-benthos, simply depending upon their ability to pass through sieves of some specified mesh-size. Accordingly, microbenthos include such animals which are not retained by a sieve of 40-60 μm mesh-size; meiobenthos are retained by the said sieve but can pass through the sieve of 600 μm mesh-screen, while macrobenthos are retained by the sieve of the last category (Mc Lusky, 1971).

Microbenthic organisms of the mangroves of these Bay islands have not been studied so far. On the other hand, Rao (1986) has studied the meiofauna of mangrove sediments in South Andaman and recorded nematodes, copepods, gastrotrichs, kinorhynchs, archeannelids, polychaetes and ostracods from those sediments (Table 9). Among these meiofauna, nematodes were found to be very common comprising 80% of the total fauna followed by copepods which comprise only 12%. Earler Rao (1980) studied the meiofauna of these islands from the beaches devoid of any mangrove. In such habitat copepods were found to be dominant element comprising 40% of the total fauna followed by annelids (20%). Nematodes represented only 10% of the total meiofauna.

Both qualitative and quantitative studies of macrobenthic forms have been carried out from the mangroves of these Bay islands during the present investigation. So far, 8 species of polychaetes, 100 species of molluscs, 59 species of crustacea, 6 species of echinoderms and 2 species of sipunculids have been collected and identified (Table 8). Furthermore, there are some nectonic forms, mainly fishes which are also found in the intertidal area.

Macrobenthos may be divided under two categories - the infauna and the epifauna, although there may be a considerable overlapping between the

two. Infauna includes such animals which burrow and penetrate the substratum while epifauna consists of those animals which move over the surface. Infauna may be further categorised into mud-burrowers and wood-borers and epifauna into mobile and sedentary epibenthos as dealt with by Das (1985). But, instead of following such classification for the discussion of benthic forms, the systematic classification of the mangrove fauna has been adopted here because, by such approach ecological differences among the allied species or groups can more clearly be demonstrated.

**I. Polychaetes :**

The mudflats and the burrows deserted by marine borers in the mangrove areas are found to be the ideal habitats for the polychaete worms. Eight species of polychaetes have been identified so far from the mangrove areas of these islands. Among them, *Marphysa mossambica* has been found to thrive in highly deoxygenated soil of Andaman mangroves. This species has also been reported from the mangrove swamps of the Sundarbans (Misra and Choudhury, 1985) as well as mangrove shore in South Africa (Macnae, 1968). *Eurythoe complanata, Eurythoe parvecarunculata, Perinereis nigropunctata, P. vancaurica, Namalycastis indica, Eunice aphroditois* and *Eunice* sp are the other 7 species occurring in the mangroves of these Bay islands.

Mention may be made that Radhakrishna and Ganapati (1969) recorded two species of polychaetes, namely, *Eurythoe parvecarunculata* and *Micronereis* sp from the mangrove zone of the Kakinada Bay. These polychaetes were found to occupy burrows made by the wood borers in the mangroves. Misra and Choudhury (1985) have recorded 30 species of polychaetes from the mangrove swamps of the Sundarbans. Among these, nereids, eunicids and capitallids were found to be the most abundant and the species, such as, *Dendronereis aestuarina, Dendronereides heteropoda, Namalycastis indica, Lumbrineris heteropoda, L. polydesma* and *Marphysa massambica* were most commonly encountered.

Polychaete worms were reported to be dominant benthic fauna at Mandovi estuary, Goa, where these worms constituted more than 80 per cent of the biomass (Dwivedi *et. al.* 1974). According to Sasekumar (1974) polychaete worms accounted for 30-50 per cent of the infauna of Malayan mangroves. In the two stations of South Andamans, however, polychaetes were found in large numbers but their biomass was not measured.

**II. Sipunculids :**

Two species of sipunculid worms have been found to inhabit the mangroves of Andaman island. These are *Phascolosoma arcuatum* and *Sipunculus inclusus*. Specimens of *Sipunculus inclusus* have been collected underneath the pebbles in sandy-muddy substratum among the thickets of *Rhizophora* forest at Chidyatapu (South Andaman). Halder (1977) recorded this species from Mayabunder (North Andaman) and Port Blair (South Andaman). Specimens of *P. arcuatum* has been found to occur in waterlogged muddy substratum of *Rhizophora* forest at Chidyatapu and *Avicennia* groves at Corbyn's Cove (South Andaman). Upto ten individuals in one square metre have been observed at Chidyatapu. Mention may be made that so far only one species, *Phascolosoma lurca* is known from mangrove. The said species was reported from Malay by Sasekumar (1974). Halder (personal communication) has also recorded *P. arcuatum* from the mangrove areas of Sundarbans.

**III. Mollusca :**

In the mangroves of the Bay islands molluscs are the dominant macro-benthos both qualitatively and quantitatively. So far, 66 species of gastropods, 32 species of bivalves and one species each of chiton and cephalopod have been collected from the mangrove areas of these islands (Table -8). Occurrence of such large number of molluscan species in this zone may be attributed to the fact that mangroves provide diversified ecological habitats where these animals can conveniently take shelter and multiply. It is worth-while to mention here that 20 species of molluscs have been reported from the Mahanadi estuary (Subba Rao and Mukherjee, 1969), 11 species of molluscs from the Godavari estuary (Ganapati and Rao, 1959), 9 species of molluscs from the Krishna estuary (Radhakrishna and Janakiram, 1975), 10 species of molluscs from the mangrove swamp of Machilipatnam, Andhra (Murthy and Balaparameswara, 1977), 6 species of molluscs around the mangroves of Palk Bay and Gulf of Mannar (Pillai and Appukuttam, 1980) and 10 species of molluscs from the Pichavaram mangrove, Tamilnadu (Kasinathan and Shanmugam, 1985). In the course of studying the malaco-fauna of Muriganga estuary, Sundarbans, West Bengal, Subba Rao *et. al.* (1983) recorded the occurrence of 8 species of gastropods from the mangroves areas.

In the Andaman mangroves molluscus are found to inhabit tree canopy, mangrove roots and stems, dead stumps, pebbles, rock surface, brackish water pool and muddy substratum. These are being dealt with as follows :

*Tree Canopy :*

This zone extends from mid-tide level to extreme highwater marks. *Littorina scabra scabra* (Fig. 11) occupies the highest zone on the tree surface and may reach more than 2.5 metres above the ground level. Just below this level *Cerithidea quadrata* (Fig. 12) may be found. This gastropod occurs towards supra-littoral zone and remains clinging to tree trunks.

*Dead stumps and mangrove roots :*

Dead stumps and logs which are often found lying in large numbers in the mangrove areas, support various groups of molluscs. Gastropods, like, *Onchidium tigrinum, O. verruculatum, Naquetia capucina* and *Nerita articulata* crawl on the surface of the wood. Both the species of *Onchidium* move up above the water level at high tide and go down to the moistened part of the tree when the tide recedes. There are also some bivalves, like, *Saccostrea cucullata* and *Crassostrea gryphoides* which are permanently attached with the wood-substratum. Predatory snails like *Thais hippocastanum* and *Drupa* sp are occasionally found on these encrusting bivalves (also among encrusting barnacles found in the same zone), which provide an easy source of food for these snails. A large number of gastropods belonging to the species - *Ellobium aurisjudae* (Fig. 13), *Ellobium gangeticum, Cassidula aurisfelis, Cassidula nucleus, Melampus castaneus* and *Melampus striatus* are found to occupy crevices and deserted burrows of the wood-borers.

On the stilt and prop roots of *Rhizophora* and pneumatophores of *Avicennia* gastropods, namely, *Nerita semirugosa, N. articulata* and *Thais hippocastanum* are often found to be attached. They may be either solitary or in cluster.

*Mudsurface :*

This zone extends from terrestrial part of the mangrove unaffected by normal tides to seaward fringe. Here, the physiography of the substratum varies and so also the fauna. On the clayey substratum, *Nassarius* (*Zeuxis*) *taenia, Cerithium corallinum* (Fig. 18), *Cerithium columna, Onchidium tigrinum* and *O. verruculatum* occur.

Substratum which are clayey to moderately firm in nature and which receives full sunlight has been found to be preferred by *Terebralia palustris* and *Cerithidea alata* (Fig. 17). *T. palustris* has been found to inhabit those

substrata which receive freshwater from nearby sources. The species also occurs in dark within the thickets of *Rhizophora* forests (Fig. 16) and *Avicennia* groves. On hard and rocky substratum this snail is normally not found except at Peel Island (South Andaman). However, this species of snail, found at Peel Island, was stunted in growth.

Among the cerithids, four species have been found to invade the mangroves. These are *Cerithium corallinum, Clypeomorus trailli, Rhinoclavis vertagus* and *R. aspera.* The first two species are found in muddy to sandy-muddy substratum, though they have been found to prefer muddy bottom. Generally, both the species occur together. Occasionally, *C. columna* has been found to occupy the higher zone in the crevices of boulders or on trunks and prop roots of mangrove trees. *Rhinoclavis vertagus* and *R. aspera* have so far been seen in sandy substratum in the mangroves of Barakhari (Rutland Island).

On open mudflats having sandy-muddy substratum, *Nassarius* (*Plicarcularia*) *globosus, Nassarius* (*Nassarius*) *immersa* and *Polynices tumidus* have been found to occur. *Nassarius* (*Zeuxis*) *taenia* occasionally takes shelter in the cracks and crevices already made by the molluscan wood borers, particularly the members of the family Teredinidae.

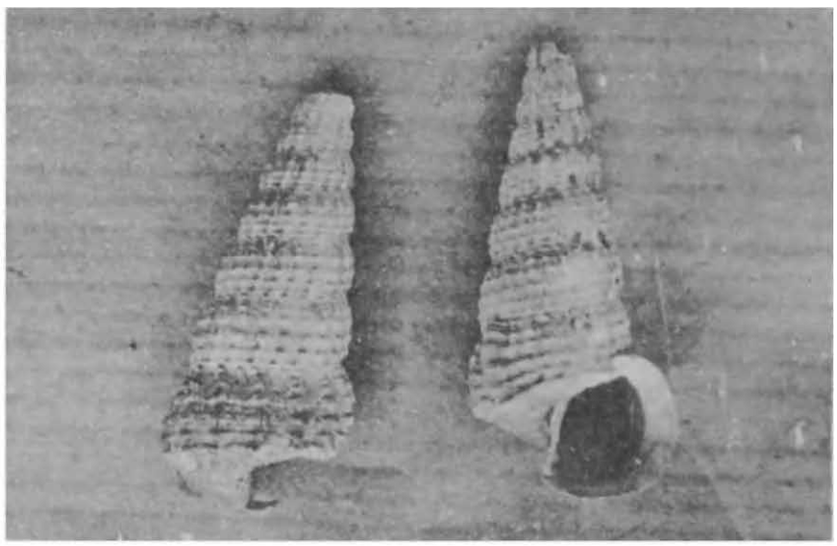
*Stenothyra hungerfordiana* usually occurs in small pools, on algae, decayed leaves and under bark of dead logs, lying on the ground where condition is typically estuarine. This species has also been found in large number in *Bruguiera* and *Rhizophora* forests of Little Andaman under estuarine conditions.

*Assiminea francesiae, A. brevicula* and *A. woodmasonia* have been found on the sandy mud and muddy substratum amongst algal mass. *A. woodmasonia* has so far been found to occur in Little Andaman only in estuarine condition in association with *S. hungerfordiana.* The other two species, *A. francesiae* and *A. brevicula* have been found to occur in marine condition.

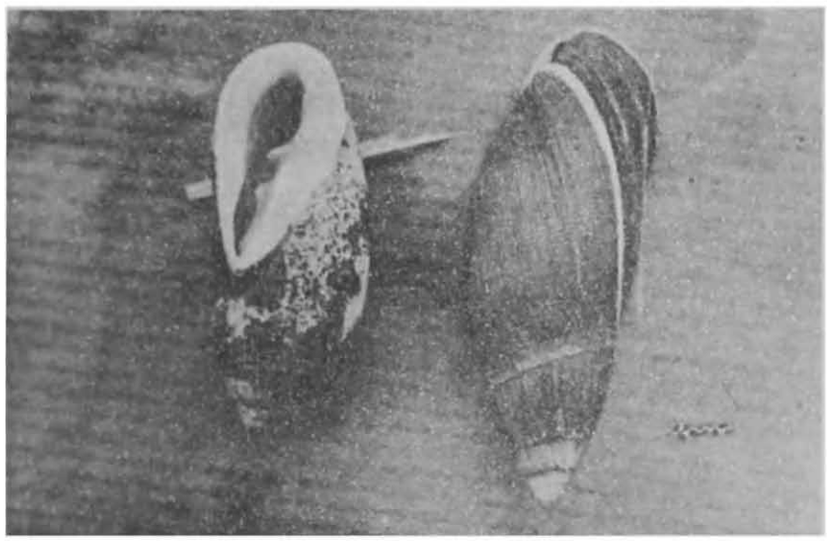
Distribution of various species of the family Neritidae in the mangroves are very interesting. *Nerita semirugosa* has been found to occupy the highest zone and occurs on tree trunks and stilt roots of *Rhizophora* spp upto a height of 1.5 meters above the ground. *Nerita articulata* inhabits at a lower height to the extent of about 1.0 meter above the ground. At a still lower height, about 10.0 cm above the ground, *Nerita planospira* occurs. The other species like *Nerita polita, N. squamulata, N. chamaeleon* and *N. albicilla* occur on the sandy habitats and stones and pebbles.

Figs. 11-15. Mangrove molluscs

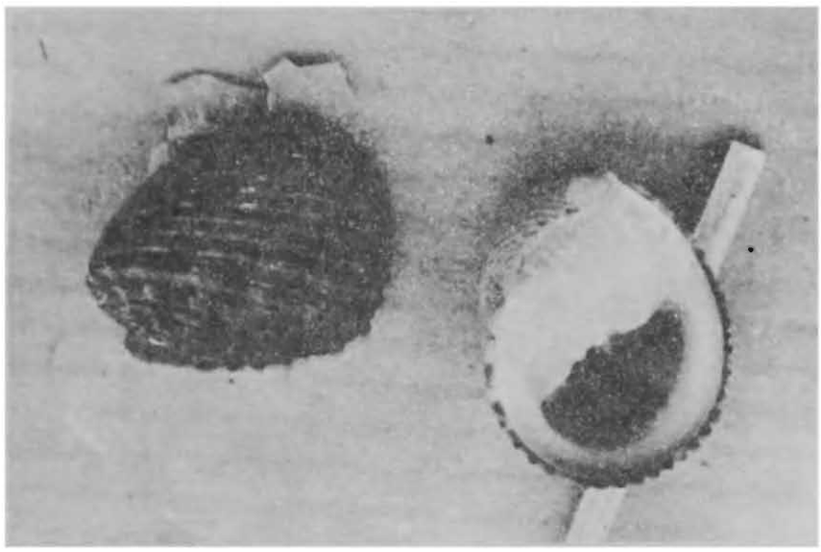
11. *Littorina scabra scabra*, usually occupying highest zone on tree surface.



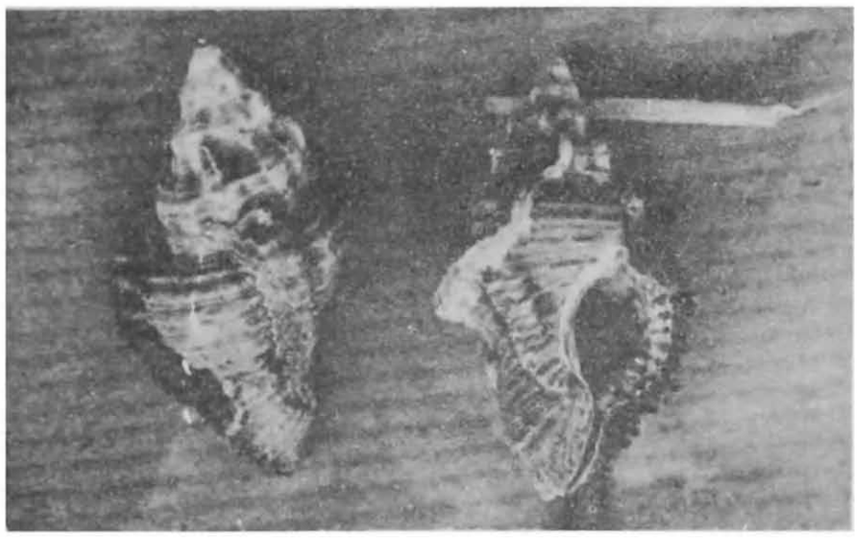
12. *Cerithidea quadrata*, usually cling to mangrove trees above supra littoral zone.



13. *Ellobium aurisjudae,* commonly met in Andaman mangroves.



14. *Nerita costata,* usually found in mangroves near rocky shores.



15. *Naquetia capucina,* usually found in mangroves near rocky shores and coral reefs.

Fig. 16. Thick population of *Terebralia palustris* in *Rhizophora* thickets in Peel island, during low tide.

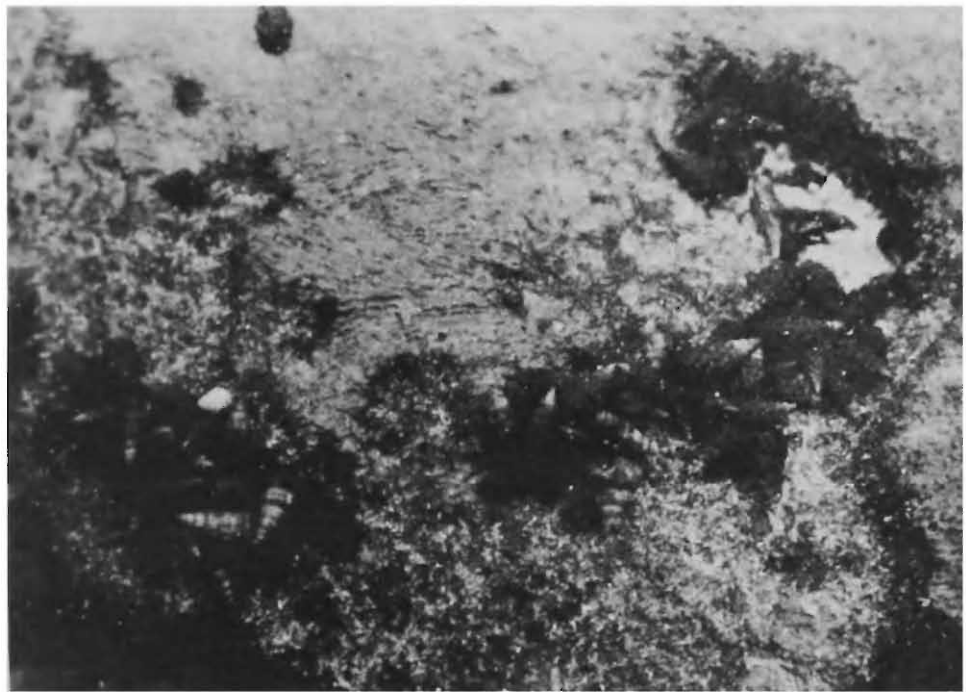


Fig. 17. *Cerithidea alata* in clusters in the mangroves of Peel island, during low tide.

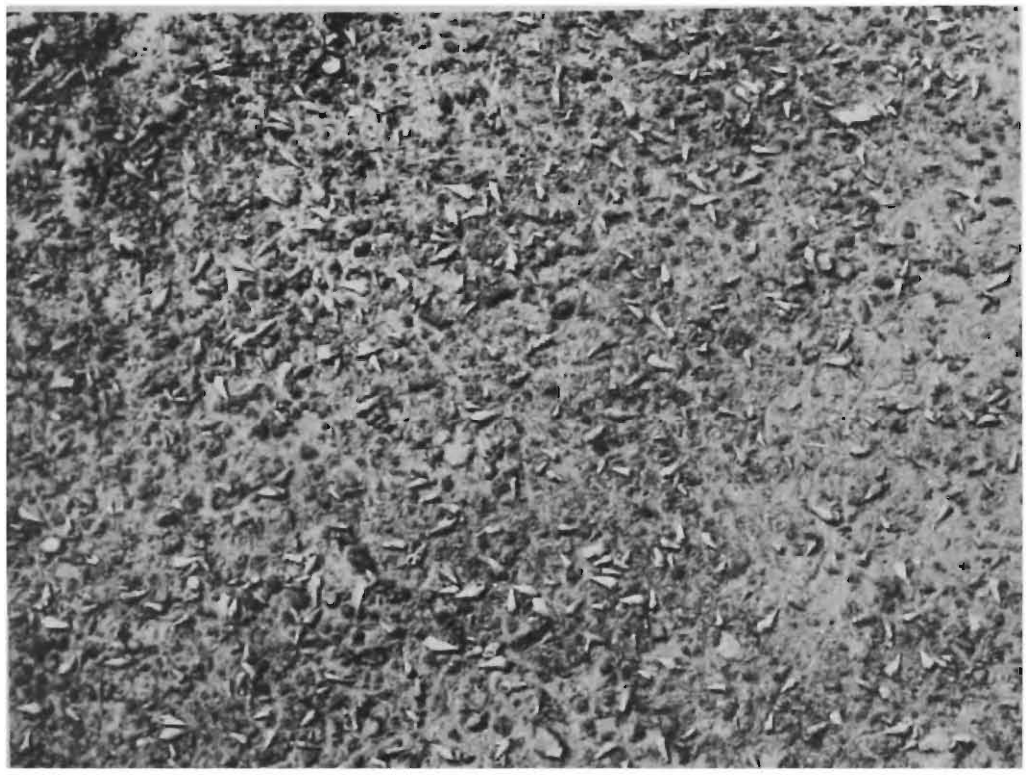


Fig. 18. *Cerithium* sp. in open mudflats near the mangroves of South Andaman.

*Neritina* (*Dostia*) *violacea* has been found to crawl on the mud at ebb tide. Occasionally, these snails may be seen attached to logs in pools and under bark of dead logs. *Neritina* (*Neripteron*) *auriculata* has been collected under bark of logs and also in pools under above conditions. *Neritina* (*Vittina*) *variegata* and *Pseudonerita sulculosa* occur under bark of dead logs. *Neritina* (*Vittina*) *variegata* has also been collected within the sheaths of *Nypa fructicans*. *Clithon bicolor* from *Rhizophora* groves of Rangachang (South Andaman) and *Neritina* (*Vittina*) *turrita* from *Avicennia* groves of Carbyn's Cove (South Andaman) have also been recorded but these were obtained only on one occasion and hence, further collections are needed to substantiate their occurrence in mangrove ecosystems. *Clithon corona* occurs in almost fresh water condition in the mangroves of Little Andaman. Some species like *Nerita polita*, *Neritina* (*Vittina*) *variegata* and *Clithon corona* exhibit strong polymorphism. Snails belonging to the species, *Thiara tuberculata* has been found to occur in estuarine condition in Little Andaman.

The gastropod, *Pythia plicata* has been found abundantly among the crevices of dead corals towards the supralittoral part of Havelock Island (South Andaman). The Periwinkle, *Littorina undulata* clusters in large number on the logs or any other hard substratum towards the lower level.

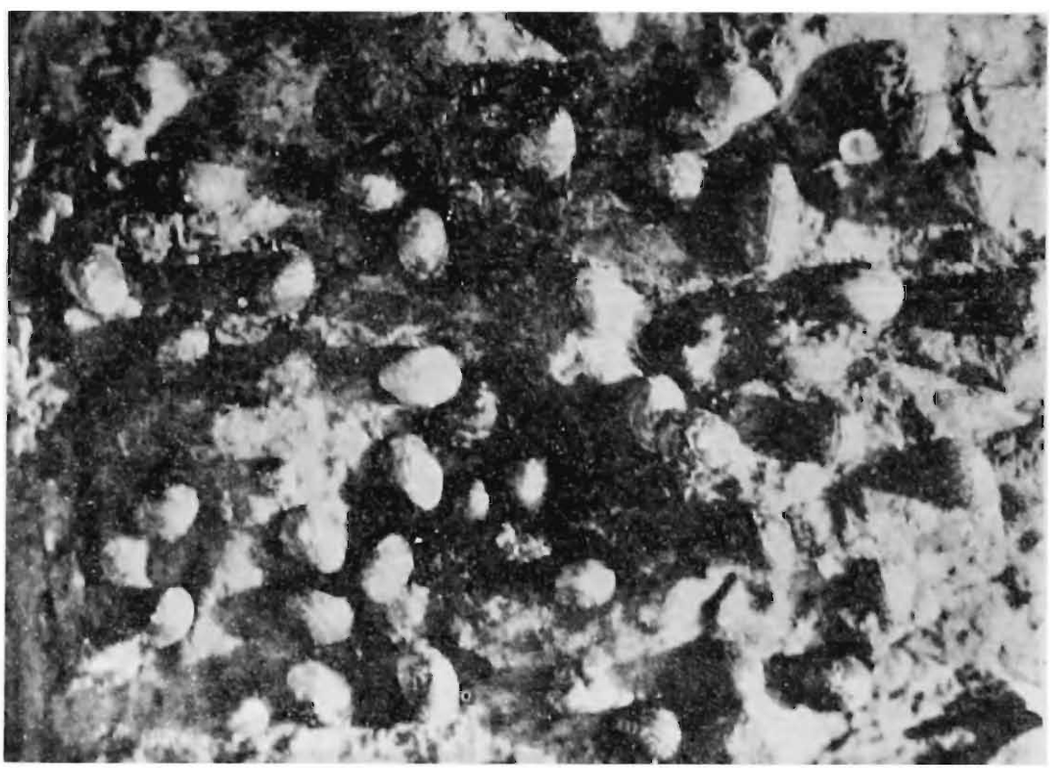


Fig. 19. *Nerita* sp. in thick aggregates in the mangroves of South Andaman.

Frequently, on the dead and decayed roots and dead stump some nudibranchs are found to crawl, the identification of which is in progress. This is to mention that Edmunds (1964) reported thirteen species of Eolid nudibranchs from the mangrove roots in Jamaica.

*Octopus* sp is the only species of cephalopods found so far in the mangrove areas of these islands. These animals were found to take shelter under dead corals during low tide. Frequently, mangroves which stretch towards coralline shores are inhabited by a group of molluscs which are typically marine in nature. At such shores of Barakhari (Rutland Island), Chidyatapu (South Andaman), Neil Island and Aereal Bay (Diglipur, North Andaman) species like *Monodonta labio, Turbo porphyrites, Nerita costata, Naquetia capucina, Planaxis sulcatus, Cronia ochrostoma, Cronia (Ergalatax) contracta, Morula anaxeres, Muricopsis bombayanus, Engina alveolata, Mitra scutulata* and *M. paupercula* have been found to occupy different niches amongst the pebbles and rocks (Figs. 14, 15, 19). Sometimes they make zonations, with *Nerita costata* on the top, followed by *Planaxis sulcatus* and then others. Sometimes the chiton, *Ischnochiton winckworthi* remains adhered to the pebbles at Chidyatapu (South Andaman) at undersurface within the mangrove ecosystem.

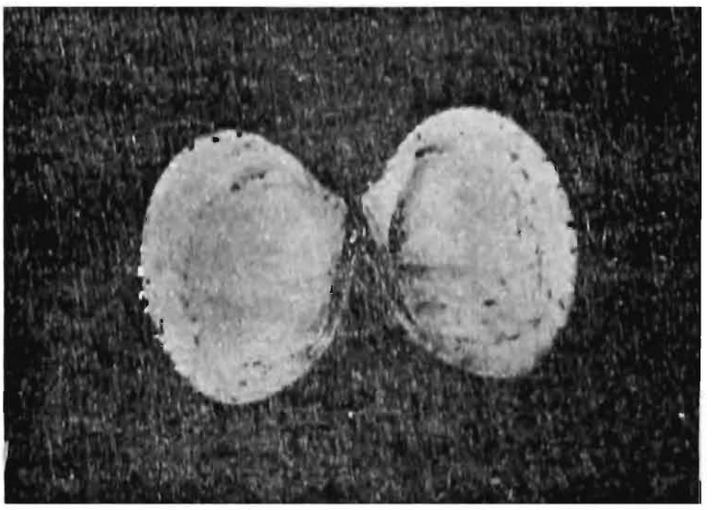
Occasionally gastropods, like *Strombus erythrinus, Strombus variabilis, Chicoreus brunneus* and even *Lambis lambis* enter the mangroves during the high tide probably in search of food and shelter.

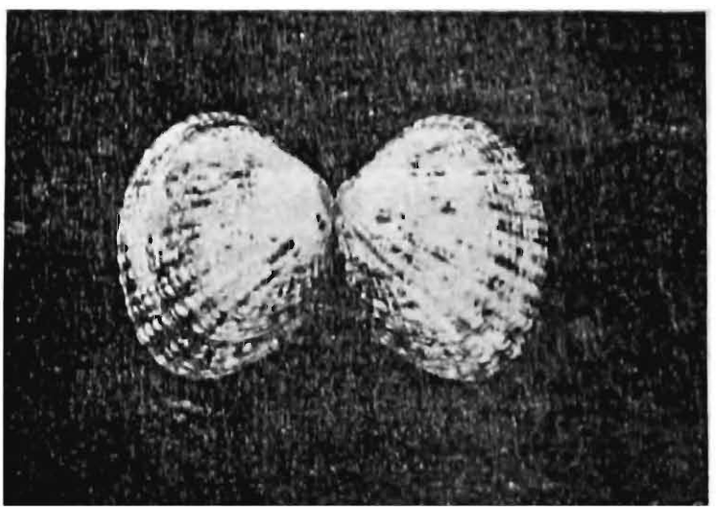
Nine species of bivalves have been found to occur in muddy habitats of mangroves. These are *Batissa inflata, B. similis, Geloina galatheae, G. siamica, Gafrarium tumidum* (Figs. 20-21), *Paphia malabarica, Dosinia tumida, Codakia tigerina* and *Anadara granosa.* The first four species which belong to the family Corbiculidae very often remain fully burried under mud. The same is also the case with the venirid bivalves, namely, *G. tumidum, P. malabarica* and *D. tumida.* In Sippighat mangrove areas and its adjacent swamp, *Perna viridis* and *Placuna placenta* are available. Further, Daniel and Rajagopal (1974) reported the occurrence of *Donax cuneatus, Donax lubricus* and *Meretrix attenuata* between the littoral fringes at Campbell Bay, Galathea Bay and Casurina Bay of Great Nicobar.

*Sessile molluscs :*

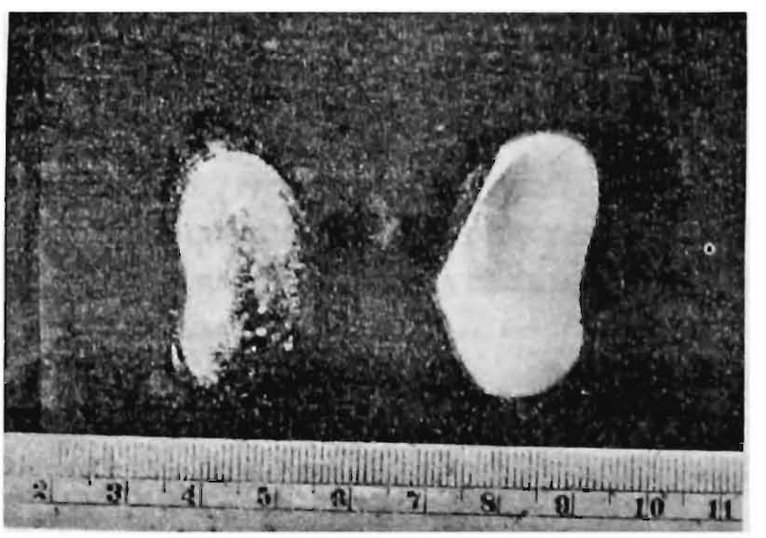
The settlement of fouling organisms on the underwater structures in inshore and offshore waters of Andaman islands is reported to be rich and varied (Karande, 1978). By exposing the test panels at five different sites in

Figs. 20-22. Mangrove molluscs





20-21. *Gafrarium tumidum*, mud burrowing bivalves of Andaman mangroves.



22. *Barbatia helblingii*, bivalve usually associated with mangrove foulers.

various depths of near shore and offshore waters in Port Blair for 30 months, Karande (1978) recorded polyzoans, barnacles, cirripides and ascidians as fouling organisms. During the present investigation the authors have encountered large number of sedentary animals, encrusted on the roots and trunks of many living mangroves as well as dead stumps. Many of those forms are also found to remain attached permanently on stones or rocks, lying in the mangrove areas.

Bivalves, namely, *Isognomon ephippium, Barbatia helblingii* (Fig. 22), *Modiolus striatulus* and *Saccostrea cucullata* (Fig. 23) are the common forms, sometimes thickly covering the roots and stems of the mangroves. *Crassostrea madrassensis, Crassostrea gryphoides* (Fig. 24) and *Arca* sp are often found to remain cemented on the stones and rocks within the mangrove areas.

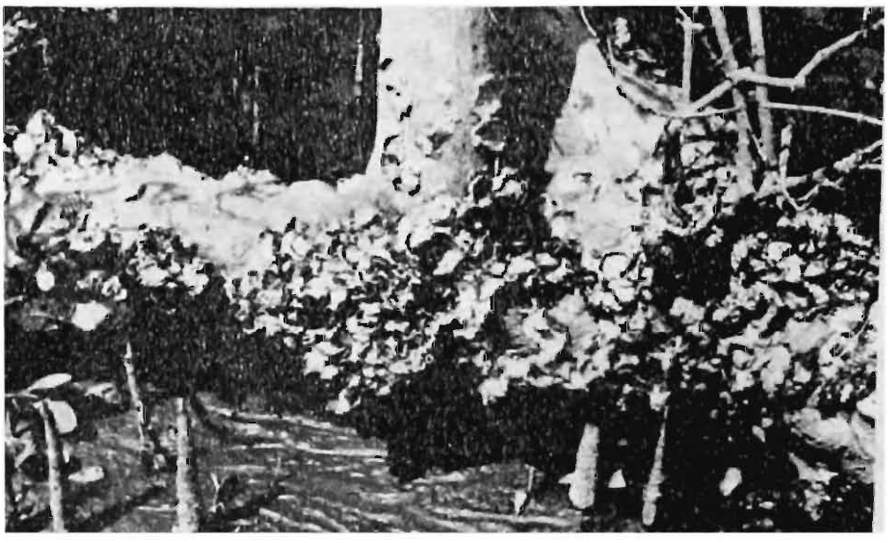
Other than molluscs, animals like barnacle (*Balanus amphitrite*) (Fig. 25) and serpulid worms (Fig. 26) are often found as sedentary forms in the mangroves of South Andaman.

*Wood-boring molluscs :*

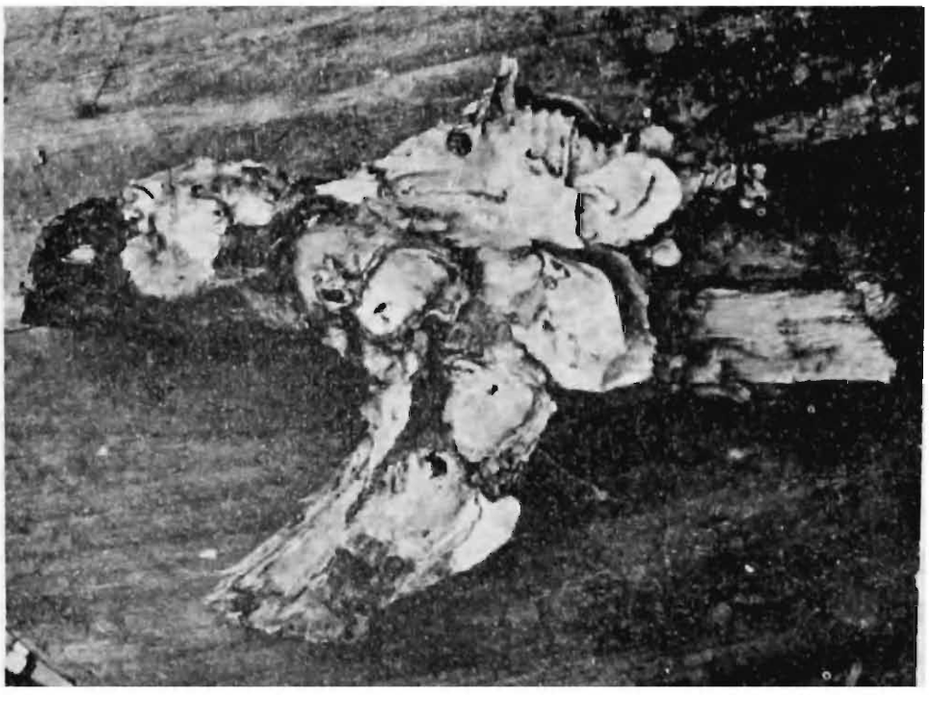
Wood-boring molluscs consist of teredinids (shipworms) and pholadids (piddocks) which cause considerable damange to living and dying mangroves as well as other wooden structure lying in the mangrove areas of Indian coasts and Bay islands. Each group of borers has its own ecological niche ensuring efficient use of the habitat. Thus, while piddocks occupy the surface of the wood (Figs. 29, 30), shipworms penetrate it deeper and deeper and their tunnels extend more and more even up to the heartwood (Figs. 27, 28). The tunnels of shipworm are zigzag in most of the cases, possessing calcareous lining and their growth continues as long as space is available. The maximum width of the tunnel is found near the shell. The tunnel gradually tappers towards the region where the pallet lies (Fig. 27). A small piece of mangrove log may contain several hundreds of these animals with the result that it becomes riddled entirely (Fig. 28). In the tunnel of piddocks calcareous lining is absent (Fig. 30). The molluscan borers drill into the wood for protection only as their food consists of planktonic organisms.

The marine wood borers of mangroves of the Bay islands have been dealt with in some details by Das (1985), Das and Dev Roy (1980, 1981, 1984 a, b), Tiwari *et al* (1980) and, Dev Roy and Das (1985). In the course of said investigations 10 species of teredinids and one species of pholadid

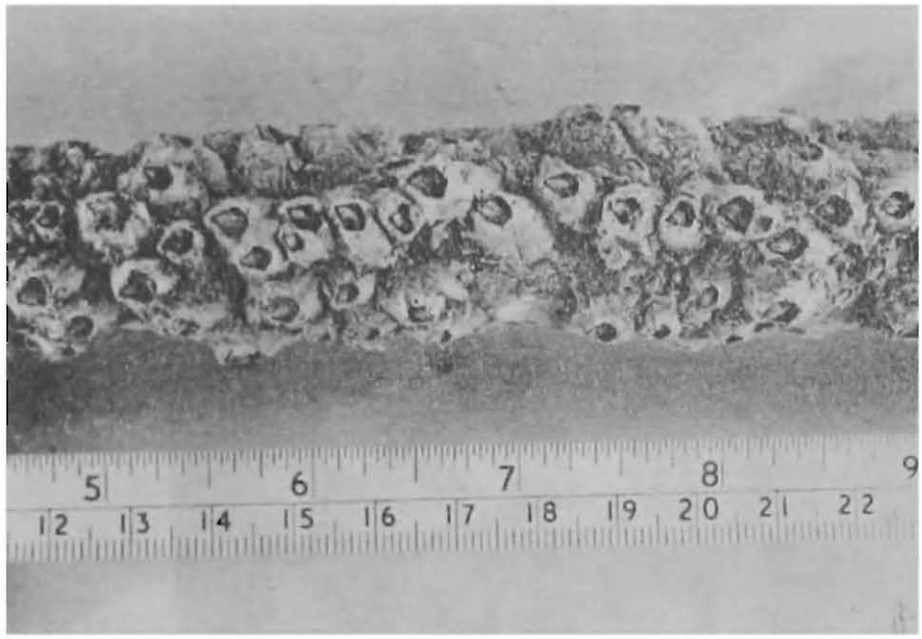
Figs. 23-26. Mangrove foulers



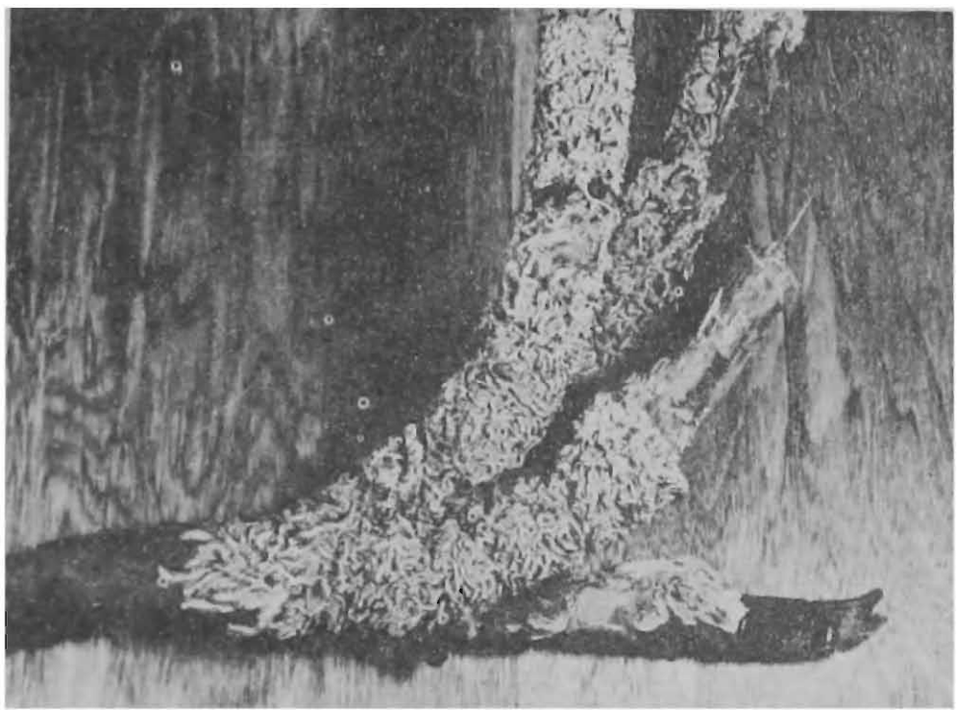
23. *Saccostrea cucullata* in South Andaman



24. *Crassostrea* sp. in Great Nicobar




25. *Balanus amphitrite* in Great Nicobar



26. Serpulid worm, *Pomatoceros* sp

Fig. 27. Tunnels of teredinid borers

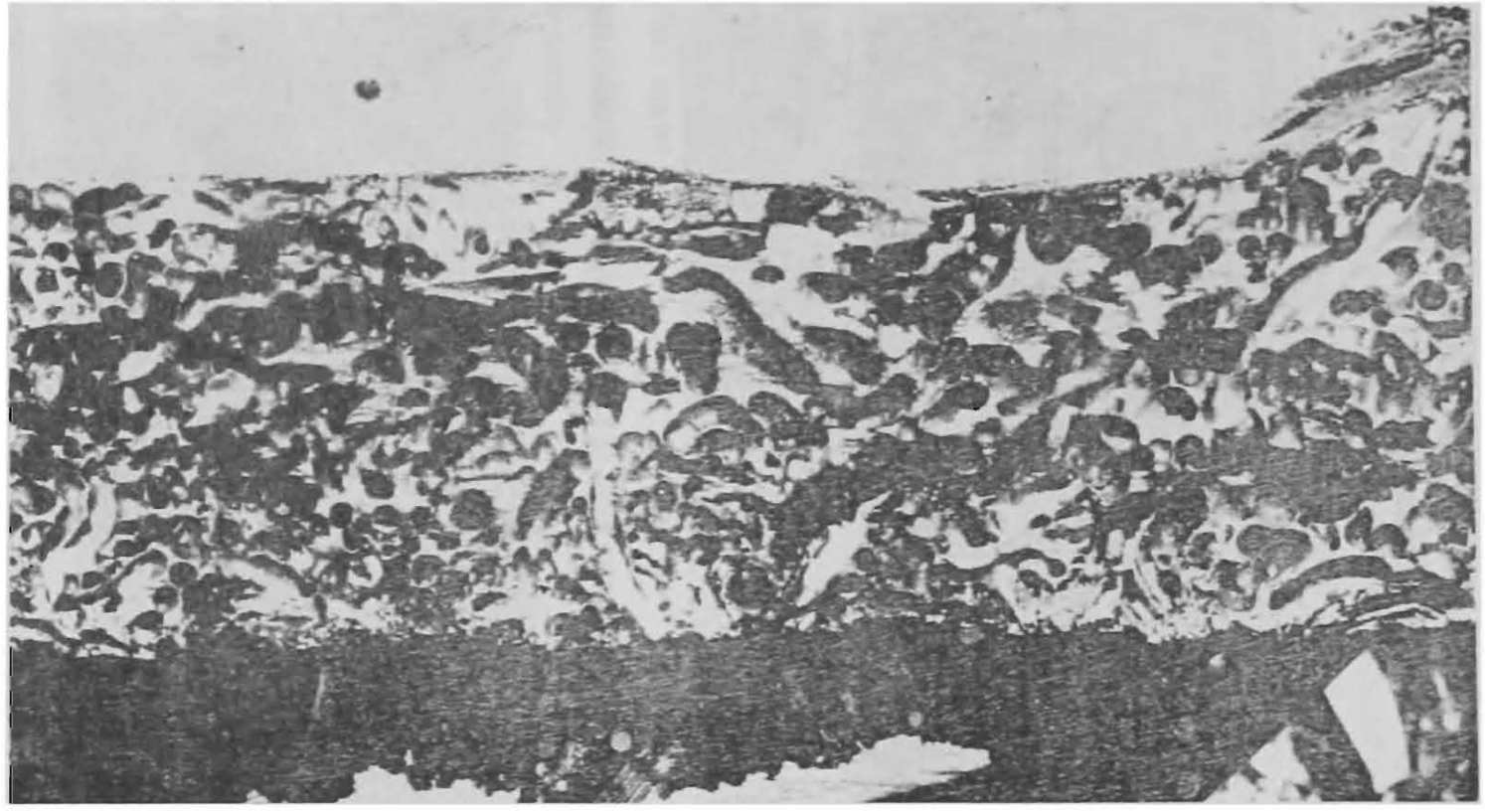


Fig. 28. Mangrove log riddled by teredinid borers (caleareous lining of some tunnels visible)

have been recorded from the mangrove areas of North, Middle, South and Little Andamans, Ritche's Archepelago, Car Nicobar, Camorta and Great Nicobar.

Among the 10 species of teredinids, 6 species, namely, *Teredo furcifera, Nausitora hedleyi, Bankia bipennata, Bankia rochi, Nototeredo edax* and

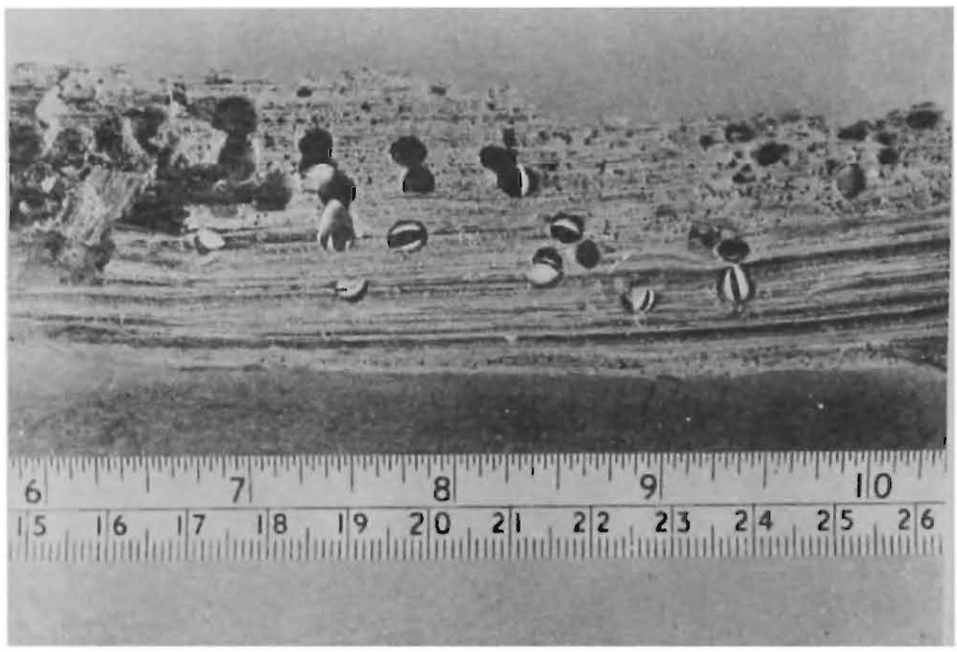


Fig. 29. Drift wood in the mangrove areas of Campbel Bay, Great Nicobar affected by *Martesia striata*

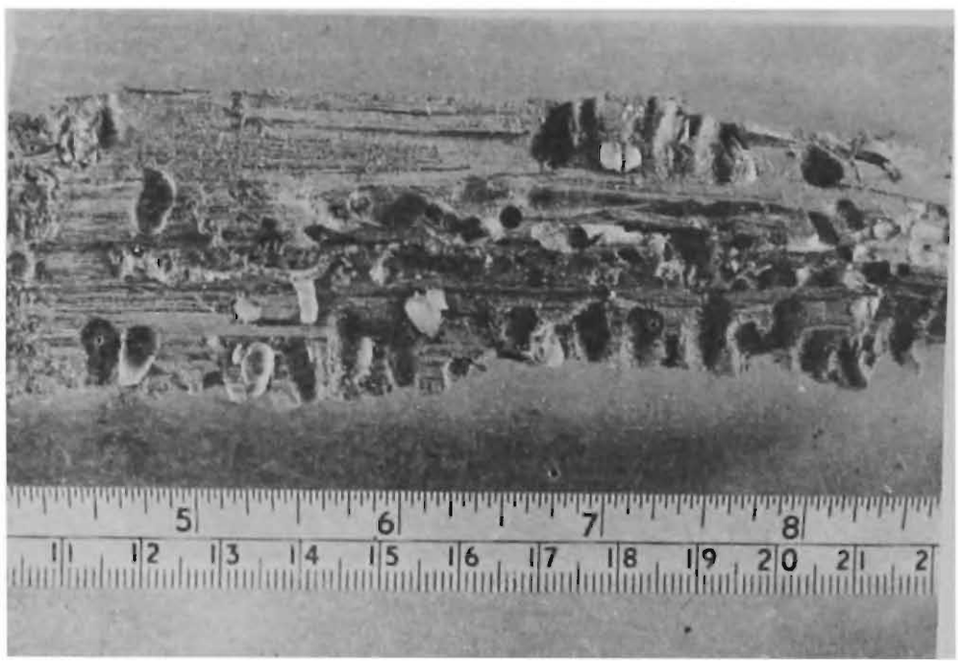


Fig. 30. L.S. of mangrove stumps, affected by *Martesia striata*

*Uperotus rehderi* are reported so far from Andaman mangroves only, while 4 species, namely, *Bactronophorus thoracites, Dicyathifer manni, Lyrodus pedicellatus* and *Nausitora dunlopei* have been recorded from the mangrove areas of both Andaman and Nicobar islands. *Martesia striata* is the only species of pholadid found from the mangroves of these islands. Mention may be made here that from Indian mangroves 19 species of shipworms and 3 species of piddocks have been reported so far (*see* Santhakumaram, 1985 b and Rao, 1986).

Occurrence of marine wood borers and their relative abundance in the mangrove areas of these Bay islands are as follows (Table. 1) :

TABLE - 1. Relative abundance of marine wood-borers in mangroves of South Andamans.

| Borer species | * Relative abundances on | | | |
|---|---|---|---|---|
| | Living mangrove trees | | Dead mangrove stumps | |
| MOLLUSCA | Andaman | Nicobar | Andaman | Nicobar |
| *Bactronophorus thoracites* | — | — | A | A |
| *Dicyathifer manni* | — | — | C | C |
| *Uperotus rehderi* | — | — | VR | — |
| *Teredo furcifera* | — | — | VR | — |
| *Lyrodus pedicellatus* | — | — | C | C |
| *Nototeredo edax* | — | — | VR | — |
| *Nausitora hedleyi* | — | — | C | — |
| *Nausitora dunlopei* | — | — | VR | C |
| *Bankia bipennata* | — | — | C | — |
| *Bankia rochi* | — | — | R | — |
| *Martesia striata* | — | — | R | C |
| CRUSTACEA | | | | |
| *Sphaeroma terebrans* | A | A | A | A |

* Based on average number of at least ten samples. VR: Very rare (upto 5 specimens); C : Common; A : Abundant (above 51 specimens); –: Not recorded.

** Isopods, namely, *Sphaeroma triste, Cirolana parva, C. elongata* and one species of amphipod, *Melita zeylanica* have been collected from mangrove logs of Little Andaman, but their boring activities are not ascertained. Hence, these are excluded from the list.

Among the teredinid borers, *Bactronophorus thoracites* is the most abundant and destructive species which causes considerable damage to the mangroves of these islands except in Great Nicobar from where this species has not yet been reported (see Dev Roy and Das, 1985). Besides, *Dicyathifer manni, Lyrodus pedicellatus, Bankia bipennata* and *Nausitora hedleyi* are very common in the mangale of Andamans. The first two are common in Nicobars also. *Nausitora dunlopei* has so far been found in the mangroves of Little Andaman (Das and Dev Roy, 1984 a), Car Nicobar (Tiwari *et al,* 1980) and Great Nicobar (Dev Roy and Das, 1985) in the areas of very low salinity (0.6°/oo to 2.5°/oo).

During the course of present investigation no teredinid borer has been found to infest any living mangrove stems in these islands. Only dead stumps, roots and logs of mangroves have been found to be attacked by these borers. In Great Nicobar, however, live pneumatophores and cable roots of the mangroves, *Sonneratia alba,* were found to be infested with teredinid borers (Dev Roy and Das, 1985). These borers were too immature to be identified even upto generic level. It is every probable that nature of attack, extent of damage and agents causing destruction to mangroves differ from region to region. In the Sundarbans Roonwal (1954 a, b; 1966) observed heavy infestation of teredinid borers in the living mangroves whereas Subba Rao (1968) found such infestation in the living mangroves only in a few instances. Further, Sivics (1928), Moll (1939), Ganapati and Rao (1959), Santhakumaran and Pillai (1974), Nair and Dharmaraj (1980 a, b), Santhakumaran (1983, 1985 a) and Rao (1986) have recorded several species of teredinids attacking live mangrove trees at different places of India and abroad.

The present investigation also reveals that there is no host-plant specificity or host-plant preferences for these borers.

The data available elsewhere also corroborates our findings. The species assemblage of these borers in a particular abode seems to be random. This observation, however,. is not in conformity with that of Rajagopal (1964 b) who reported some wood preferences of the teredinid borers to the 'kind of trees they attack' in the West Bengal part of the Sundarbans.

The effects of marine foulings on the wood borers in the mangrove areas of these Bay islands have also been observed during the present investigation. As mentioned earlier, bivalves of different species cover thickly the roots and stems of mangroves at the undersurface. Among those bivalves,

TABLE - 2. Showing species-assemblage of molluscan wood-borers in a particular abode in South Andaman.

| Locality | Habitat | Nature of species assemblage in particular abode |
|---|---|---|
| Chidyatapu | Dead stumps of mangroves | 1. *Lyrodus pedicellatus* and *Nausitora hedleyi* |
| | — do — | 2. *Lyrodus pedicellatus* and *Bankia bipennata* |
| | — do — | 3. *Lyrodus pedicellatus* and *Bactronophorus thoracites* |
| | — do — | 4. *Lyrodus pedicellatus, Bactronophorus thoracites, Nausitora hedleyi* and *Nototeredo edax* |
| Rangachan | Dead stumps of mangroves | 1. *Nausitora hedleyi* and *Bactronophorus thoracites* |
| | — do — | 2. *Nausitora hedleyi,* and *Bankia bipennata* and *Bactronophorus thoracites* |
| | — do — | 3. *Nausitora hedleyi, Dicyathifer manni, Bactronophorus thoracites* and *Lyrodus pedicellatus* |
| Wright Myo | Dead stumps of mangroves | 1. *Nausitora hedleyi* and *Bactronophorus thoracites* |

*Isognomon ephippium* and *Modiolus striatulus* are common and abundant. Further, there are barnacles (*Balanus amphitrite*) (Fig. 23), tubicolus polychaetes (Fig. 24) and bryozoa which also densely cover the mangroves of underwater surface. These organisms inhibit the settlement of borers either by serving as mechanical barrier for shipworm larvae or by utilising them as food as mentioned by many workers in the past (*see* Nair and Saraswathy. 1971).

Mention may be made here that first publication on the wood boring molluscs of mangroves of India, causing extensive damage dates back to 1954 when Roonwal reported the occurrence of a teredinid borer, *Bactronophorus thoracites* as a 'pest' of the Sunderban mangroves. Since then, there have been many reports (mostly during the eighty's) on the incidence of several species of wood borers in different mangrove areas on east and west coasts of India as well as of Bay islands (*see* Santhakumaran, 1985b, Rao, 1986). The following are the marine wood borers (both molluscs and crustaceans) from different mangrove areas along Indian coasts and Bay islands.

| Species | MANGROVE AREA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4* | 5 | 6 | 7 | 8 | 9 |
| 1. *Bactronophorus thoracites* | + | + | + | | + | - | + | - | + |
| 2. *Bankia bipalmulata* | - | - | + | | - | - | - | | - |
| 3. *Bankia bipennata* | - | | | | | - | - | - | + |
| 4. *Bankia campanellata* | + | + | + | | + | + | + | - | - |
| 5. *Bankia carinata* | - | + | + | | + | + | + | - | - |
| 6. *Bankia fimbriatula* | - | + | - | | - | - | - | - | - |
| 7. *Bankia nordi* | + | - | - | | - | - | - | - | - |
| 8. *Bankia rochi* | + | + | + | | | - | + | + | + |
| 9. *Dicyathifer manni* | + | + | + | | - | + | + | + | + |
| 10. *Lyrodus massa* | - | - | - | | - | - | + | - | - |
| 11. *Lyrodus pedicellatus* | - | + | + | | + | + | + | - | + |
| 12. *Nausitora dunlopei* | + | + | + | | - | - | + | - | + |
| 13. *Nausitora fusticola* | - | + | - | | - | - | - | - | - |
| 14. *Nausitora hedleyi* | - | + | - | | + | + | + | - | + |
| 15. *Nototeredo edax* | - | - | + | | - | - | - | - | + |
| 16. *Nototeredo knoxi* | - | + | - | | - | - | - | - | - |
| 17. *Teredo clappi* | - | - | - | | - | - | - | + | - |
| 18. *Teredo furcifera* | - | - | + | | + | + | - | - | + |
| 19. *Teredora princesae* | - | + | - | | - | + | - | - | - |
| 20. *Teredothyra excavata* | - | - | - | | - | + | - | - | - |
| 21. *Teredothyra smithi* | - | - | - | | - | + | - | - | - |
| 22. *Uperotus rehderi* | - | - | - | | - | - | - | - | + |
| 23. *Martesia striata* | - | + | + | | + | + | + | - | + |
| 24. *Martesia* sp | - | - | - | | + | + | + | - | - |
| 25. *Barnea biramanica* | - | - | - | | + | - | - | - | - |
| CRUSTACEA | | | | | | | | | |
| 26. *Sphaeroma terebrans* | - | - | + | | + | + | + | - | + |
| 27. *Sphaeroma annandalei* | - | - | + | | + | + | + | - | - |
| 27a. *Sphaeroma annandalei* var *travancorensis* | - | - | + | | - | - | + | - | - |

## IV. Crustacea :

Within mngroves, crustaceans are represented by prawns, amphipods, isopods, stomatopods, hermit crabs, procellanid crab and brachyuran crabs.

*Prawns and shrimps :*

In the mangrove ecosystem prawns are found in creeks, puddles, dead logs and also under stones. *Palaemon coneinnus, Palaemon debilis, Penaeus semisulcatus, Penaeus indicus, Metapenaeopsis coniger. Caridina brachydactyla, Caridina gracilivostris* and *Acetes* spp have been collected from the mangroves of these islands. A bulk of collection remains still unidentified and the number of species would invariably go up once the identification is complete. Alpheid prawns, *Alpheus* sp are frequently found in the mangroves of these islands. These are more abundant particularly in *Rhizophora* forests. These prawns make a characteristic 'click' sound. Some prawn species enter the crevices of logs and a few species occupy burrows of dead teredinid borers.

Gravid prawns have been found throughout the year, indicating thereby that they breed in mangroves. Juveniles of peneid prawns use mangroves as their nursery grounds.

Further, fishermen of South Andaman are sometimes found to catch many prawn species from the mangrove fringed creeks and bays of the islands, namely, *Penaeus canaliculatus, Penaeus indicus, Penaeus monodon, Penaeus merguiensis, Metapenaeus dobsoni, Metapenaeus affinis* and *Metapenaeus brevicornis.*

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N.B. Three species of isopods, namely, *Sphaeroma triste, Cirolana parva* and *C. elongata* and one species of amphipod, *Melita zeylanica* collected from logs *Rhizophora* spp in Little Andaman are not included in the list, as their boring activities are not ascertained (Das and Dev Roy, 1984a).

* Genera *Bactronophorus, Lyrodus, Teredo* and *Sphaeroma* have been recorded from this area (Krishna estuary) without mentioning any specific name of the borers.

Areas : (1) Sundarbans, West Bengal (Roonwal, 1954 a, b, 1966; Rajagopal 1961, 1964 a, b); (2) Mahanadi estuary, Orissa (Subba Rao, 1968); (3) Godavari estuary, Andhra Pradesh (Ganapati and Rao, 1959; Rao, 1986); (4) Krishna estuary, Andhra Pradesh (Rambabu, Prasad and Balaparameswara Rao, 1985); (5) Pichavaram, Vellar-Coleroom estuarine system, Tamil Nadu (Nair and Dharmaraj, 1980b, Srinivasan and Chandramohan, 1973); (6) Talapady estuary and its surrounding backwaters, Karnataka (Dharmaraj and Nair, 1981; Rao, 1986); (7) Mangroves near Goa area (Santhakumaran, 1983, 1985a); (8) Mangroves near Bombay Harbour (Santhakumaran and Pillai, 1974); (9) Mangroves in Bay islands (Das, 1985; Das and Dev Roy, 1980, 1981, 1984 a, b; Dev Roy and Das, 1985; Tiwari *et al.* 1980).

*Isopods and amphipods :*

Four species of isopods, namely, *Sphaeroma terebrans, S. triste, Cirolana parva* and *C. elongata* have been recorded from the mangrove areas of these islands. Among these, only *S. terebrans* causes extensive damage to the mangroves. Although the other three species have been collected from the damaged logs of *Rhizophora* spp lying in different mangrove areas of Little Andaman, still their wood boring activities could not be ascertained by the present authors. Further, boring activities of these isopods have never been established by any previous workers also.

*S. terebrans,* on the other hand, can burrow into live as well as dead mangroves and other dead stumps lying in the mangrove areas (Figs. 31-32). The burrows are cylindrical and at right angle to the surface, about 5.0-5.5 mm in diameter and 2.5-8.5 mm in depth (Das and Dev Roy, 1984a). These isopods cause severe damage to live prop roots of *Rhizophora* spp, particularly at Guptapara, Sippighat and Wright Myo at South Andaman and Magar Nallah in Great Nicobar (Dev Roy and Das, 1985). They are also seen to be very active in North and Little Andamans. They also bore live pneumatophores of *Sonneratia* sp and *Avicennia* sp at Chydiatapu and Rutland island (South Andaman) as well as Little Andaman (Das and Dev Roy, 1980; 1984a). In Great Nicobar this species of isopod is reported to attack live knee roots of *Bruguiera gymnorhiza* in large numbers in Magar Nallah, where salinity was 0.6°/oo at the time of investigation (Dev Roy and Das, 1985). In Little Andaman, this isopod was collected at varying salinities, ranging from 5.15°/oo to 32°/oo (Das and Dev Roy, 1984a). Mention may be made here that Mc Neil (1932) reported this species from the freshwater of Brisbane river. In Bay islands attack of this species of isopod has been found to be concentrated more towards the intertidal level, a few centimetres above the mud line, on the concave sides of the prop roots. From the logs selected at random in the mangrove areas of Little Andaman, Das and Dev Roy (1984a) have noted 37 holes and 400 hundred nymphs and adults (on average) of *S. terebrans* per 5 $mm^2$ area.

*S. terebrans* is provided with mandibles which accomplish the process of boring. It bores into the wood for shelter. Breeding appears to be continuous in these islands. The developmental stages of this isopod are completed within the prop roots, and youngs on reaching the maturity start boring activity afresh.

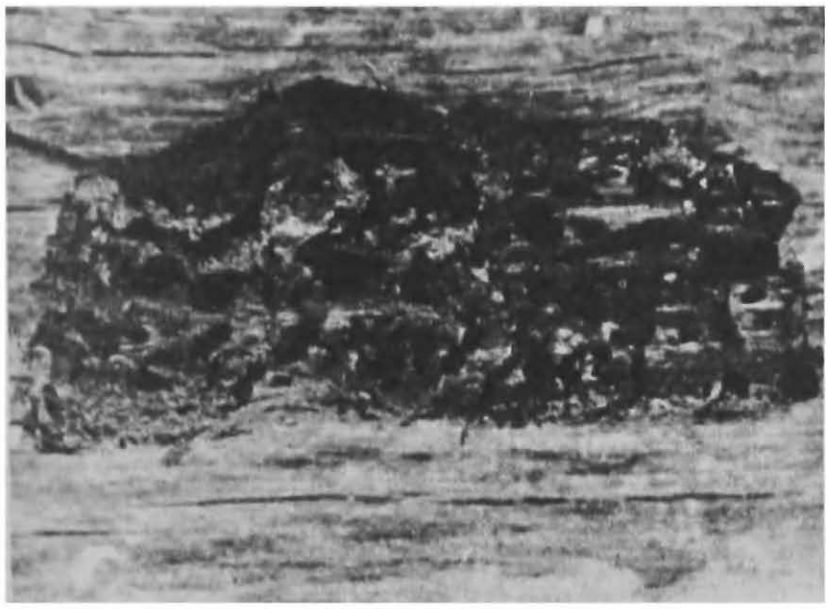


Fig. 31. Mangrove stumps infested by crustacean borer. *Sphaeroma terebrans*

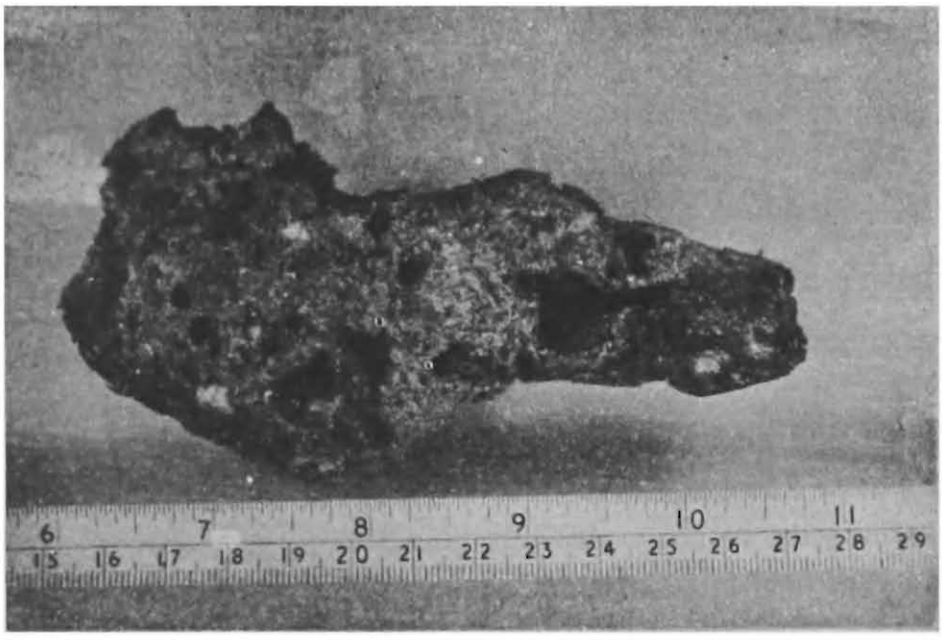



Fig. 32. Live knee root of *Bruguiera gymnorhiza* affected by *Sphaeroma terebrans*.

One species of amphipod, namely, *Melita zeylanica* has been found in the mangroves of Little Andaman. The authors were not able to study the habit of this amphipod, although in one occasion it was found to scrape the surface of the submerged timber in the Kerala backwater (Pillai, 1967). John (1955) has studied the physiology of digestion of this species in detail and established that by some sort of browsing action it can reduce wood to fine powder. *M. zeylanica, Cirolana elongata* and *C. parva* were collected from the logs lying in the brackishwater in the mangrove areas of Little Andaman, having 5.15°/oo salinity while *Sphaeroma triste* was collected in 32 °/oo salinity. It may be mentioned that Myers (1985) has reported the occurrence of *Melita zeylanica* from the mangrove litter of Fiji.

*Stomatopods :*

Among the stomatopods two species belonging to the genus *Gonodactylus* have been found to invade mangroves of these islands. At high tide *Gonodactylus chiragra* (Fig. 33) enters the mangroves and at ebb tide it may be found under stone, pools and puddles of this ecosystem. The second species of *Gonodactylus* (Fig. 34) which is yet to be identified has been extracted from pneumatophores of *Sonneratia alba* at Chidyatapu (South Andaman) and in the left over burrows of marine borers. Stomatopods in dead teredinid burrows have been found in *Rhizophora* log at Havelock Island and Little Andaman. The only stomatopod known from the mangroves elsewhere is *Squilla choprai* (Tweedie, 1935) from Malaya.

*Procellanid crabs :*

These small anomuran crabs are found under stones and dead corals from mid tide level to highwater mark in the mangroves of Andaman island. The species, *Petrolisthes lamarckii* has been found on the shingle shores at Corbyn's Cove and Chidyatapu. During the present study some biological observations were made on this species, which reveal that berried females were found throughout the year. The egg mass contained 14-99 eggs. Eggs are circular in shape and their size varied from 476 to 666 μm in diameter. Mention may be made here that Sankolli (1966) reported berried females of *P. lamarckii* from August to May at west coast of India.

*Brachyuran crabs :*

Rich communities of brachyuran crabs inhabit the mangrove shores of the Bay island. They form a major component of the macrofauna of Andaman mangrove shores and occur almost throughout the intertidal zone,

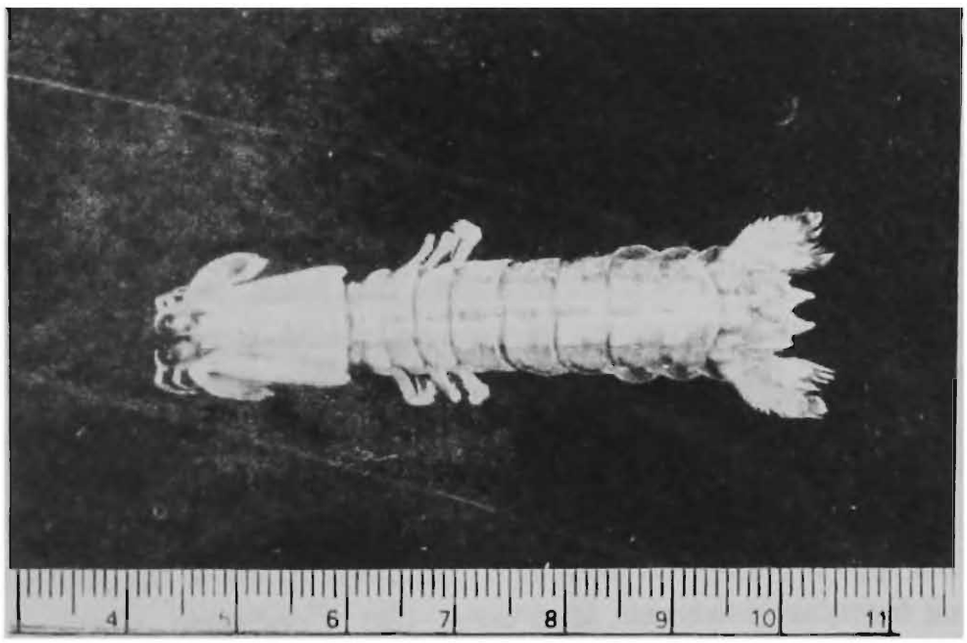


Fig. 33. *Gonodactylus chiragra*

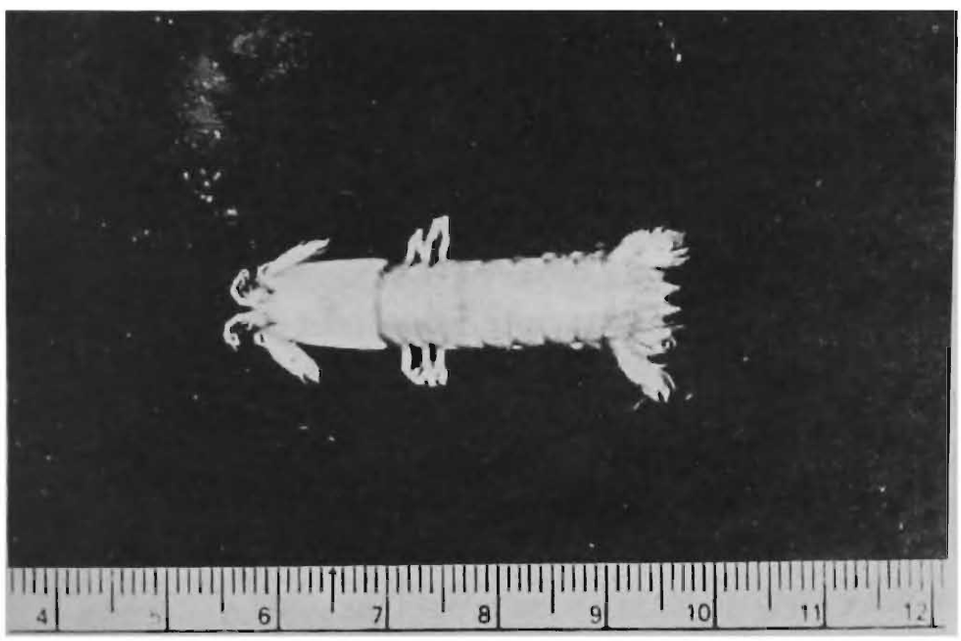


Fig. 34. *Gonodactylus* sp.

displaying their abundance in the zone from mean low tide level to mean high water level of spring tides. In all, 31 species of brachyuran crab have been observed in the mangroves of Andaman and Nicobar islands. These crabs belong to the families Portunidae, Grapsidae, Ocypodidae, Mictyridae, Xanthidae and Gecarcinidae, comprising 18 genera, namely *Uca, Ocypode, Dotilla, Macrophthalmus, Grapsus, Metopograpsus, Sesarma, Metasesarma, Metaplax, Portunus, Thalamita, Scylla, Charybdis, Mictyris, Epixanthus, Pilumnus, Baptozius* and *Cardisoma.* They occupy various ecological niches, such as, crevices of mangrove logs, tree holes, under stones and puddles, cracked pneumatophores, burrows and creeks. Some of these crabs are zoned across the shore in distinct species-groups. For example, *Macrophthalmus* occurs on the lowest zone of the shore, well below the mangrove tree zone. Above this zone *Metaplax* as well as some species of *Uca* (*U. vocans*) are found. From about mid-tide level and upwards fiddler crabs (*Uca* spp) are found to dominate. *Sesarma* occurs in the landward mangrove forest zone whereas land crabs, like *Cardisoma carnifex* are found at the landward edge and well into the terrestrial zone.

*Ocypodid crabs :*

The family Ocypodidae are represented by seven species, namely, *Ocypode ceratophthalmus, Uca lactea lactea, Uca dussumieri spinata, Uca vocans, Uca tetragonon, Dotilla myctiroides* and *Macrophthalmus convexus. Ocypode ceratophthalmus* (Fig. 39) is essentially a sand dwelling species. But these crabs often penetrate mangrove zones during the high tide particularly during the night. These crabs have been collected from mangroves in Chidyatapu and Corbyn's Cove (South Andaman). In Neil Island, during the high tide, these crabs were found in hundreds near the edge of water on the sandy beach fringing with mangroves. These crabs make burrows in sandy flats and in muddy sand areas adjacent to the mangroves between the High Water Spring Tide (HWST) and High Water Neap Tide (HWNT). Burrows of the adult crabs are circular at the top with diameter extending up to 75 mm. These burrows are generally deep, sometimes descending more than a metre from the surface. Burrows of the juveniles are found in the areas wetted by all tides, their depth ranged from 8 to 25 mm.

*O. ceratophthalmus* is a noctural species but their juveniles are seen during the day. These crabs are adapted to use rich micro and meiofauna of the habitat, though they may prey on macrofauna including other species of crabs, *e.g. Uca* sp and *Thalamita* sp. At Inhaca Island, Africa, Hughes

(1966) observed the cannibalistic habit of this species, apart from its foraging, scavenging and predatory feeding.

Four species of fiddler crabs, namely, *Uca lactea lactea* (Fig. 35), *U. dussumieri spinata* (Fig. 36), *U. tetragonon* (Fig. 38) and *U. vocans* (Fig. 37) occur in the mangrove areas of these islands. Each species constructs and occupies a burrow at dusk or prior to flooding by tide. These crabs display an interesting pattern of distribution in the mangroves. In unshaded region, that is, in the open mudflats and coral reef-flats, bordering mangroves distribution of *Uca* seems to be related to the sediment or soil grade. Whereas, in the shaded cover, particularly in the shores of the creeks fringing with mangroves the substratum is more or less uniform. In such condition the degree of vegetation cover and tidal level seem to influence the distribution of *Uca*.

In unshaded region of mangrove areas, *U. lactea lactea* prefers firmer substratum with fine grained texture, having an appreciable admixture of sand and mud. It prefers sand flats bordering mangrove and also banks of small channels within mangroves, having muddy sands. *U. dussumieri spinata* on the other hand, occurs in open mud flats having coarse substratum with little per centage of sand and *U. tetragonon* is found to occur in coarse substratum in the shaded areas of mangroves (at Chidyatapu in South Andaman), occupying crevices of stones, dead corals or shelly conglomerate with muddy sand substratum at the bottom. They are also found in the burrows constructed under the roots of sparsely distributed mangroves, namely, *Rhizophora* spp and *Bruguiera* spp in the said area. *U. vocans* prefers soft, muddy bank of the substratum in some places.

In the shaded areas of the mangroves *U. lactea lactea* prefers well drained substratum and partial shade. Therefore, this species is not usually found below Mean High Water Neaps (MHWN) on mangrove shores. But *U. dussumieri spinata* avoids vegetation cover and consequently prefers to occupy shore position below MHWN. The third species of fiddler crabs, *U. vocans* is occasionally found near low tide level.

Mention may be made here that 4 species of fiddler crabs namely, *Uca lactea annulipes, U. dussumieri dussumieri, U. triangularis bengali* and *U. acuta acuta* have also been reported from the mangrove areas of the Sundarbans (Chakraborty and Choudhury, 1985 and Mandal and Misra, 1985). Distribution of fiddler crabs in relation to substratum, vegetation and salinity has been worked out by Teal (1958), Kerwin (1971), Macintosh (1977, 1982, 1984) and Miller and Mauer (1973).

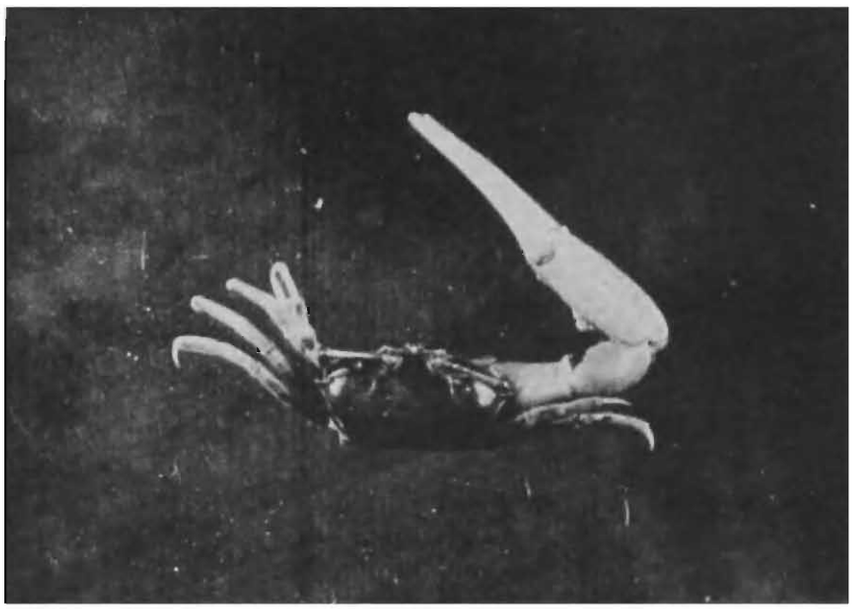


Fig. 35. Fiddler crab: *Uca (Celuca) lactea lactea*

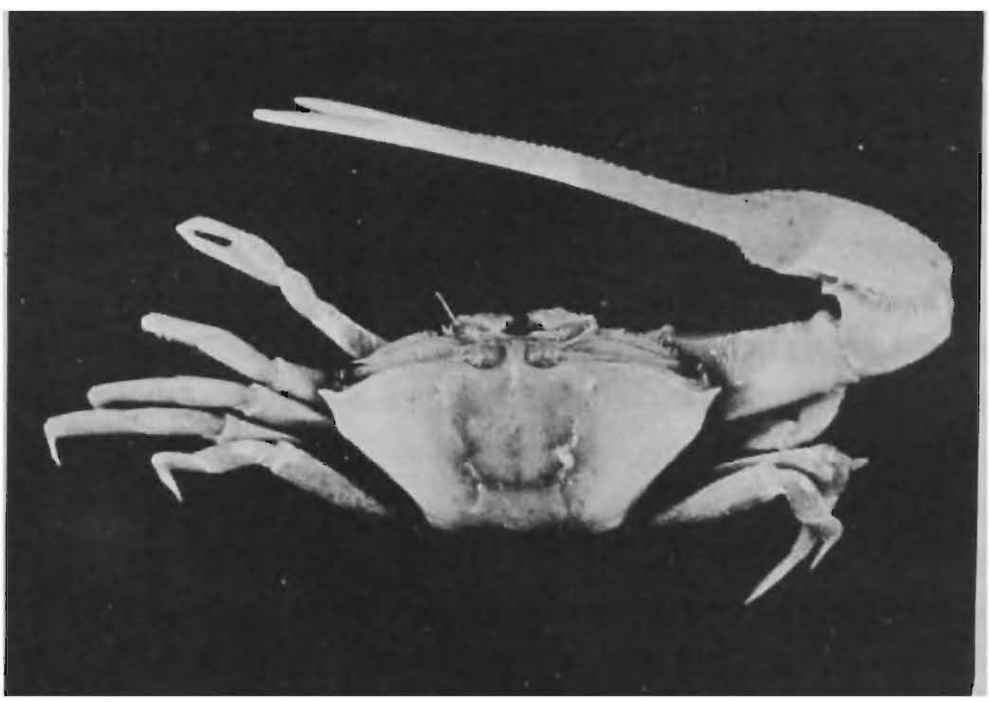


Fig. 36. Fiddler crab: *Uca (Deltuca) dussumieri spinata*

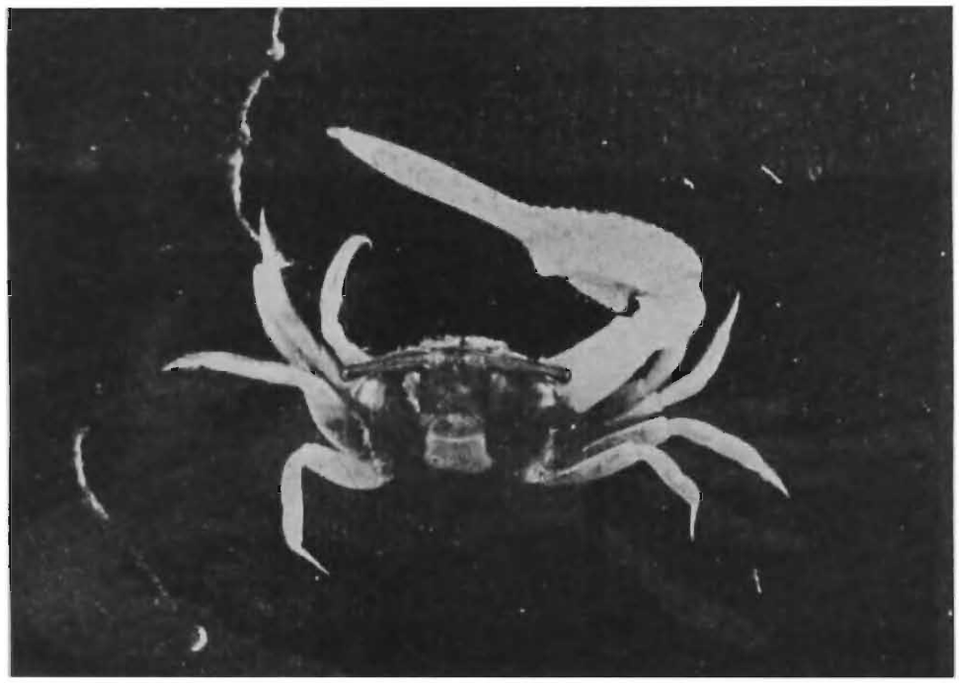


Fig. 37. Fiddler crab: *Uca (Thalassuca) vocans*

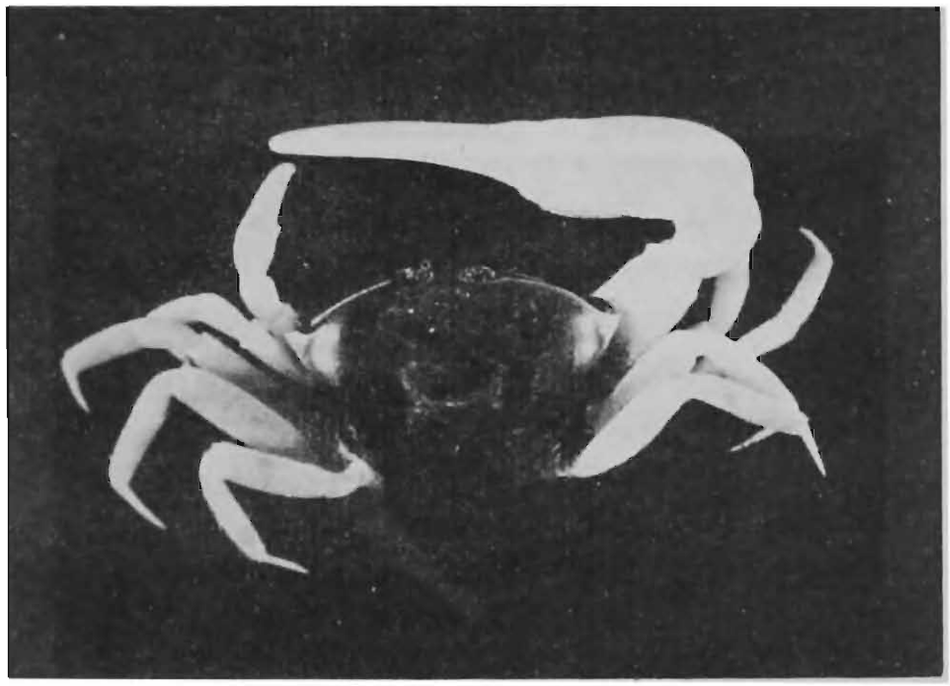


Fig. 38. Fiddler crab : *Uca (Thalassuca) tetragonon*

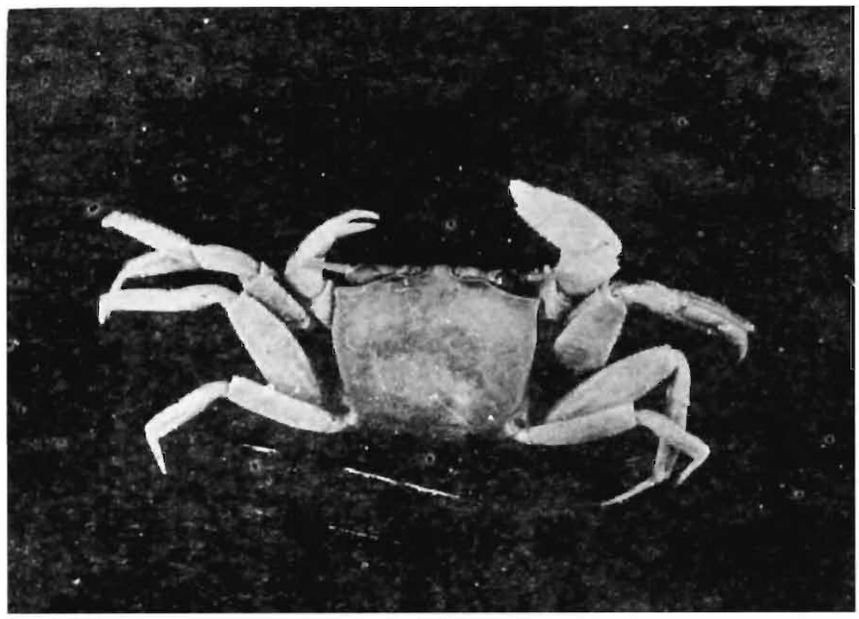


Fig. 39. Ocepodid crab : *Ocepode certophthalmus*

The reproductive activity of *Uca lactea lactea, U. vocans* and *U. dussumieri spinata* was studied for two years in the mangroves of South Andaman. Ovigerous females of these three species were found throughout the period indicating that these species of crabs breed all the year round. But they show monthly fluctuations in breeding intensity (Fig. 52). It has been observed that egg-hatching is synchronised to the days of spring tide associated with full moon and new moon. This, as Macintosh opined (1982), invariably favours survival of the planktonic larval stages because spring tides are more likely to carry them beyond the mangrove zone into coastal waters where temperature and salinity conditions are most stable.

During the present investigation temperature inside the burrows of *Uca* spp at 10 cm depth was measured in three stations at Corbyn's Cove (South Andaman) both in shaded and unshaded areas of mangroves for a period of one year (January to December, 1982). All observations were made between 7.00 and 9.30 IST. The results are featured in Fig. 8 which reveal that during the investigation burrow temperature was always higher than air temperature and lower than surface (soil) temperature.

Macintosh (1977) studied the thermal tolerance of fiddler crabs in the mangrove areas of Malaysia. During the course of such study he noted air, surface and burrow temperature of *Uca* for a continuous period of 24 hrs, at

4 hrs interval. He recorded maximum air temperature at 37°C and surface temperature at 41°C in the open and 30°C in shade. But in all cases he found burrow temperature at 10 cm depth varied from 28° to 30°C. So, despite considerable variation in surface temperature in Malaysian mangroves burrow temperature fluctuated very little. The same is also somewhat true with Andaman mangroves where fluctuation of burrow temperature was only 3.4°C (28.1° - 31.5°C) as compared to 6°C (29.4 -35.4°C) at soil surface.

Of the remaining ocypodid species *Macrophthalmus convexus* occurs on the lowest low water marks of the shore, while *Dotilla myctiroides* occupy sandy areas near high tide level and penetrate the mangales occasionally. *D. myctiroides* is sometimes found to co-exist with *Uca* spp.

*Portunid crabs :*

Among the Portunid crabs of the mangroves of these islands, *Scylla serrata* (Fig. 40) is the most important species. These crabs are met on the forest floor of *Rhizophora* spp and *Bruguiera* spp, in puddles and creek banks. Specimens living within the mangroves are generally dark or dark mottled green in colour and those of the channels have a brownish hue. The burrows of these crabs are elliptical in shape and are very deep, having connection with water level. These crabs have a good market price. *Thalamita crenata* (Fig. 41) and *T. prymna* (Fig. 42) enter the mangroves in

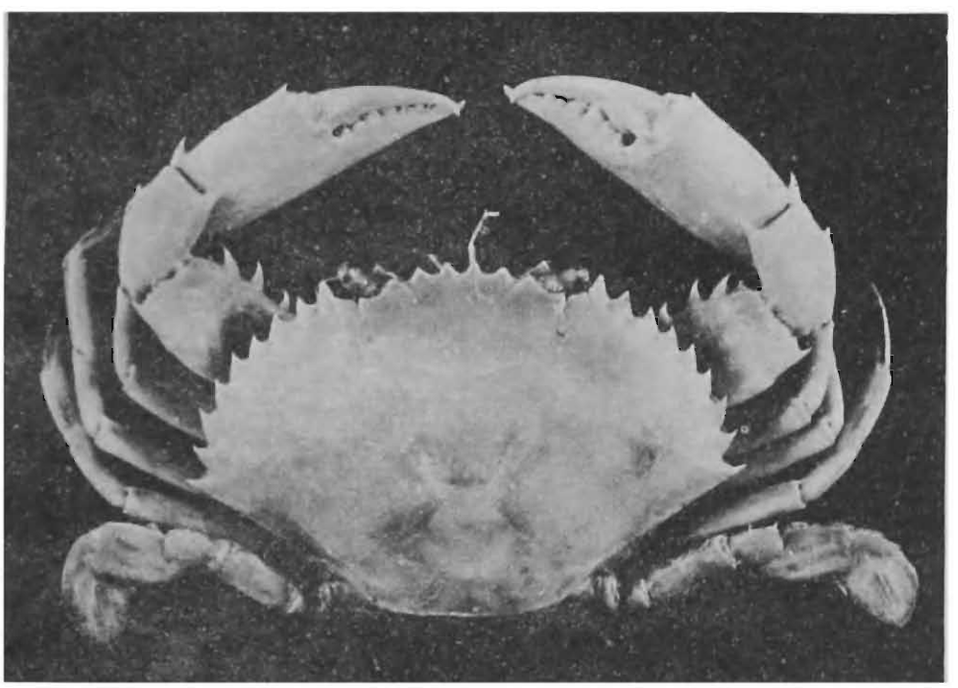


Fig. 40. Portunid crab, *Scylla serrata*

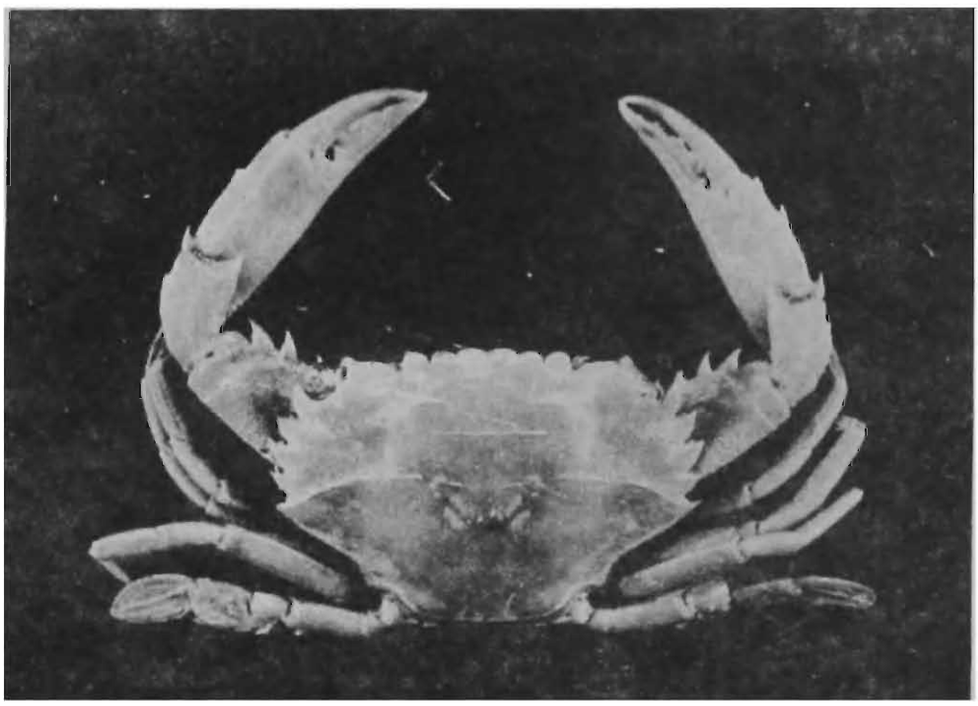


Fig. 41. Portunid crab, *Thalamita crenata*

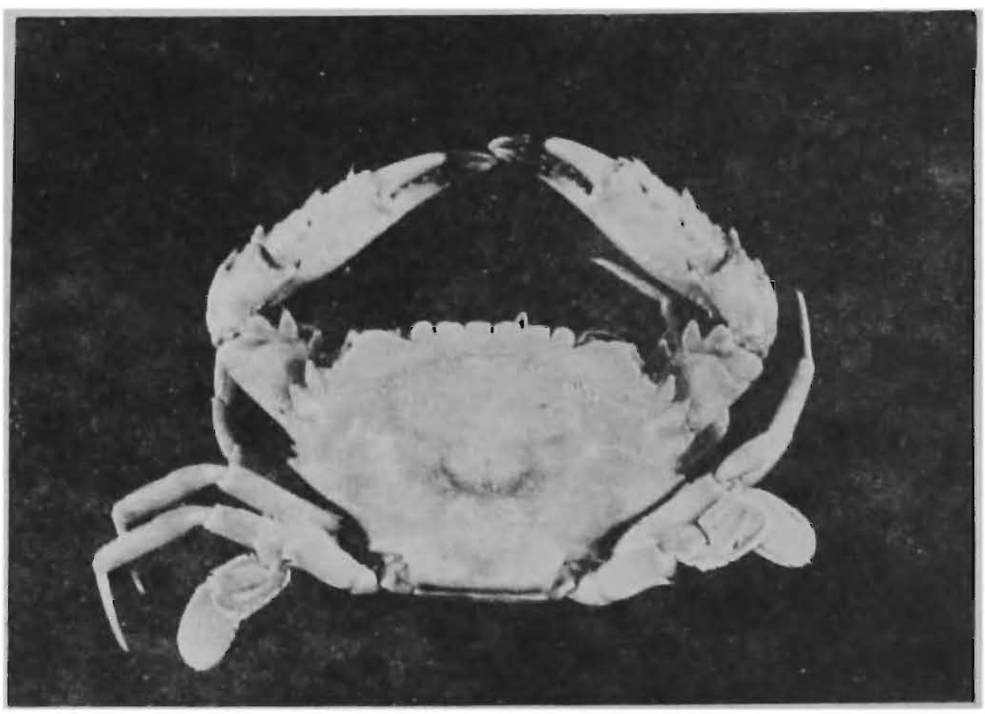


Fig. 42. Portunid crab, *Thalamita prymna*

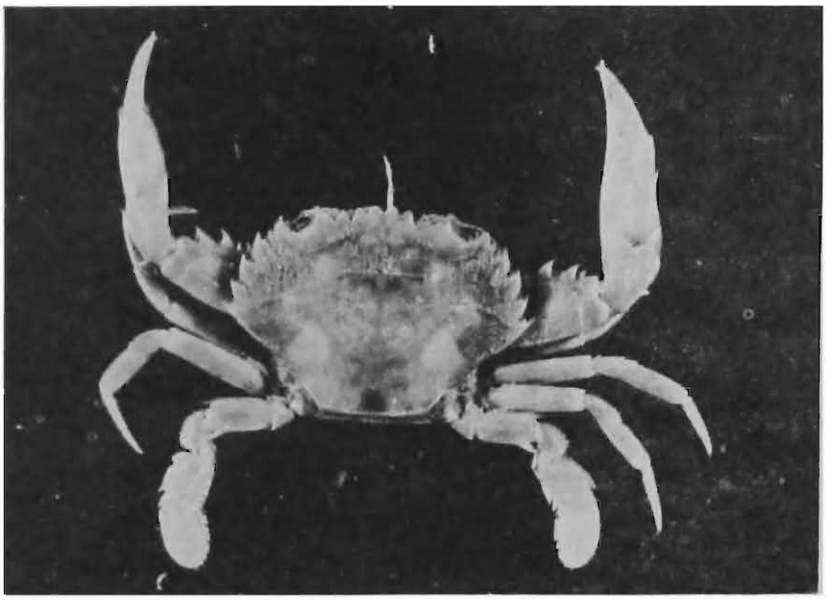


Fig. 43. Portunid crab, *Charybdis orientalis*

large number during high tides. *Charybdis orientalis* (Fig. 43) is found in mangroves adjacent to rocks and dead corals. Other portunid crabs collected from the mangroves of these islands are *Portunus sanguinolentus* and *Portunus pelagicus*. These crabs invade mangroves in Mayabander (North Andaman) during high tide only.

*Grapsid crabs :*

Thirteen species of grapsid crabs have been collected from the mangroves of these islands of which eight species belong to the genus *Sesarma*, namely, *S. andersoni*, *S. bidens* (Fig. 45), *S. intermedium*, *S. longipes*, *S. latifemur*, *S. quadrata*, *S. taeniolata* (Fig. 44) and *S. tetragonum*. Most of the sesarmid crabs occur towards the landward mangroves in *Rhizophora*, *Bruguiera* and *Avicennia* grooves. *S. quadrata* occurs in higher numbers in *Avicennia* groves, *S. bidens* is found in the region where substratum remains wet only during spring tides. *S. taeniolata* occupies still higher zone and occurs in the thickets of the fern, *Acrostichum* sp and mixed mangrove plants. The species is nocturnal in habit but these crabs have been observed during day time at cloudy weather. The burrows of these crabs are circular in cross section and penetrate till they reach ground water level.

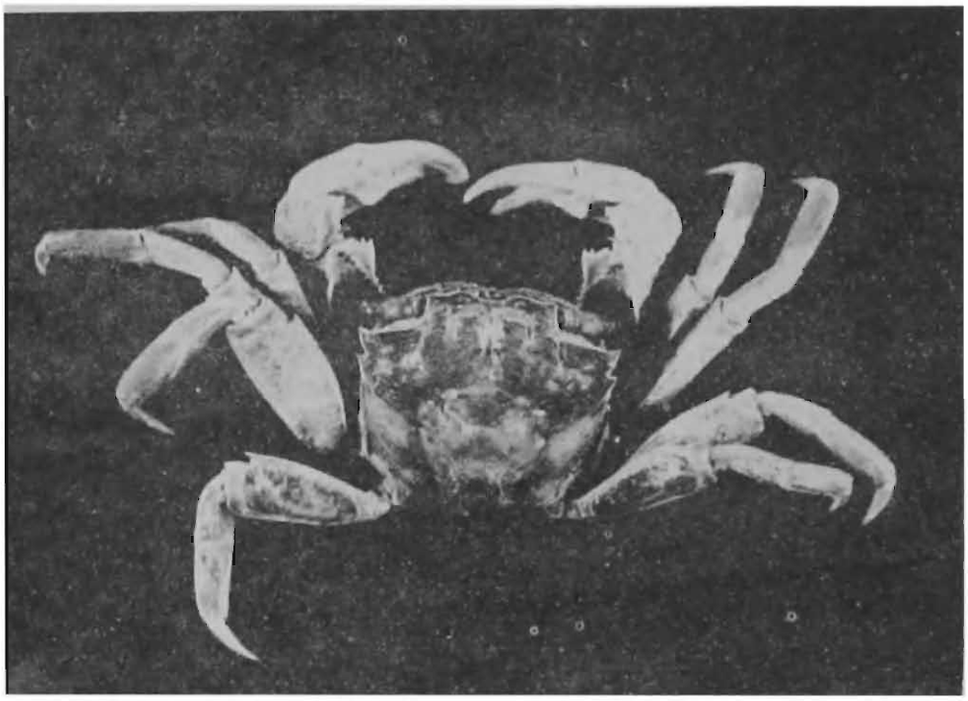


Fig. 44. Grapsid crab, *Sesarma (Sesarma) taeniolata*

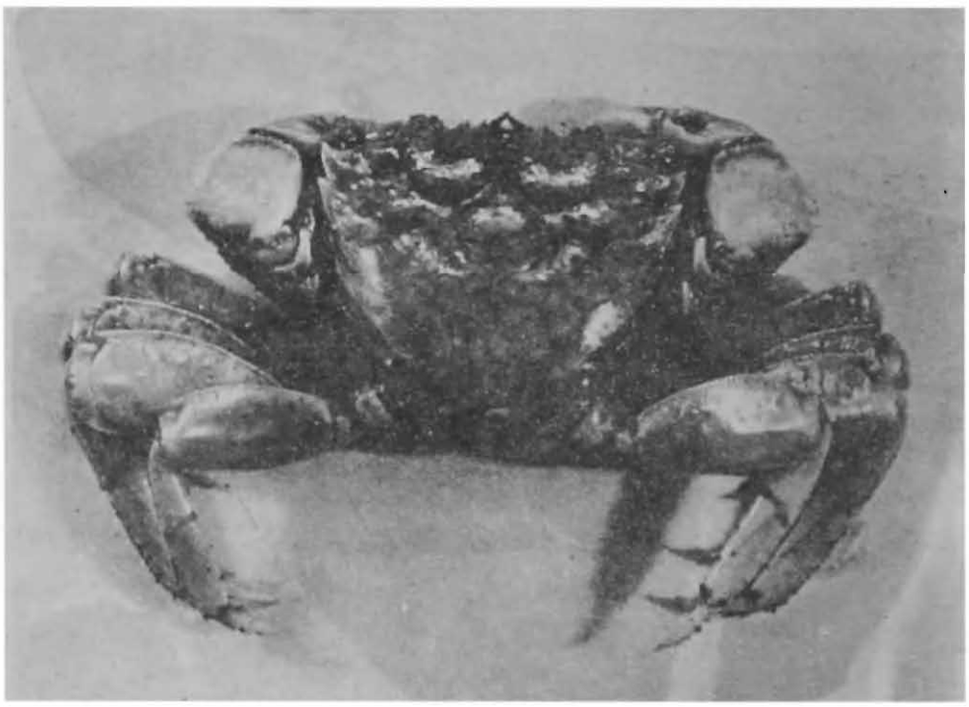


Fig. 45. Grapsid crab, *Sesarma (Sesarma) bidens*

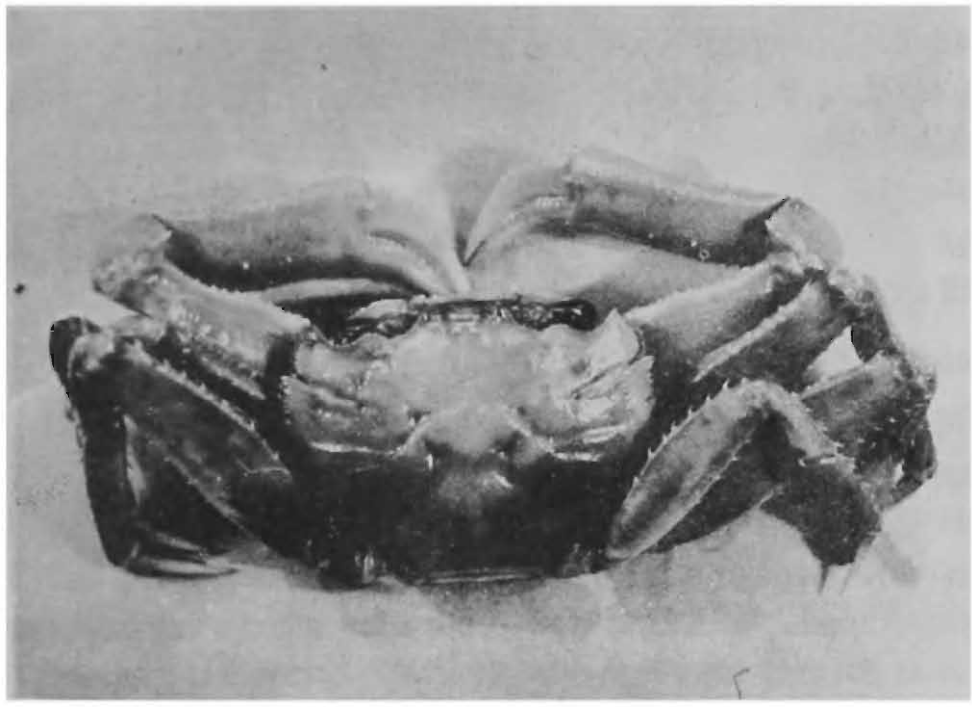


Fig. 46. Grapsid crab, *Metaplax crenulata*

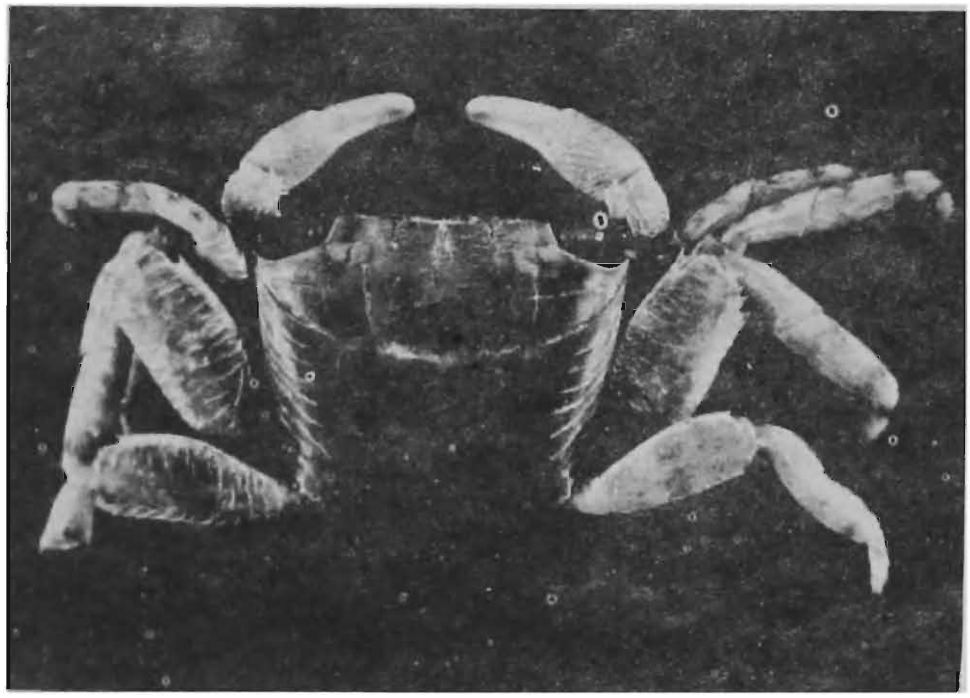


Fig. 47. Grapsid crab, *Metopograpsus messor*

*Grapsus strigosus* have been found to occupy tree trunks and tree crevices of *Sonneratia alba, Avicennia marina* and other mangrove species. These crabs are also seen on the surface of floating logs and rafts during the low tide. During the present study *Metaplax elegans* and *M. crenulata* (Fig. 46) have been collected from the *Rhizophora* thickets of Bakultala (Middle Andaman) and Baratang island (South Andaman). *Metopograpsus messor* (Fig. 47) occurs in under stone, pebbles and muddy banks near nullah and occupies mid to high tide level. *Metasesarma rousseauxi* are found nearer to supra littoral zone under stones, logs and timbers.

*Xanthid and Mictyrid crabs :*

Three species of xanthid crabs have been collected from Andaman mangales. Among them *Pilumnus cursor* is found among crevices of dead corals near low water level. *Baptozius vinosus* occurs under dead corals, stones and boulders and even in sandy mud between mid tide level to highwater mark. Both these crabs occur a few metre away from mangrove tree zone but they enter mangale frequently. *Epixanthus frontalis* (Fig. 48) abounds in sandy areas under pebbles and stones near high tide mark and often penetrates mangroves in search of food.

The mictyrid crabs are represented by single species, namely, *Mictyris longicarpus* (Fig. 49) and occupy the same zone as that of the ocypodid crab, *Dotilla myctiroides.*

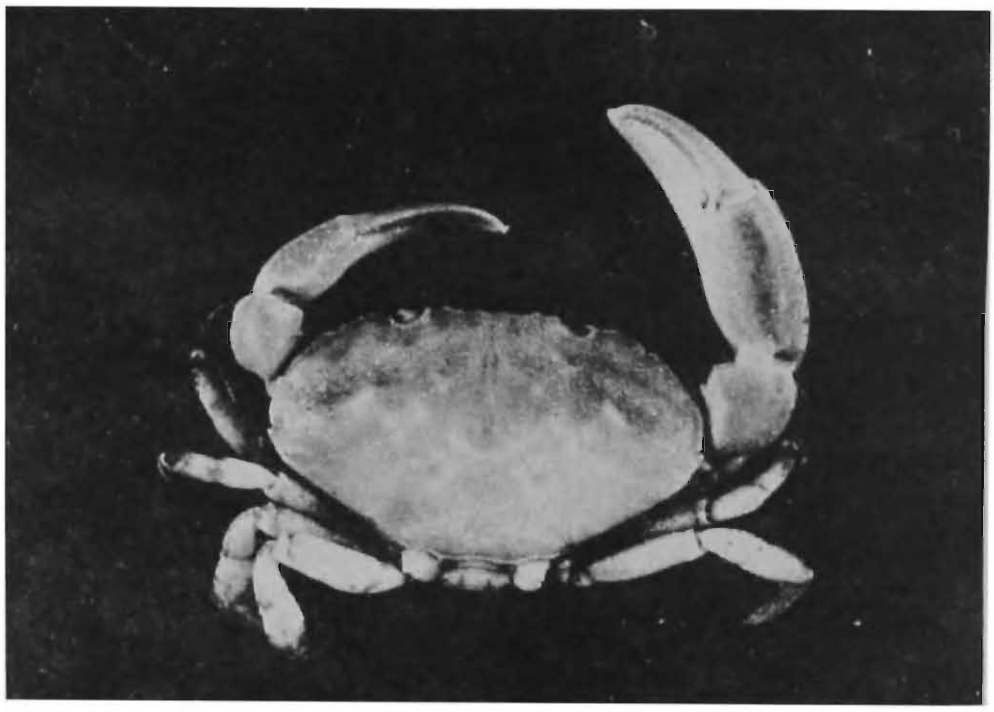


Fig. 48. Xanthid crab, *Epixanthus frontalis*

Fig. 49. Mictyrid crab, *Mictyris longicarpus*

*Gecarcinid crabs :*

*Cardisoma carnifex* (Fig. 50) is the only species of gecarcinid crab which invades mangroves in the supra littoral region and occasionally just above the high tide level. The crab is remarkable for its ability to dig out heaps of soil which looks like a mound from the top (Fig. 51), the basal part being widest in diameter (recorded upto 94 mm) which diminishes considerably (recorded upto 20 mm) as the height increases. The height of the castle may vary from 0.5 to 1 m. The burrows which are deep (1.5 to 2 m) and arranged spirally are circular in cross section and tend to continue to the water level. Silas and Sankarankutty (1960) have studied the castle building habit of this crab in these islands. They ascribed the castle building nature of the species to be a seasonal one and as a means of protection against tidal water and probably also against intruders. The entrances of the castles are plugged during day time. But, their presence can be ascertained by fresh layer of soft and wet mud which is added on the top. The excavated mud consists of pellets of irregular size and shape and these pellets are mixed with water. These crabs are noctural but occasionally come out during the day in cloudy weather.

Brief habitat ecology of some mangrove crabs of these islands is presented in Table 3. The same for the remaining species can not be incorporated here due to lack of sufficient data.

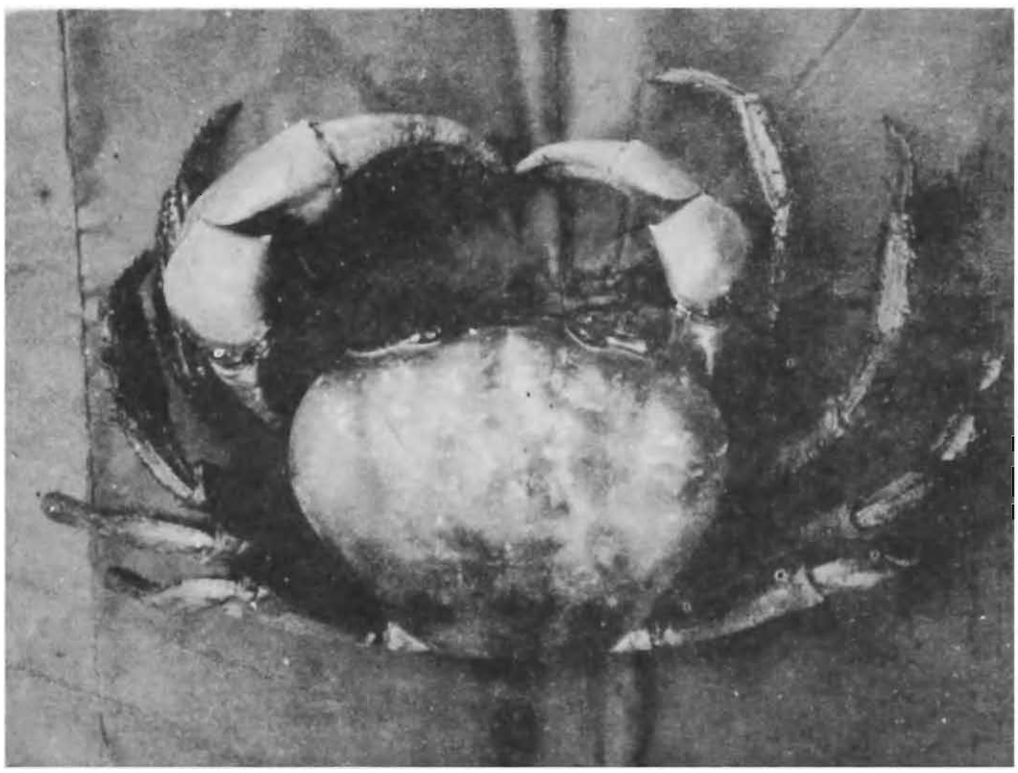


Fig. 50. Gecarcinid crab, *Cardisoma carnifex*

Fig. 51. Castle (mound) of *Cardisoma carnifex* in the mangrove areas of South Andaman.

Table - 3. Comparative data on habitat ecology of the crabs in the mangrove areas of Andaman and Nicobar islands.

| Sl. No. | Name of the species | Habitat |
|---|---|---|
| 1. | *Ocypode ceratophthalmus* | Sandy shores and muddy sand areas adjacent to mangroves between HWST and HWNT |
| 2. | *Uca lactea lactea* | Open sand flats bordering mangroves; ubiquitously present between EHWS and MLWN. |
| 3. | *Uca dussumieri spinata* | Open mud flats bordering mangroves and banks of the creeks having muddy to sandy substratum. Sometimes among conglomerates of dead corals and shells (as in Chidyatapu, South Andaman). Also occur in shaded patches of mangroves especially *Rhizophora* spp; generally between MHNN and MTL. |
| 4. | *Uca tetragonon* | Shaded areas of mangroves, in the crevices of stones, dead corals and occasionally among conglomerates of shells and dead corals, with muddy sand substratum at the bottom. Also found in the burrows constructed under the roots of *Rhizophora* spp and *Bruguiera* spp. Rarely in open shores. Generally between mid and high tide level (MHWN to MTL). |
| 5. | *U. vocans* | Open sandy mud to mud, with soft substratum. Generally in lower tide level and sometimes upto mid tide level. |
| 6. | *Dotilla myctiroides* | Sandy areas near high tide level. |
| 7. | *Macrophthalmus convexus* | In the areas covered by every high tide. Usually around MTL and sometimes down upto MLWS. |
| 8. | *Metaplax crenulata* | Open mud flats, with soft well drained substratum. |
| 9. | *Metaplax elegans* | Mud flats and banks just below mangrove zone, between MHWN and MTL. |
| 10. | *Grapsus strigosus* | Usually among dead corals, rocks and boulders; sometimes on tree trunks and crevices of mangroves and on floating logs and rafts. Generally between mid to high tide level. |
| 11. | *Metopograpsus messor* | Under stones, pebbles and muddy banks of the channels. Also between mid to high tide level. |
| 12. | *Sesarma taeniolata* | Landward mangrove forests, especially thickets of the fern, *Acrostichum* sp and mixed mangrove plants. |
| 13. | *Sesarma bidens* | Open mud flats within mixed forests, covered by almost all spring tides. |
| 14. | *Sesarma quadrata* | Among roots of mangroves, especially *Avicennia* sp. |

| Sl. No. | Name of the species | Habitat |
|---|---|---|
| 15. | *Metasesarma rousseauxii* | Under stones, logs and timbers lying on the supra littoral zone in mangroves. |
| 16. | *Scylla serrata* | In burrows made at muddy banks of channels, creeks, puddles and within thickets of mangroves from low to high water marks. |
| 17. | *Thalamita crenata* | Under dead corals and boulders adjacent to mangrove trees. |
| 18. | *Thalamita prymna* | Same as *Thalamita crenata* |
| 19. | *Charybdis orientalis* | Same as *Thalamita crenata* |
| 20. | *Pilumnus cursor* | Among crevices of dead corals near low water level. |
| 21. | *Epixanthus frontalis* | In sandy areas under pebbles and stones near high water mark. |
| 22. | *Baptozius vinosus* | Under dead corals, stones and boulders; also in sandy substratum. Between mid tide level to highwater mark. |
| 23. | *Cardisoma carnifex* | Occur in burrows and construct castle in mangroves; upper tidal level to supra littoral forest floor. |

*Annual breeding pattern :*

The annual breeding pattern of various species of brachyuran crabs of the mangrove areas of the Bay islands is presented in the Figs. 52-54. Data collected during the present investigation indicate that most of the species breed throughout the year. Peak and lean season of reproductive activity, however, varied considerably during different months of the year. For *Uca vocans* (Fig. 52) and *Scylla serrata* (Fig. 54) the peak breeding activity was noticed in September (as evidenced by 91% and 71% ovigerous females respectively), for *Uca lactea lactea, Uca dussumieri spinata* and *Sesarma bidens* in December (81%, 82% and 94% respectively) (Figs. 52, 53), for *Portunus pelagicus* and *P. sanguinolentus* in January (65% and 55% respectively) (Fig. 54) and for *Epixanthus frontalis* in March (48.9%) (Fig. 53).

The lean period of reproductive activity of *Uca dussumieri spinata* was found in February (12.5%) while for *Expixanthus frontalis* and *Portunus sanguinolentus* it was noticed in August (0.6% and 10% respectively). For some species of crabs, namely, *Uca vocans, Scylla serrata* and *Portunus pelagicus* no such lean period was found. On the other hand, no berried female of *Uca lactea lactea* was observed in January, March to June and August to October. The probable reason for complete absence of ovigerous females during these months can not be attributed at present.

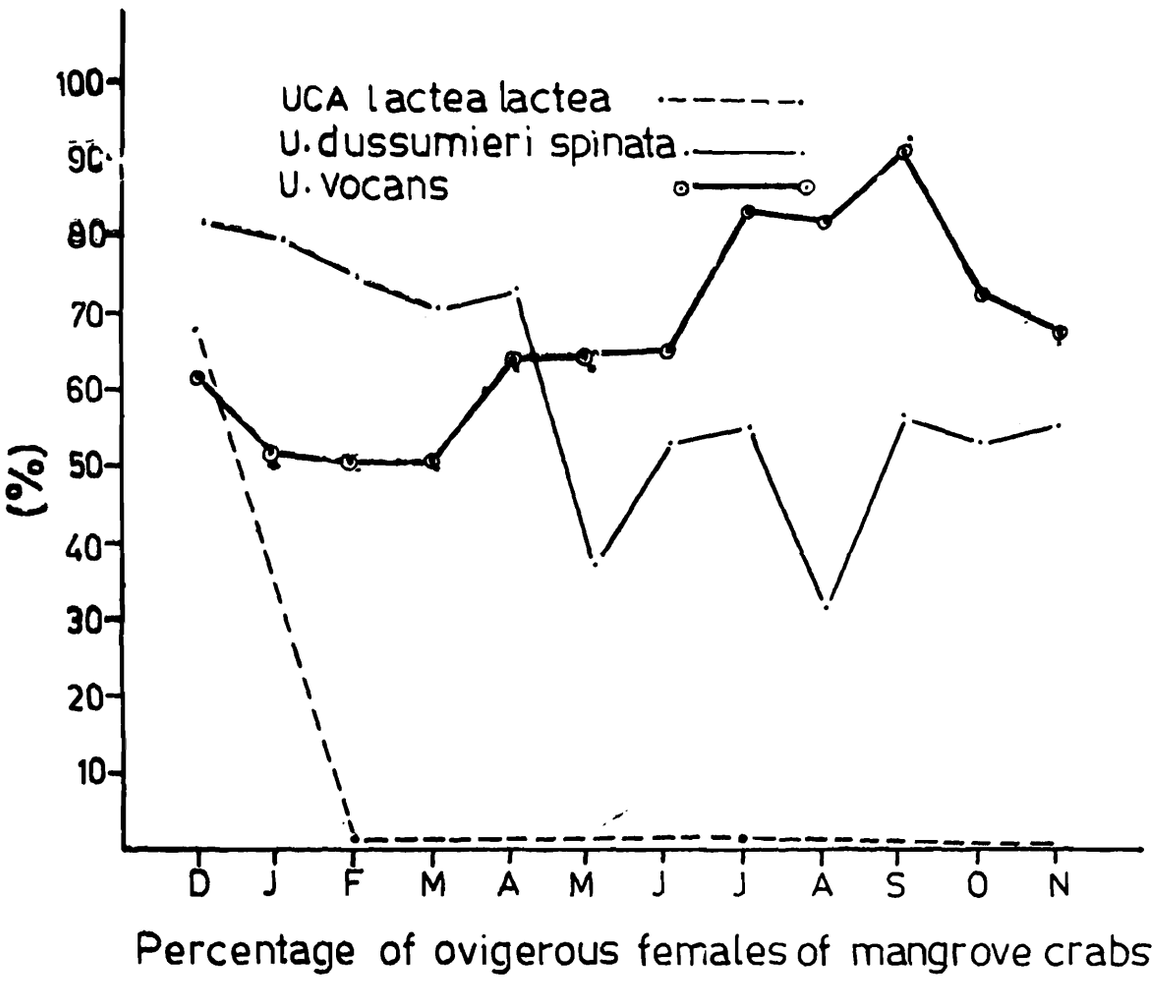



Fig. 52. Percentage of ovigerous females of fiddler crabs, *Uca lactea lactea, U. dussumieri spinata* and *U. vocans*

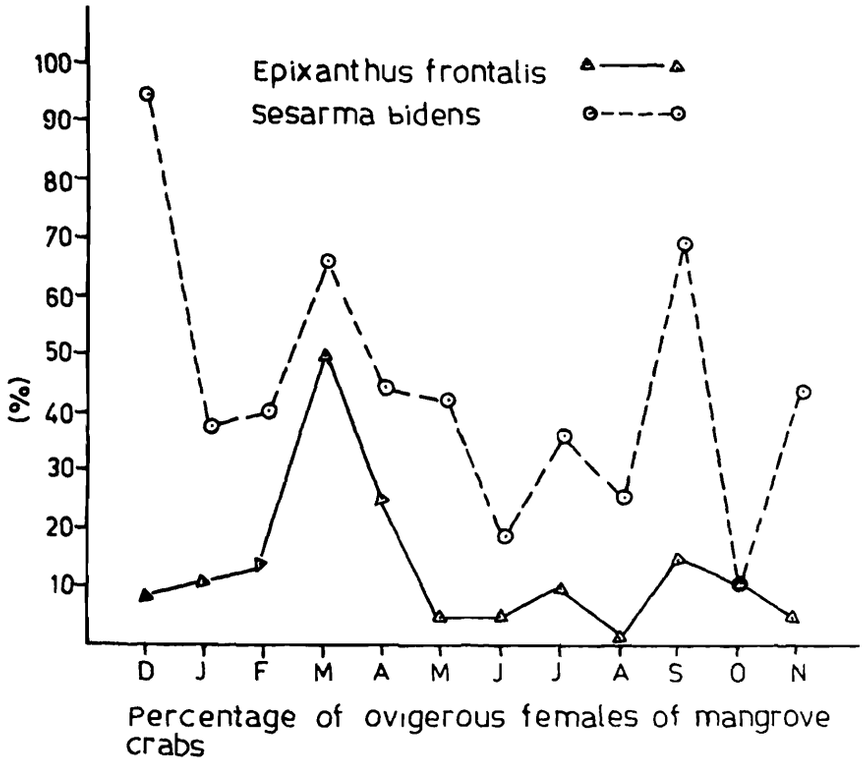



Fig. 53. Percentage of ovigerous females of *Epixanthus frontalis* and *Sesarma bidens*.

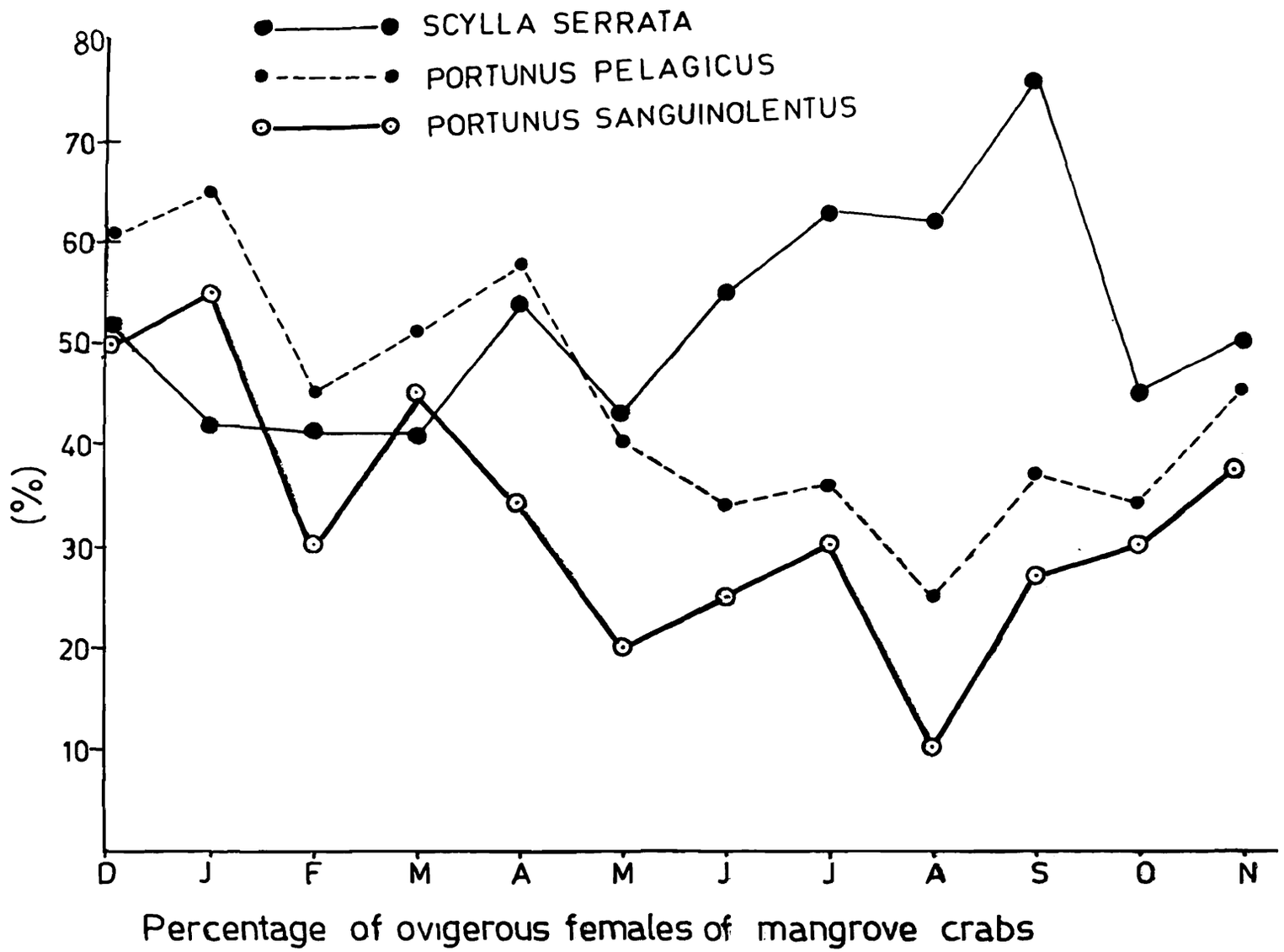



Fig. 54. Percentage of ovigerous females of portunid crabs, *Scylla serrata, Portunus pelagicus* and *Portunus sanguinolentus*

*Hermit crabs and Mud lobster :*

A good number of hermit crabs inhabit mangrove regions of Andaman islands. *Clibanarius longitarsus* is found in the intertidal region whereas *Coenobita cavipes* occupies the supra-littoral areas. In the course of present investigation authors collected *Clibanarius longitarsus* from the shells of *Terebralia palustris* and *Purpura* sp and even from the land snail, *Achatina fulica* whereas *Coenobita cavipes* was found to occuppy shells of *Nerita planospira, N. chamaeleon, N. polita, N. albicilla, N. semirugosa, N. articularа, Cerithidea quadrta, Cerithium corallinum, Clypeomorus trailli* and *Polynices tumidus.* While selecting shells, *Clibanarius longitarsus* has been found to prefer shells of *Terebralia palustris* rather than *Purpura* sp and *Achatina fulica.* This is because dead shells of *T. palustris* abounds in the mangroves. This observation was made at Chidyatapu and Corbyn's Cove (South Andaman). It may be mentioned that Sripathi *et. al.* (1977) recorded *C. longitarsus* from 72 species and *Coenobita cavipes* from 16 species of gastropod shells from South India. As early as 1905, Alcock reported the occurrence of another hermit crab, *Pylocheles mierssi,* specimens of which were 'tightly impacted in sunken drift twigs of bamboo and mangroves'

Data on annual reproductive cycle of *Clibanarius longitarsus* and *Coenobita cavipes* are depicted in Fig. 55. The peak breeding of *C. longitarsus* and *C. cavipes* have been observed in March (72.5%) and April (65%) and the lean periods in July (20%) and August (19%) respectively. Khan and Natarajan (1977) studied the breeding activity of *C. longitarsus* in the Vellar estuary, South India. They observed the peak seasons of its reproductive activity in March (23%) and August (36%). In this context, notable features in the reproductive activity of the hermit crabs in the mangrove areas of the Bay islands are that their ovigerous females are found throughout the year including monsoon and that percentage of ovigerous females is very high during the peak period of their preproductive activity.

The mud-lobster, *Thalassina anomala* is another remarkable anomura generally found in *Rhizophora* forest in such region where the substratum remains water-logged. This crab has been found to scoop mud with their second walking leg on cloudy and rainy days. *T. anomala* has been reported to bring out heap of mud in *Ceriops* zone in Africa (Macnae, 1968). But in Andaman mangroves this was not observed.

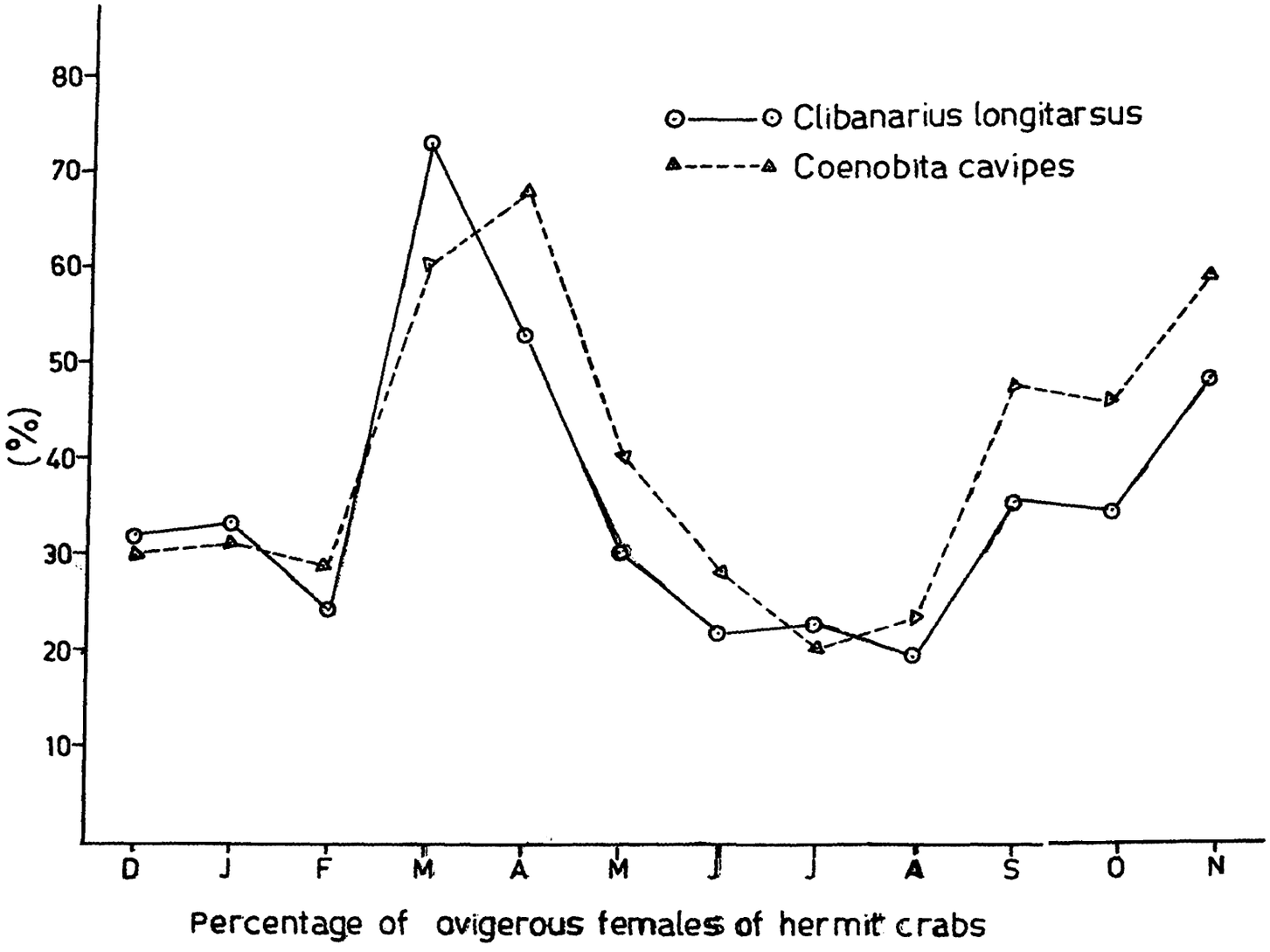



Fig. 55. Percentage of ovigerous females of hermit crabs, *Clibanarius longitarsus* and *Coenobita cavipes*

## V. Echinoderms :

The bays and sheltered coasts fringed with mangroves are ideal abodes for many holothurians and species like *Synapta maculata, Actinopyga echinites, Stichopus variegatus, Holothuria scabra* and *Polycheira rufescens* occur in Wandoor (South Andaman) (Figs. 56-58). *P. rufescens* is also found in similar habitat at Mayabunder (North Andaman).

On shingle shore, the stelleroid, *Patiriella pseudoexigua* occurs.

## VI. Fishes :

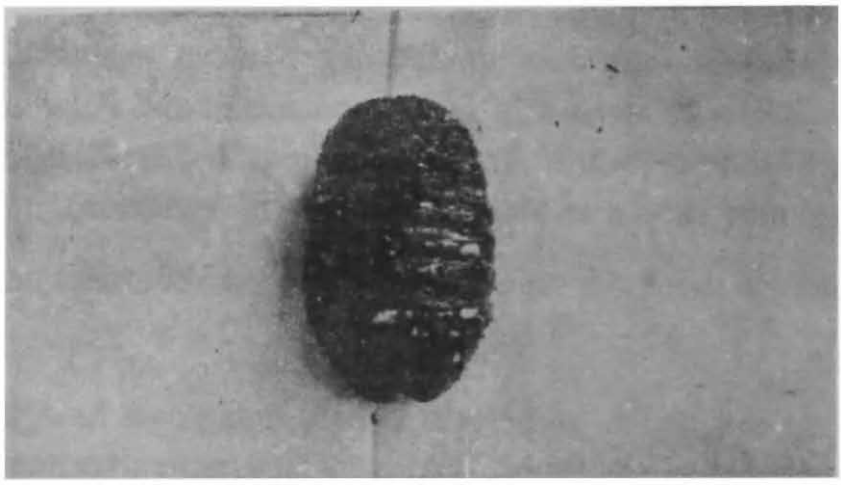
The shallow waters and creeks around mangroves have been found to support many species of fishes. Because of rich nutrient contents, mangroves serve as ideal places for nursery ground of various fisheries which are dependent on estuarine condition.

While identification of bulk of the fish collections from the creeks and tidal mudflats of mangroves of Andamans is yet to be made, specific identity of only a few species of fishes is known from this area. Among these, *Oxyuricthys dasi* is an endemic species collected from the mangrove fringed creek of Sippighat, South Andaman (Talwar *et. al.*, 1982). From the mangrove areas of North Andaman an endemic gobiid fish, *Callogobius andamanensis* has also been reported. Other fishes collected from Andaman mangroves are *Periophthalmus vulgaris, P dipus, P. scholosseri, Boleophthalmus boddarti, Acentrogobius viridipunctatus* (Fig. 63) and *Istiblennius dussumieri.* Mudskippers belonging to the genera *Periophthalmus* and *Boleophthalmus* are very conspicuous in such areas of mangroves where mud is semifluid. Both *P. vulgaris* and *P. dipus* construct bowl-shaped burrows in the vicinity of channelward or seaward mangroves trees (Figs. 59, 62).

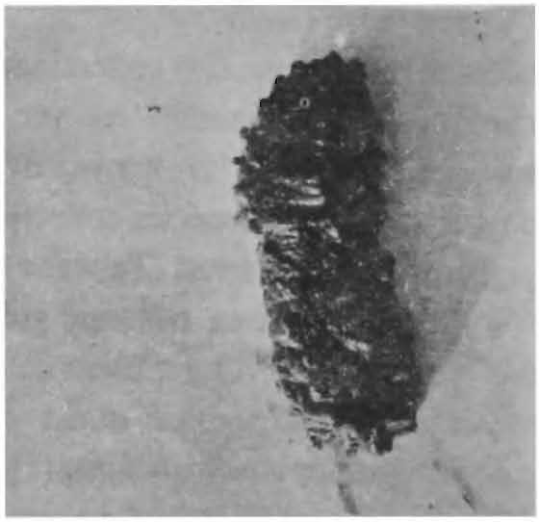
Most common commercial eel of Andaman islands, *Anguilla bengalensis, bengalensis,* is found in mangrove fringed creeks and bays. This species of eel attains lengths upto 120 cm (Talwar and Kacker, 1984). Another eel, *Anquilla bicolor bicolor* (Fig. 64) has been collected from the mangrove areas of Wright Myo and Kadakachang (South Andaman) where estuarine condition is prevalent to some extent.

Mention may be made here that sardines (*Sardinella* spp) are occasionally caught by the fishermen near mangrove fringed creek of Corbyn's Cove (South Andaman).

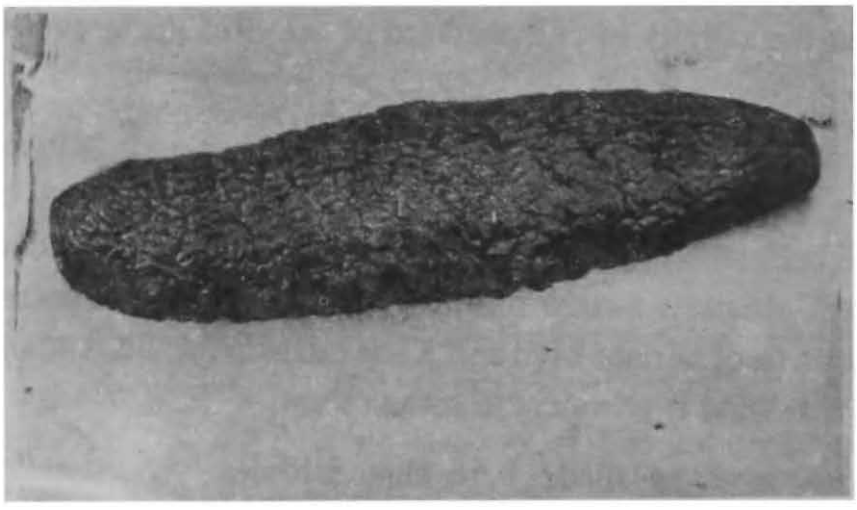
Figs. 56-58. Sea cucumbers of Andaman mangroves adjacent to coral reefs.



56 *Holothuria scabra*



57. *Stichopus variegatus*



58. *Actinopyga echinites*

Fig. 59. *Periophthalmus* sp (dorsal view), a typical gobiid fish of mangroves.

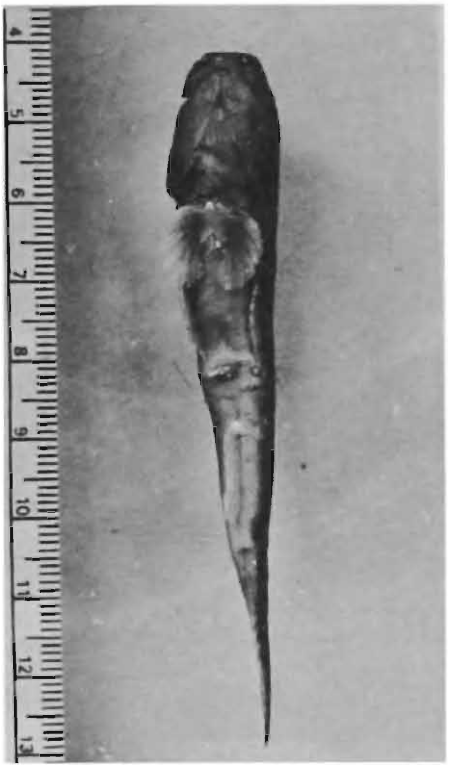


Fig. 60. *Periophthalmus* sp (ventral view)

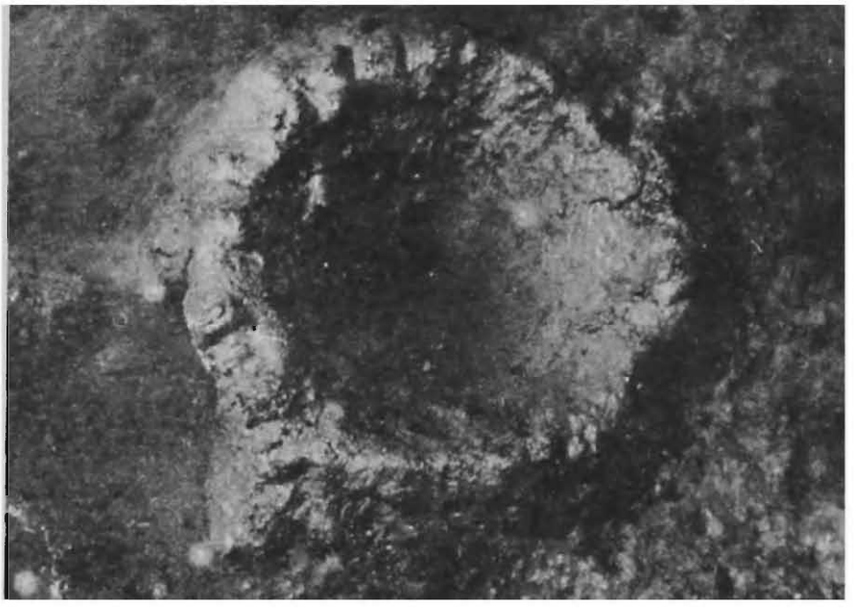


Fig. 61. Bowl-shaped nest burrow of *Periophthalmus* sp.

Fig. 62. *Periophthalmus* sp. clinging to the mangrove log in the supralittoral zone during high tide.

Fig. 63. *Acentrogobius viridipunctatus* from the mangroves of South Andaman

Fig. 64. *Anguilla bicolor,* an eel collected from the mangrove areas of Andaman islands.

From the bays and mangrove fringed rivers of Great Nicobar, Menon and Talwar (1972) have recorded the following 24 species of fishes :

*Galathea bay and river :*

*Salarias fuscus, Callogobius hasselti* and *Chelonodon fluviatilis*

*Alexandra river :*

*Periophthalmus koelreuteri, Platycephalus indicus*

*Dogmar river :*

*Hippichthys spicifer, Oryzias melanostigma, Liza macrolepis, Liza melinoptera, Ambassis gymnocephalus, Gazza minuta, Gerres oblongus, Butis gymnopomus, Bunaka gyrinoides, Eleotris andamanensis, Eleotris fusca, Ophiocara aporos, Kraemericus smithi, Pseudogobiopsis romeri, Quisquilius eugenius*

*Jubilee river :*

*Valamugil cunnesius, Ambassis commersoni, Leiognathus equulus, Monodactylus argenteus*

Mention is to be made here that proper exploration of fishes in the mangrove areas of the Bay islands has not yet been done.

**Terrestrial components**

Terrestrial components of mangrove ecosystem exploit mangroves either as resident or as visitor. A host of insects, bats and several birds use mangrove foliage as habitat and derive food from leaves, flowers and fruits whereas some mammals like monkeys, pigs, etc., many birds and reptiles invade the intertidal area of the mangroves temporarily during the low tide.

I **Mammals** : Very few species of mammals have been observed in the mangroves of these Bay islands. Wild pigs, *Sus scrofa andamanensis* and *S. scrofa nicobarica* often invade mangrove areas of Andaman and Nicobar islands respectively in search of food. The Crabeating Macaque, *Macaca fascicularis umbrosa* which prefers littoral forests with thick undergrowth in Great Nicobar, Little Nicobar and Katchal has also been observed near the mangrove fringed shores of Great Nicobar. The Andaman Masked Civet, *Paguma larvata tytleri* has sometimes been seen near the coast lines of South Andaman, covered with mangroves perhaps to catch some animals like

crabs, fishes, etc., which constitute its food. A few species of bats also visit mangroves at dusk of which three species, namely, *Pteropus melanotus tytleri, Pteropus giganteus* and *Cynopterus sphinx* have been identified. Nicobar Tree Shrew, *Tupaia nicobarica* are sometimes seen to visit mangroves in Great Nicobar island.

II **Birds :** In all, 53 species of birds have been observed in the mangrove areas of these islands of which 30 are endemic, 12 resident, 10 winter visitors and one is an introduced species. Mangroves provide trunk, branches, foliages and shades along the coasts, bays and creeks. Hence, this ecosystem provides ideal sites for birds for feeding, roosting, transit and also nesting particularly in view of the fact that mangrove areas in many places of these islands are least disturbed.

Majority are the roosting birds in the mangroves of these islands, although a few species of birds may use mangroves as transit. Three species of birds have also been reported to built nests in the mangrove trees. Boden Kloss (1903) refers to several nests of Sunbirds, *Nectarinia jugularis klossi* (= *Arachnotheria klossi*) from Nicobar mangroves, overhanging water. Osmaston (1906) found one nest of Eastern Sparrow Hawk, *Accipiter virgatus gularis* situated in a dense and lofty mangrove forest of Baratang Island at the top of a mangrove pole about 30 ft from the ground. Osmaston, Wickham and Anderson (*see* Abdulali, 1964) are said to have collected many nests of Andaman Little Green Heron, *Ardeola striatus spodiogaster* 'during May-June on various islands in mangroves.' During the present investigation the said sunbird and Andaman Little Green Heron have been noticed in the mangroves of Great Nicobar and Middle Andaman respectively, but their nesting activities were not observed. Recently, present authors have observed a nest of Andaman Whitebreasted King Fisher, *Halcyon smyrnensis saturatior* inside the hole of a mangrove tree, *Sonneratia alba* at Rangat Bay, Middle Andaman. Some birds, namely, Common Myna, *Acridotheres tristis tristis* and Eastern Jungle Corw, *Corvus macrorhynchus levaillanti* were also observed in the mangroves of such localities of South Andaman where human settlements are nearby.

There are very few reports on the birds of mangroves from Indian mainland. Mukherjee (1975) enlisted 25 species of birds from the Indian part of Sundarbans, of which 9 are resident, 10 seasonal visitors and 6 rare visitors. Recently Samant (1985) has recorded 121 species of birds around Ratnagiri mangroves, of which 66 species are resident and local migrants, 28

species are resident with migratory population, 24 species are true migrants and 3 species are vagrants. Mention is to be made here that Khan (1986) has reported the occurrence of 261 species of birds from Sundarbans, Chakoria Sundarbans and other mangrove formations of Bangladesh.

The following are the list of birds observed in the mangroves of Andaman and Nicobar islands.

| Sl. No. | Name of birds | Locality | Status |
|---|---|---|---|
| | Order Ciconiiformes | | |
| | Family Ardeidae | | |
| 1. | Eastern Grey Heron, *Ardea cinerea rectirostris* | A & N | R |
| 2. | Andaman Little Green Heron, *Ardeola striatus spodiogaster* | A & N | E |
| 3. | Small Egret, *Egretta intermedia intermedia* | A & N | R |
| 4. | Chestnut Bittern, *Ixobrychus cinnamomeus* | A & N | R |
| 5. | Yellow Bittern, *Ixobrychus sinensis* | A & N | R |
| | Order Anseriformes | | |
| | Family Anatidae | | |
| 6. | Andaman Grey Teal, *Anas gibberifrons albogularis* | A | E |
| | Order Falconiformes | | |
| | Family Accipitridae | | |
| 7. | Eastern Sparrow-Hawk, *Accipiter virgatus gularis* | A & N | R |
| 8. | Andaman Crested Hawk-Eagle, *Spizaetus cirrhatus andamanensis* | A | E |
| 9. | Waterbellied Sea Eagle, *Halieetus leucogaster* | A & N | R |
| 10. | Andaman Pale Serpent Eagle, *Spilornis cheela davisoni* | A & N | E |
| | Order Gruiformes | | |
| | Family Rallidae | | |
| 11. | Andaman Whitebreasted Waterhen, *Amaurornis phoenicurus insularis* | A & N | E |
| | Order Charadriiformes | | |
| | Family Charadriidae | | |
| 12. | Whimbrel, *Numenius phaeopus phaeopus* | A & N | Winter visitor |

| Sl. No. | Name of birds | Locality | Status |
|---|---|---|---|
| 13. | Terek Sandpiper, *Tringa terek* | A & N | -do- |
| 14. | Red Shank, *Tringa totanus* | A & N | -do- |
| 15. | Eastern Golden Plover, *Pluvialis dominica fulva* | A & N | -do- |
| 16. | European Little Ringed Plover, *Charadrius dubius curonicus* | A | -do- |
| 17. | Pintail Snipe, *Gallinago stenura* | A & N | -do- |
| | Order Columbiformes | | |
| | Family Columbidae | | |
| 18. | Andaman Green Imperial Pigeon, *Ducula aenea andamanica* | A | E |
| 19. | Pied Imperial Pigeon, *Ducula bicolor* | A & N | R |
| | Order Psittaciformes | | |
| | Family Psittacidae | | |
| 20. | Large Andaman Parakeet, *Psittacula eupatria magnirostris* | A | E |
| 21. | Andaman Redbreasted Parakeet, *Psittacula alexandri abbotti* | A | E |
| 22. | Andaman Redcheeked Parakeet, *Psittacula longicauda tytleri* | A | E |
| 23. | Nicobar Redcheeked Parakeet, *Psittacula longicauda nicobarica* | N | E |
| 24. | Indian Lorikeet, *Loriculus vernalis vernalis* | A & N | R |
| | Order Cuculiformes | | |
| | Family Cuculidae | | |
| 25. | Andaman Crow-Pheasant, *Centropus andamanensis* | A & N | E |
| | Order Caprimulgiformes | | |
| | Family Caprimulgidae | | |
| 26. | Andaman Longtailed Nightjar, *Caprimulgus macrurus andamanicus* | A | E |
| | Order Apodiformes | | |
| | Family Apodidae | | |
| 27. | Andaman Greyrumped Swiftlet, *Collocalia fuciphaga inexpectata* | A & N | E |
| | Order Coraciiformes | | |
| | Family Alcedinidae | | |

| Sl. No. | Name of birds | Locality | Status |
|---|---|---|---|
| 28. | Andaman Blueeared Kingfisher, *Alcedo meninting rufigaster* | A | E |
| 29. | Andaman Storkbilled Kingfisher, *Pelargopsis capensis osmastoni* | A | E |
| 30. | Nicobar Storkbilled Kingfisher, *Pelargopsis capensis intermedia* | N | E |
| 31. | Blackcapped Kingfisher, *Halcyon pileata* | A & N | R |
| 32. | Andaman Whitebreasted Kingfisher, *Halcyon smyrnensis saturatior* | A & N | E |
| 33. | Andaman Whitecollared Kingfisher, *Halcyon chloris davisoni* | A | E |
| 34. | Nicobar Whitecollared Kingfisher, *Halcyon chloris occipitalis* | N | E |
| 35. | Andaman Ruddy Kingfisher, *Halcyon coromanda mizorhina* | A | E |
| | Order Piciformes | | |
| | Family Picidae | | |
| 36. | Andaman Black Woodpecker, *Dryocopus javensis hodgei* | A | E |
| 37. | Andaman Fulvousbreasted Pied Woodpecker, *Picoides macei andamanensis* | A | E |
| | Order Passeriformes | | |
| | Family Laniidae | | |
| 38. | Philippine Shrike, *Lanius cristatus* | A & N | Winter visitor |
| 39. | Andaman Rackettailed Drongo, *Dicrurus paradiseus otiosus* | A | E |
| | Family Oriolidae | | |
| 40. | Andaman Blacknapped Oriole, *Oriolus chinensis andamanensis* | A | E |
| 41. | Andaman Blackheaded Oriole, *Oriolus xanthornus reubeni* | A | E |
| | Family Artamidae | | |
| 42. | Whitebreasted Swallow-Shrike, *Artamus leucorhynchus humei* | A | E |
| 43. | Common Myna, *Acridotheres tristis tristis* | A | Introduced |

| Sl. No. | Name of birds | Locality | Status |
|---|---|---|---|
| | Family Corvidae | | |
| 44. | Eastern Jungle Crow, *Corvus macrorhynchus levaillanti* | A | R |
| | Family Campaphagidae | | |
| 45. | Barred Cuckoo-shrike, *Coracina striata dobsoni* | A | E |
| 46. | Eastern Small Minivet, *Pericrocotus cinnamomeus vividus* | A | R |
| | Family Muscicapidae | | |
| 47. | Mangrove Whistler, *Pachycephala grisola* | A | R |
| 48. | Thickbilled Warbler, *Acrocephalus aedon aedon* | A & N | Winter visitor |
| 49. | Arctic Leaf Warbler, *Phylloscopus borealis borealis* | A | -do- |
| | Family Motacillidae | | |
| 50. | Blueheaded Yellow Wagtail, *Motacilla flava beema* | N | -do- |
| | Family Dicaeidae | | |
| 51. | Andaman Olivebacked Sunbird, *Nectarinia jugularis andamanica* | A | E |
| 52. | Nicobar Olivebacked Sunbird, *Nectarinia jugularis klossi* | N | E |
| 53. | Car Nicobar Olivebacked Sunbird, *Nectarinia jugularis proselia* | N | E |

**III Reptiles :** The Salt Water Crocodile, *Crocodilus porosus* is found in almost all such large islands of the Andamans and the Nicobars which support extensive mangrove swamps and tidal creeks. Belt of cane brakes near transitional zone of tidal mangroves and riverine forests seems to be the best nesting habitat for this crocodile, specially in North Andaman islands (Tikader and Das, 1985). The pebble beds along shallow tidal creeks of the mangrove also provide an excellent habitat for *Crocodilus porosus.* The Andaman Water Monitor, *Varanus salvator andamanensis* is often found in the mangroves. It is comparatively common during the breeding season of the crocodile as this lizard is very fond of crocodile eggs. Other lizards, like *Goniocephalus subcristatus* and *calotes* sp, have been collected from the mangrove areas of South Andaman. These animals invade the zone only in search of food.

Mention may be made here that the Dogfaced Water Snake, *Cerberus rhynchops* is frequently seen in the mangrove swamps and estuaries of these islands. It usually lives in crab-holes and never goes far from water. It has been found to be very active during the night and live chiefly on crabs and fishes. Both male and female of one species of marine snake, *Laticauda* sp have been collected from a single tree hole of mangrove, *Sonneratia alba* in the intertidal zone in Neil Island, South Andaman (Fig. 65). The Pit Viper, *Trimeresurus* sp has been seen on several occasion among the mangroves of South Andaman.

IV **Amphibians :** Among the amphibians *Rana limnocharis limnocharis* (Fig. 66), *Rana limnocharis andamanensis* and *Rana cancrivora* have been found in the mangrove fringed creeks and swamps of South Andaman islands where salinity is of very low magnitude (0.6°/oo to 10.0°/oo). *R. cancrivora* and its tadpoles have been recorded from brackish water ponds and mangrove areas of South East Asia (Macnae, 1968). Pearse (1911) reported this species to lay eggs in crab holes. However, no tadpole has been observed during the present investigation.

V **Insects and Mites :** Mangrove associated insects mostly include mosquitoes and biting midges as mangroves appear to be an ideal breeding place for them. Most of the insects invade mangroves for food or shelter or for both. Gall causing insects and mites are also found to occur in mangroves. These are host specific. The following insect groups are found to occur in the mangrove areas of Andaman and Nicobar islands during the present investigation.

A. *Coccids :* These insects are usually found on the leaves of *Rhizophora stylosa, R. mucronata* and *R. apiculata.* At Pongibalu (South Andaman) coccids have been found to be abundant on both dorsal and ventral side of the leaves of *R. stylosa* and *R. mucronata.* The leaves become pale in colour due to the feeding activity of the nymphs and females of these insects. These insects excrete honeydew on which a black sooty mould develops. This sort of mould is common on the leaves of *Rhizophora* spp at Chidyatapu, Guptapara and Pongibalu (South Andaman). The nymphs and females are coated with a whitish powder on the body surface. The males are winged and the females are apterous and oval.

Coccids have also been observed on the epicarp of the fruits of *Bruquiera gymnorhiza* at Pongibalu (South Andaman). These are found to be concentrated more on the calyx than on any other region. At Bambooflat

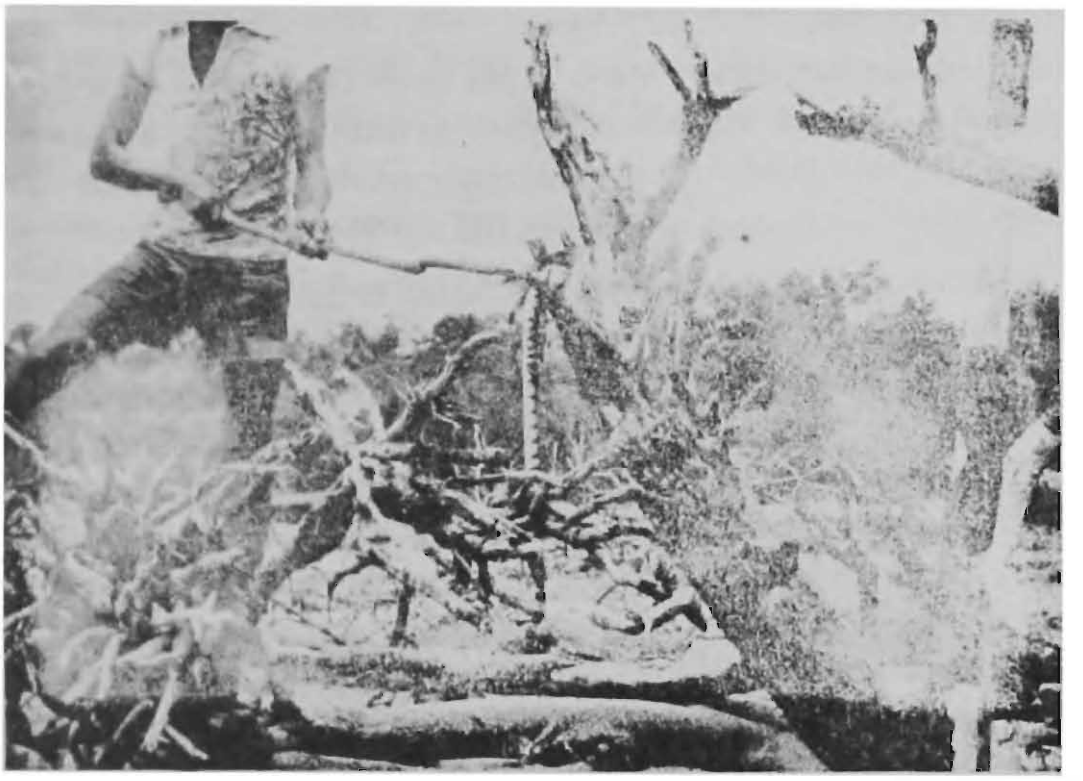


Fig. 65. Sea snake, *Laticauda* sp, collected from the mangrove areas of Neil island

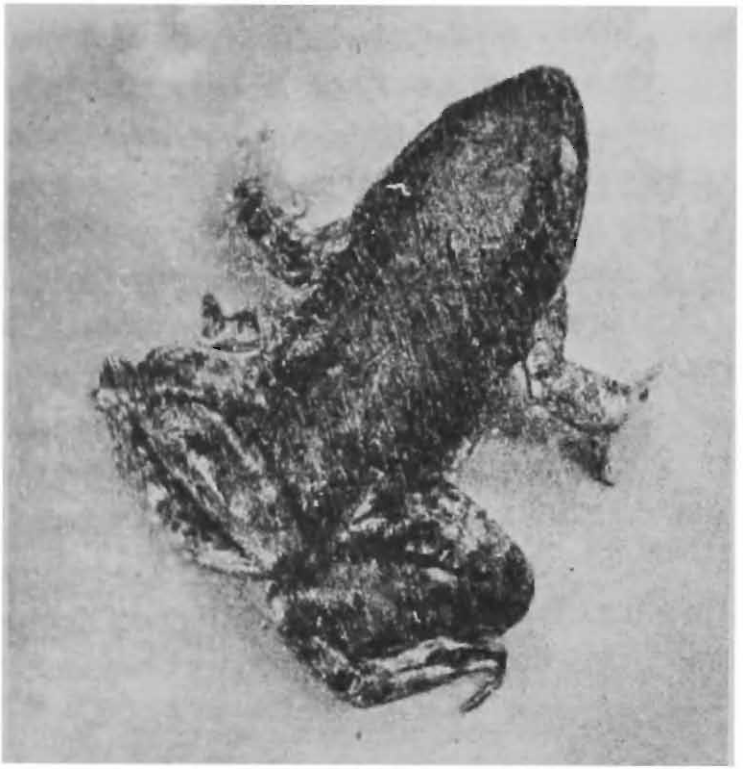


Fig. 66. *Rana limnocharis,* collected from the mangrove areas of Corbyn's Cove, South Andaman

(South Andaman) these insects are also seen on the fruits of *Heritiera littoralis* and *Excoecaria agallocha.*

Coccids are occasionally found on the leaves of *Acanthus ilicifolius* at Bambooflat. But these are more in number on stems. Here also the nymphs and females are coated with powdery mass on their body surface. The females are oval, legs poorly developed and antenna vestigial.

B. *Biting insects :* Mosquitoes and biting midges are very common almost in every mangrove area of these islands, the specific identity of which is yet to be determined. Because of the painful bite of these minute flies it is very difficult to work in the mangrove zones. Frequency of such bites appear to be more in shady places. No work has been done on the mosquitoes and biting midge complex from the mangroves of these islands. But the mangrove areas of these islands appear to be very ideal breeding ground for the mosquitoes as plenty of their larvae and pupae are often seen in the temporary water pools formed in the upper portion of the intertidal zone where tide reaches only once or twice per month. The rain and seepage water dilute the tidal sea water of the pool to the extent that suites the mosquitoes for breeding.

Mention may be made here that Macnae (1968) noted an odd breeding habitat of a mosquito, *Aedes pembaensis* on the coast of Africa to lay its eggs on the claws of a crab, *Sesarma meinerti.* Its larvae emerge in the pools formed by the burrows of these crabs and develop there into adult. In the mangroves of South Andaman we have also observed some mosquitoes to complete their life cycle in the crab holes of *Sesarma* sp and *Cardisoma carnifex* where top of those burrows are not covered by earthen mounds. But such breeding habit of those mosquitoes in the mangroves of Andaman as stated by Macnae (*op. cit.*) has not been noted. In the mangroves of Andaman, mosquito larvae are also frequently seen in the tree-holes of *Avicennia marina,* which may be filled up with tidal or rain water. Mosquito larvae are also found to occur in the similar habitats of other mangrove trees like *Sonneratia alba.* In the mangroves where rain water accumulates to form some temporary pools culicine types of mosquitoes are usually found to breed. This observation corroborates Chapman (1976).

In moist and shady places, felled mangrove leaves of *Nypa fructicans* sometimes harbour some mosquitoes, the larvae of which remain adhered to the leaves. At some places left over coconut husks thrown or washed away to mangroves have been found to contain mosquito larvae.

Small pools in the marshy swamps, having brackish water environment, have been found to contain mosquito larvae whose anal papillae are comparatively reduced than those of the fresh-water forms.

Biting midges are quite common throughout the mangrove zones of these islands particularly in the low lying areas covered by spring tides. Systematic and ecological studies on biting midges of mangroves of these islands may reveal many interesting results.

C. *Beetles :* The Jewel beetle, *Chrysobothris andamana* (Coleoptera Bupestidae) has been found to eat up foliage of *Heritiera littoralis.* The adult beetles are boat shaped, having two characteristic pale yellow, oval or circular spots on the elytra. These beetles consume the foliage in a very characteristic way from tree to tree, rest for sometime and then hover on other plants. These beetles are observed abundantly in the mangroves at Bambooflat and Saitankhari (South Andaman) and Peel Island of Ritchie's archipelage. The larvae are wood borers. Adult chrysomelid beetles, *Philopona* sp were also found to consume leaves of the mangrove tree, *Rhizophora* spp in Great Nicobar. Sometimes these beetles are seen in large number in the mangrove thicket.

A large number of Ladybird beetle (Coccinellidae) belonging to *Verania discolor* have been observed on leaves and stems of *Acanthus ilicifolius* in different mangrove areas of South Andaman. The adults are phytophagous. They seem to eat mostly on chlorophyllous tissue of the plant, due to which leaves become colourless (Fig. 67). They feed on leaves in patches sometimes to such an extent that only veins and veinlets remain. One spectacular phenomenon in the mangrove areas of Andaman islands is the synchronous flashing of fire flies belonging to *Pteroptyx* sp. This phenomenon has been observed and studied by many workers in the mangales of Singapore and Thailand (*see* Macnae, 1968).

Besides, there are some cerambycids, scolytids and curculionids which bore into the heartwood, sapwood, stem and fruits of mangrove trees. These are being discussed in separate sub-heads.

D. *Termites :* Among the destructive insects of mangrove forests, next to coleopteran and lepidopteran borers, termites need to be mentioned. Eight species of termites have so far been obtained affecting mangrove logs in Andaman islands (Table 8). These termites except *Hospitalotermes blaire* have been found to affect dead stumps, dying and dead mangrove trees and felled mangrove logs lying above the high tide level. The mangroves

Fig. 67. Leaf of the mangrove, *Acanthus* sp, eaten up by coccinellid beetle, *Verania discolor*

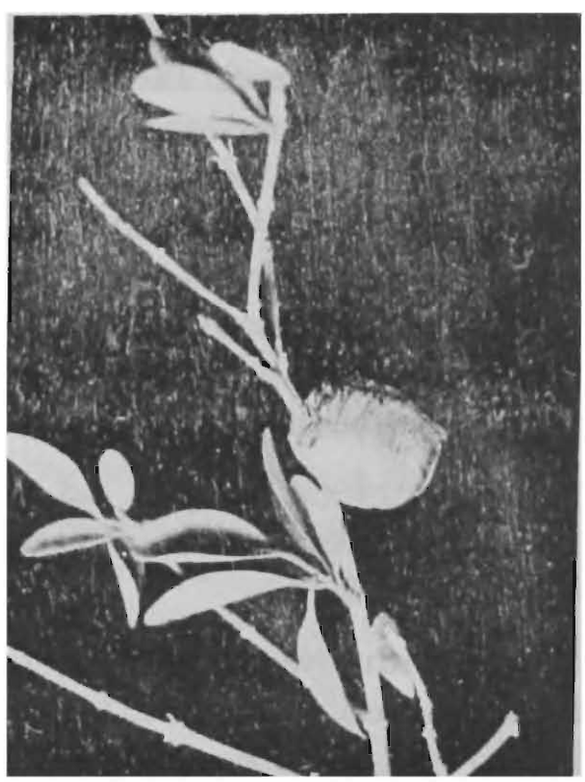


Fig. 68. Ootheca of mantid on the mangrove tree, *Rhizophora* sp.

commonly found to be infested with termites in these islands are *Xylocarpus granatum, Rhizophora stylosa, R. mucronata, R. apiculata, Bruguiera gymnorhiza, B. parviflora, Heritiera littoralis* and *Excoecaria agallocha.*

Mention may be made here that Beeson (1941) recorded *Cryptotermes bengalensis* in the wood of *Heritiera fomes* while Roonwal (1959) observed nests of *Coptotermes heimi* on *Avicennia* spp, on rafters of *Rhizophora mucronata* and on the pole of *Xylocarpus moluccensis.*

E. *Ants :* Several species of ants are active in the mangroves of these islands. Some species make nest and complete their life-cycle in the mangales, others remain active at ebb tide in search of food.

The Weaver ant, *Oecophylla smaragdina* is conspicuously found to nest on mangroves. This ant has been observed to choose mangrove species having broad leaves. Leaves of *Rhizophora mucronata, R. stylosa, R. apiculata, Bruguiera gymnorhiza* and *B. parviflora* appear to be favoured by *Oecophylla smaragdina.* Macnae (1968) reported this ant species on leaves of *Ceriops, Bruguiera, Sonneratia caseolaris* and *Xylocarpus* in Malaya. The leaves are fastened together by larval secretion. Upto ten nests per plant of various sizes and shapes have been observed in mangroves of these islands. These ants have been found to tend coccids on leaves.

In the mangroves of Bambooflat and Saitankhari (South Andaman) ants belonging to *Formica* sp have been observed to occupy deserted insect holes of *Acanthus ilicifolius* where they invade secondarily and complete their life cycle (Das *et al., in press*).

Deserted leaf gall of *Sonneratia alba* and stem gall of *Avicennia marina* have been reported to be occupied by black ants in South Andaman (Sharma *et. al.,* 1983, 1984).

Foraging *Formica* spp have been observed on leaves and tree trunks of *Rhizophora apiculata, Xylocarpus granatum, Heritiera littoralis, Acanthus ilicifolius* and *Acrostichum aureum.*

The cracks and crevices of the standing trees particularly *Rhizophora* spp and *Heritiera littoralis* have been found to harbour *Camponotus* spp. The crevices may provide adequate supplies to the ants by way of trapping animals like fish, other small invertebrates and detrital materials. Another ant, *Sima rufonigra* has been observed in few cases on tree trunks of mangrove vegetation in Andaman islands.

It may be mentioned here that Wilson (1969) reported ten species of ants from *Rhizophora mangale.* Besides, some other species has been reported to occur in dead mangrove trees and also on the epiphyte, *Tillandsia* on mangroves. Collins *et al.* (1977) reported *Azteca* sp on *Pelliciera rhizophora.*

The epiphytic myrmecophyte, *Hydnophytum formicarium* is a small shrub which grows on *Rhizophora mucronata* and *R. apiculata* in Wandoor (South Andaman) (Fig. 69). The plants are provided with a swelling at the base (Fig. 70) which is referred to as tuber. One to several branches may come out from the apex of the tubers. These tubers are smooth on outer surface. The inside of the tubers is provided with many cavities which are not uniform in size and shape (Fig. 71). The small cavities are inter-connected with larger cavities. There are holes at the root end of the tuber which leads into the cavities. The chambers are used as nesting sites by the ant *Iridomyrmex cordatus.* The interaction between ant and the plant has been investigated by many workers (*see* Huxley, 1980). It has been suggested that ants protect the epiphyte from harbivorous and other browsing animals. Moreover, the debris which the ants accumulate contain mineral nutrients. These nutrients are utilized by the plants for their growth. Huxley (1976) has shown that plants grown without minerals or ants did not have better growth than those grown with ants.

The tubers of *Hydnophytum* have been found to be used as refuge by many animals. Neil (1946) recorded skinks (Scincidae) and *Hyla macgreggori* (Amphibia) in tubers of this epyphyte. He reported skinks to lay eggs inside the tubers. Huxley (1976) observed skinks to feed on ants. In addition, other animals like *Cophixalus riparius,* Parasitic hymenoptera, lizards, centipedes, spiders, leeches, mites, small mammals and 'Cuscuses (*Phalanger* spp.)' have been reported from tubers of *Hydnophytum.* In the present investigation, the authors could not find any such animal association in the tubers.

Large number of very minute ants belonging to *Formica* sp have been collected from the root of a fern *Acrostichum aureum* in the mangrove area of Sippighat (South Andaman). The roots of *A. aureum* are provided with cavities of irregular sizes and shapes. These cavities are interconnected with each other and open to the outside through small holes. Foraging population of these ants are active at low tide. At high tide they go inside the root and plug the holes with soil particles. The occurrence of the ants in

Fig. 69. An epiphyte, *Hydnophytum formicum*, attached to the mangrove tree; tuber of the epiphyte surrounded by ant-leaf plant

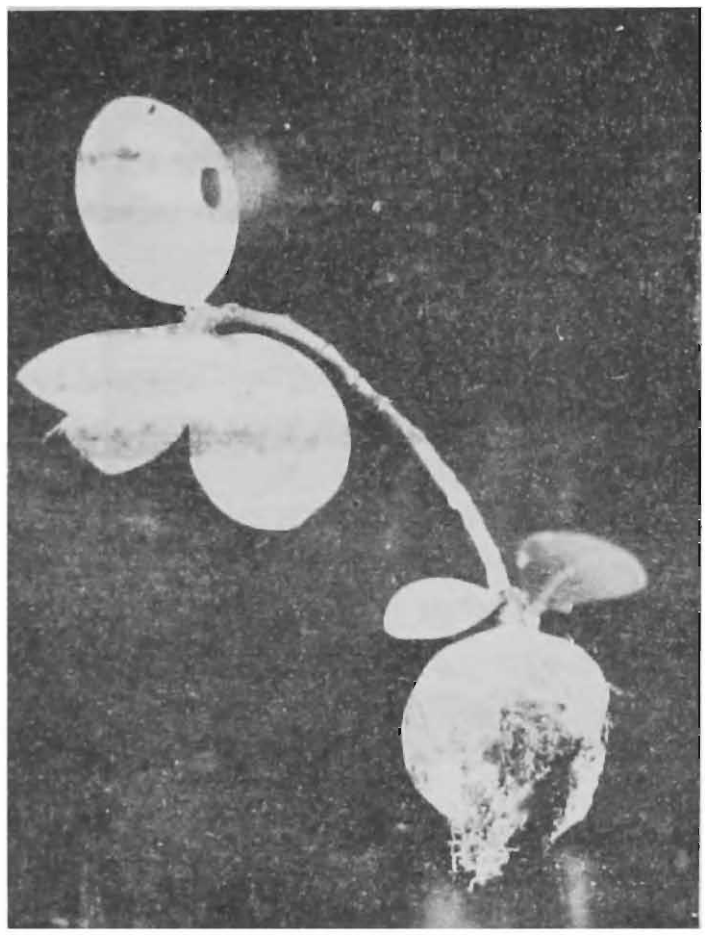


Fig. 70 *Hydnophytum formicum* isolated from the mangrove tree.

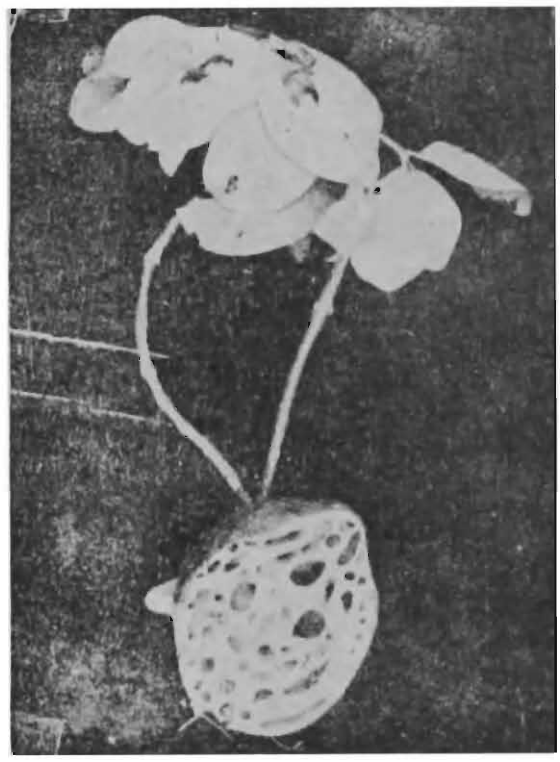


Fig. 71. Tuber of *Hydnophytum formicum* sectioned to display galleries occupied by ant, *Iridomyrmex cordatus*

Fig. 72. Another epiphyte of mangroves in Baratong island, without having any myrmecophytic ant.

such habitat implies that these ants inhabit the plants either for food or protection or both. But, whether the plant is deriving any benefit from the ants by way of receiving nutrients or protection from other browsing animals have not been studied.

F. *Honeybee :* Bee-hives are sometimes seen in the mangroves. We have observed bee-hives of considerable size in the mangrove areas of Havelock Island (South Andaman) where *Rhizophora* spp are dominant. The bee species has been identified as *Apis dorsata.* The honey has been claimed to be of good quality by the local people. This is quite contrary to the report of Macnae (1968) wherein it is mentioned that aborigines of Australia treat honey of *Rhizophora* as poisonous. The flowers of *Aegiceras corniculatum* (another mangrove species) has been found to be a good source of honey in Australia where it forms an important source of honey (Macnae, *op. cit.*).

G. *Other insects :* Once a female Coreid bug (Hemiptera : Coreidae) was seen to lay eggs on the underside of the leaf of *Rhizophora mucronata* at Pongibalu (South Andaman). The eggs were arranged in rows. These were brought to the laboratory where nymphs emerged after seven days. But, thereafter, subsequent studies were interrupted as all the nymphs died. The identification of the bug is in progress.

Ferrar (1947) observed two species of butterflies, namely, *Spalgis epeus nubilus* (Family Lycaenidae) and *Celaenorrhinus andamanica* (Family Hisperidae) in mangrove forests in Bunila beach, Little Andaman. Bhowmik (1970) has reported one species of gryllid, *Parendacustes sanyali* (Orthoptera : Gryllidae) from the mangrove fringed creek of Campbell Bay, Great Nicobar.

H. *Insect borers :* During the course of our present investigation insect borers of Andaman mangroves have been studied in some detail and four species of cerambycid beetles, three species of scolytid beetle, one species each of curculionid and scarabid beetles and a few moths have been recorded as borers of mangroves. These borers can be broadly classified as heartwood borers, sapwood borers, stem borers, fruit borers and borers of germinating seedlings (Table 4). Two more mangrove borers, one belonging to Curculionidae and the other Oedomeridae, have recently been reported from these islands (Das, Dev Roy and Mitra, *in press*). These are being discussed below.

*Heartwood borers :* Two species of cerambycid beetles, namely, *Aeolesthes holosericea* and *Cerecium flavipes* have been recorded as heartwood borer of mangroves of these islands (Tiwari *et. al.,* 1980).

*Aeolesthes holosericea* was found to bore logs and dying branches of *Rhizophora apiculata* in the supralittoral zone. The larval gallery in the sub-cortical zone is wide and irregular. It is filled with a mixture of granular and fibrous frass. Initially the pupal tunnel extends horizontally to the sap wood for some distance and then abruptly turns vertically up or down to end in the pupal chamber (Fig. 73). The outer end of the pupal chamber is closed by a calcareous operculum. The adult emerges by breaking through the operculum.

*Cerecium flavipes* was found to attack dead and unhealthy portions of the living mangroves in South Andaman and Car Nicobar. Their larval galleries are irregular, closely crowded and packed tightly with a fine powdery frass. After its entrance inside the wood, the mature larva makes its gallery more or less parallel to the wood-fibre. Just before the construction of the pupal chamber it suddenly moves deeper for a small distance somewhat obliquely. However, the pupal chamber is built on the same axis as that of the larval mine (Fig. 74). The adult escapes through the operculum in the pupal chamber.

On many occasions we have found many cerambycid larvae in the heartwood of mangrove logs belonging to *Rhizophora* spp. *Bruguiera* spp and *Heritiera littoralis* lying near the marginal area of supralittoral and intertidal zone where there are frequent tidal inundations (Fig. 75).

*Sapwood borers :* Two species of cerambycid beetles, namely, *Plocaederus obesus* and *Megopis* (*Aegosoma*) *sulcipennis* and two species of scolytid beetles, namely, *Coccotrypes brevipilosus* and *Coccotrypes fallax* have been found as sap wood borers of mangroves of these islands (Dev Roy *et. al.,* 1984 and *in press*). *Plocaederus obesus* was collected from felled logs of *Heritiera littoralis* in Bambooflat (South Andaman) within the mangrove area in such part of the intertidal zone where sea water could reach only during the high tide and submerged the logs completely (Dev Roy *et. al.,* 1984 and *in press*) (Fig. 76). These logs were found to be heavily infested with larvae which excavated wide and very irregular galleries in the sapwood. These galleries were packed tightly with coarse frass. Exact larval period of this species could not be ascertained. Pupation took place in solid cocoon and pupal chamber was formed inside a shallow

pit under the bark. Cocoons were white, hard, thick, calcareous and oval or 'tortoise-egg'-shaped (Fig. 77). In the laboratory pupal period varied from 240 to 270 days. The mature beetles emerged by breaking the cocoons (Fig. 78).

Benson (1941) described this species as heartwood borer. Khan and Maiti (1983) corroborated the same with the exception of several instances where they observed this species to form pupal chamber in the sapwood. Dev Roy *et. al.* (in press) reported this borer to complete its life cycle in the sapwood of the upper portion of the logs which were found to remain completely submerged under seawater during the hightide, the salinity of which ranged from 32.47°/oo to 34.53°/oo. The pupa within the cocoon was found to be tolerant to seawater for a considerable period and this was ascertained by the fact that adult beetles emerged safely from the cocoon even after keeping the same upto 6 hours per day for successive three days in the seawater having 34.53°/oo salinity and then placing the same in the pupal pit again in the laboratory. It is not clear how larvae withstand saline water. Rather, it has been seen that larvae can not survive if they are exposed to seawater of the above ranged salinity directly for more than an hour. It is yet to be studied whether seawater is soaked by thick layer of frass granules in such a state that water which could reach the larvae does not affect their further development.

The other cerambycid beetle, *Megopis* (*Aegosoma*) *sulcipennis* were found to attack dried up stumps of the mangrove tree, *Sonneratia alba* towards supralittoral zone of the mangrove forest near Uttara Jetty, Kadamtala, Middle Andaman. The larvae mined the sapwood, formed irregular but extensive galleries and occasionally penetrated upto the heartwood. The larval galleries were packed tightly with coarse fibrous frass. After forming a larval chamber inside the tunnel, the mature larvae underwent pupation. The pupal chamber was more or less parallel to the wood fibres (Fig. 79).

Larval period of this species could not be ascertained. Pupation took place between 8 and 10 days in the laboratory. The adult beetles emerged by penetrating the distal end of the chamber forming a more or less circular exit hole of 0.6 to 1.0 cm in diameter. Larvae infested logs were reared in galvanized iron chamber in the laboratory. A total of 19 adults emerged out of which 11 were males and 8 females.

Larvae of a scolytid beetle, *Coccotrypes brevipilosus,* were collected from the sapwood under bark of the felling trees of *Rhizophora* spp in Peel Island (South Andaman). These larvae made burrows which are tiny and pin-headed at the surface and their galleries extended horizontally. In Little Andaman larvae of this beetle were found to make galleries in the sapwood of living *Bruguiera* sp while the adults were collected under bark. Larvae of another scolytid beetle, *Coccotrypes fallax* were collected from under bark and sapwood of *Bruguiera* sp from Campbell Bay, Great Nicobar, during the present investigation. The galleries made by these larvae are more or less similar to those of *C. brevipilosus.* In the mangrove areas of Little Andaman, Kamorta and Great Nicobar islands larvae of some unidentified scarabid beetles were also found to affect the entire felled logs very severely (Fig. 80). Besides, some termites also destroy the mangrove trees by making extensive nests inside heartwood of the tree (Fig. 81). Recently, Das,Dev Roy and Mitra (*in press*) have reported one more scolytid beetle, namely, *Xyleborus bidentatus* and one oedomerid beetle, *Xanthorca* sp as sapwood borers of mangroves of Peel island (South Andaman) and Great Nicobar island respectively.

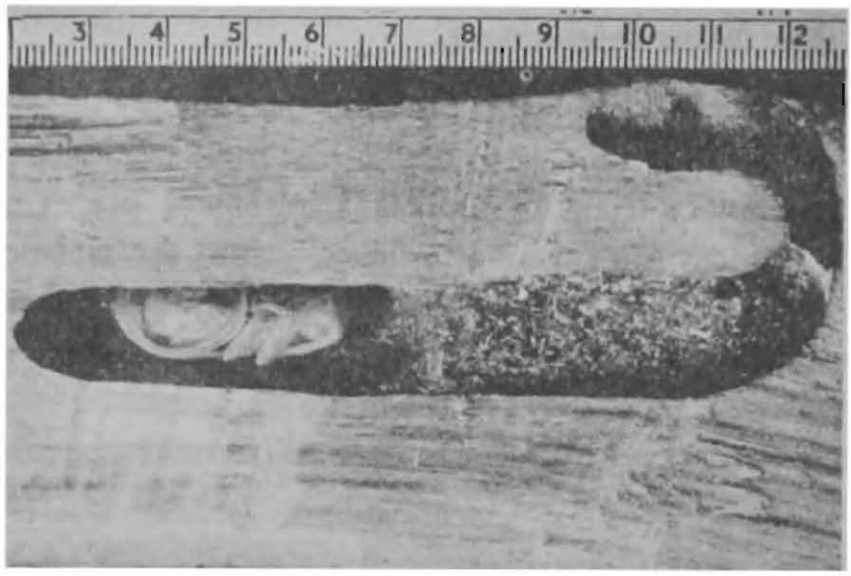



Fig. 73. Pupal chamber of cerambycid beetles *Aeolesthes holoserica,* a hear wood insect borer of mangroves.

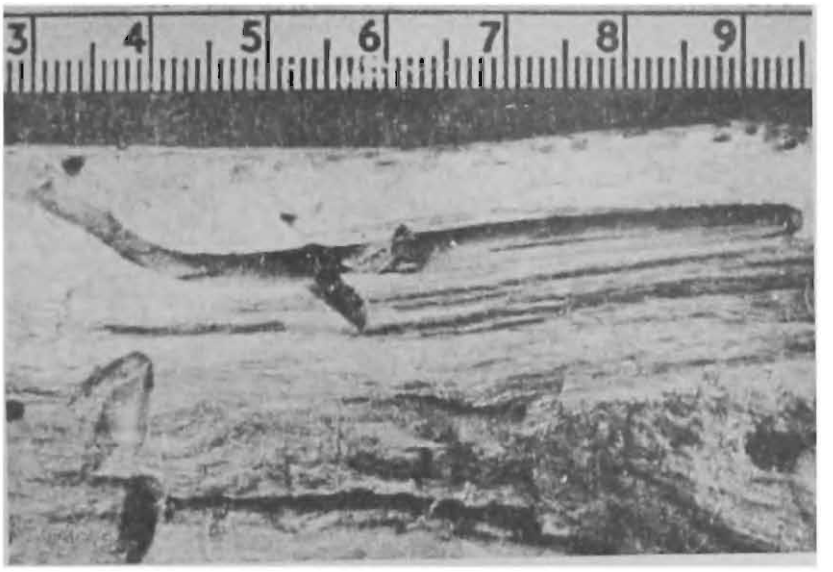



Fig. 74. Pupal chamber of cerambycid beetle, *Cerecium flavipes*.

Fig. 75. A mangrove log severely infested by cerambycid larvae

Fig. 76. Intertidal zone in mangrove areas showing felled mangrove logs infested by insect borer, *Plocaederus obsus*.

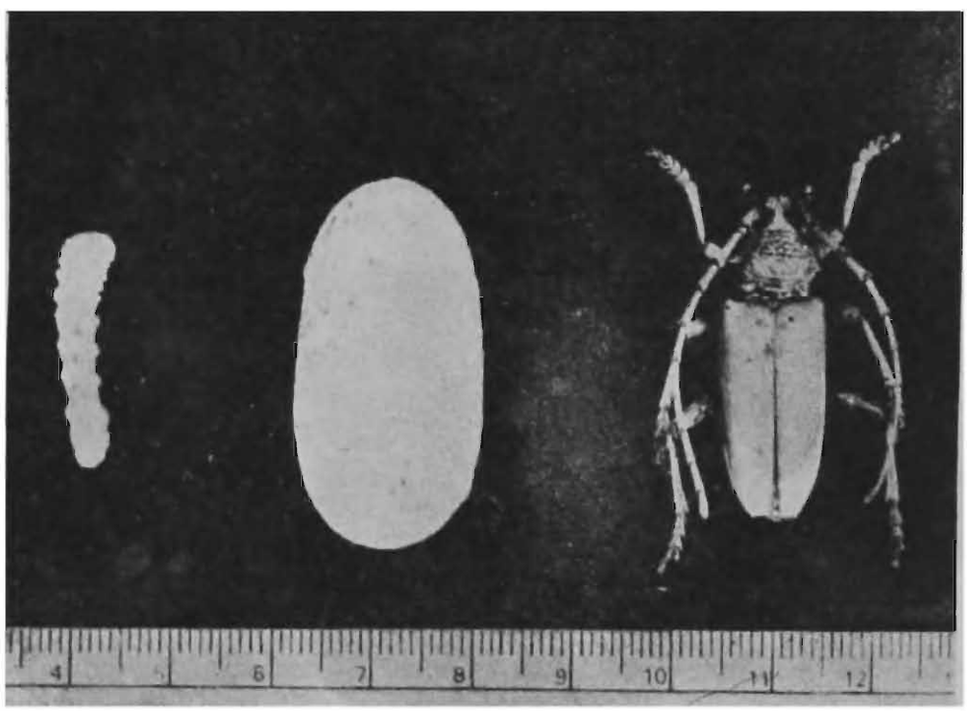



Fig. 77. Larva, pupa and adult of *Plocaederus obesus*.

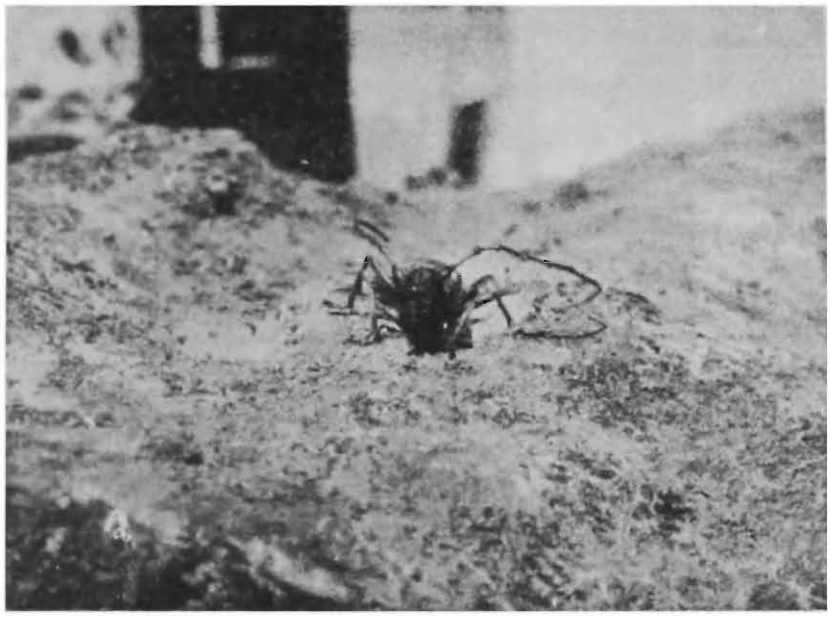


Fig. 78. Emergence of *Plocaederus obesus* from pupal chamber

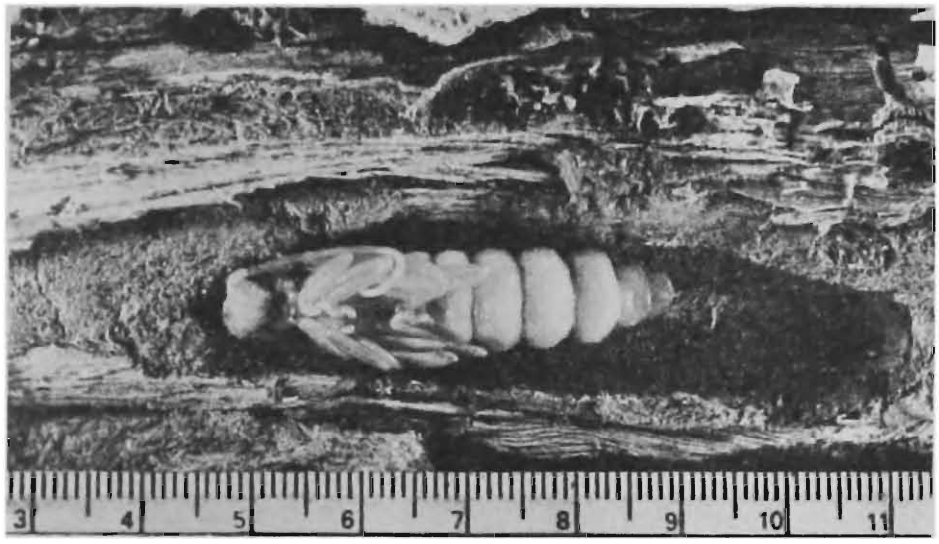



Fig. 79. Pupal chamber of cerambycid beetle, *Megopis (Aegosoma) sulcipennis*

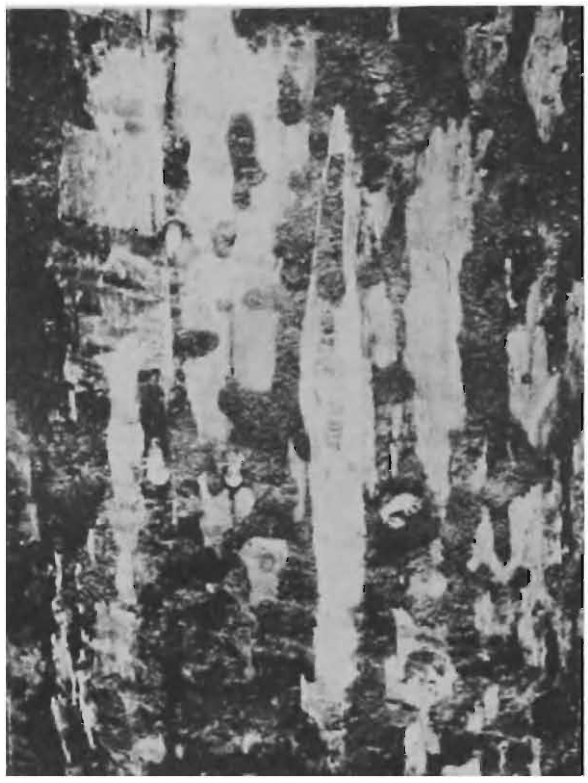


Fig. 80. Larval gallaries of scarabid beetles in decaying wood of *Rhizophora* sp.

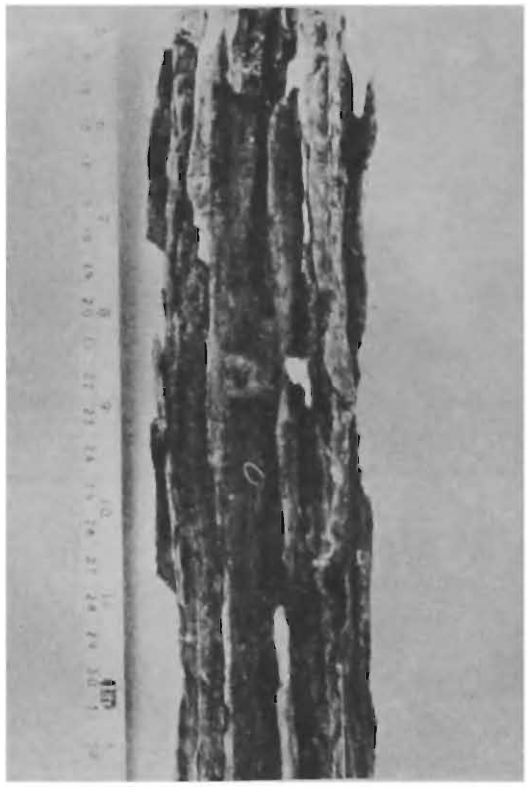


Fig. 81. A log of *Rhizophora mucronata* infested by *Neotermes andamanensis*

*Stem borers :* Green stems of *Acanthus ilicifolius* were found to be heavily infested with Lepidopteran borer in some places of South Andaman (nameiy, Bambooflat and Saitankhari). It is sometimes very difficult to trace the presence of these borers by casual examination of the external part of the stem. However, their existence can be ascertained by the presence of frass granules which come out of the hole and remain adhered to the stem. The larvae were found to feed on the sub-cortical and cortical tissues of the stem to form a cavity inside the stem. In one branch of the plant three internodes to the maximum had been found to be affected by these borers. Inspite of the damage to the stem caused by these borers, the plant looked quite green.

Exit holes of these borers were circular, the diameter of which varied from 3.0 to 4.0 mm. A white to ashy spot may develop around the old exit holes (Fig. 82). The mature larva pupates inside the stem (Fig. 83). Pupa remained enclosed in a brown cocoon. The pupation period varied from 13 to 15 days under laboratory condition.

Fig. 82. Stem of *Acanthus ilicifolius,* showing exit hole of a moth borer.

Fig. 83. Stem of *Acanthus ilicifolius*, showing two cavities (with one pupa in each).

Fig. 84. Damage caused by a moth borer in the stem of *Acanthus ilicifolius*.

Both the wings of the moth are fringed, brown in colour with several black streaks at places. Thorax and abdomen were light yellow and brown respectively.

After the emergence of the adult moth, the cavity of the stem, made by these borers are secondarily invaded by nymphs of cockroach and ant (*Formica* spp). In some cases, we have collected entire life cycle stages of two species of ants consisting of larva, pupa, soldier, winged male and female from the said cavities.

*Fruit borers :* In Andman mangroves, fruits of *Bruguiera gymnorhiza, Sonneratia alba, Xylocarpus granatum* and *Heritiera littoralis* are found to be infested with insect borers.

After bringing the infested fruits from the field and keeping them in the insect rearing chambers, the borers in their adult stages were collected. Fruits of *B. gymnorhiza, S. alba* and *X. granatum* were found to be infested by the micro-lepidoptera while those of *H. littoralis* were affected by the curculionid beetle, *Camptorrhinus humeralis.* In the case of the latter one the fruits were affected after they fell on the ground.

Micro-lepidopteran borers of *X. granatum* were identified as *Hypsipyla robusta* (Pyralidae : Lepidoptera). Identification of other fruit borers is in progress. In the case of *H. robusta,* pupation took place inside the fruit. In the laboratory, pupation period varied from 9 to 11 days (Das and Dev Roy, 1982). In the Indian part of Sunderban mangroves, this moth has been found to destroy a large number of seeds of *Xylocarpus* (= *Carapa*) *moluccensis* (Mathuda, 1957).

In South Andaman, fruits of *Sonneratia alba* were found to be heavily affected by the micro-lepidoptera (Fig. 85), the specific identification of which could not be done. Their pupation took place inside the fruit and pupation period in the laboratory extended to 12 days. Upto 4 holes were found in a single fruit indicating thereby that more than one larva may occur in the same fruit. In some cases two larvae were found in a single fruit.

Fruits of *Bruguiera gymnorhiza* were also infested with microlepidoptera. But in this case pupation took place outside the fruit. The pupa was found to adhere to the fruit by extraneous materials (Fig. 87). Pupation period extended from 9 to 11 days in the laboratory. Not more than one hole was found in a single fruit during the course of this study (Fig. 86).

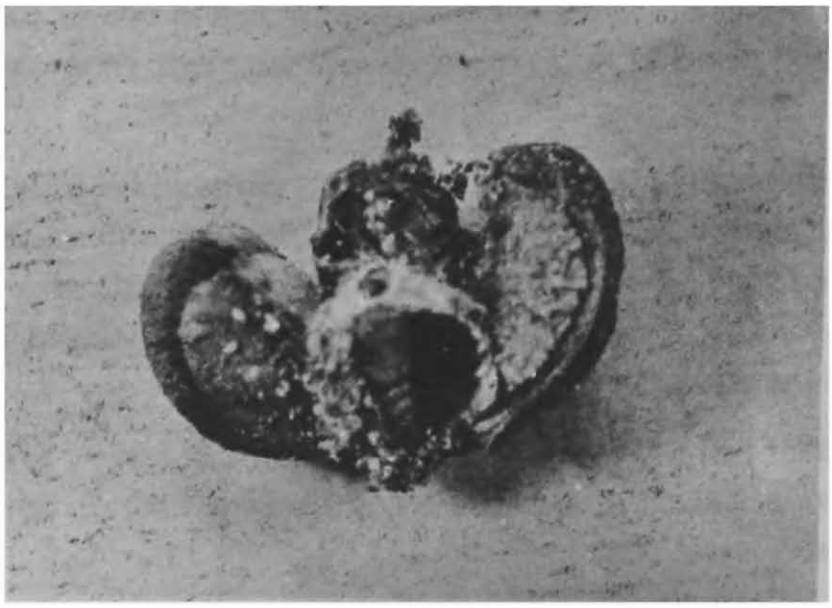


Fig. 85. L.S. of a fruit of *Sonneratia alba*, showing infestation of a moth borer.

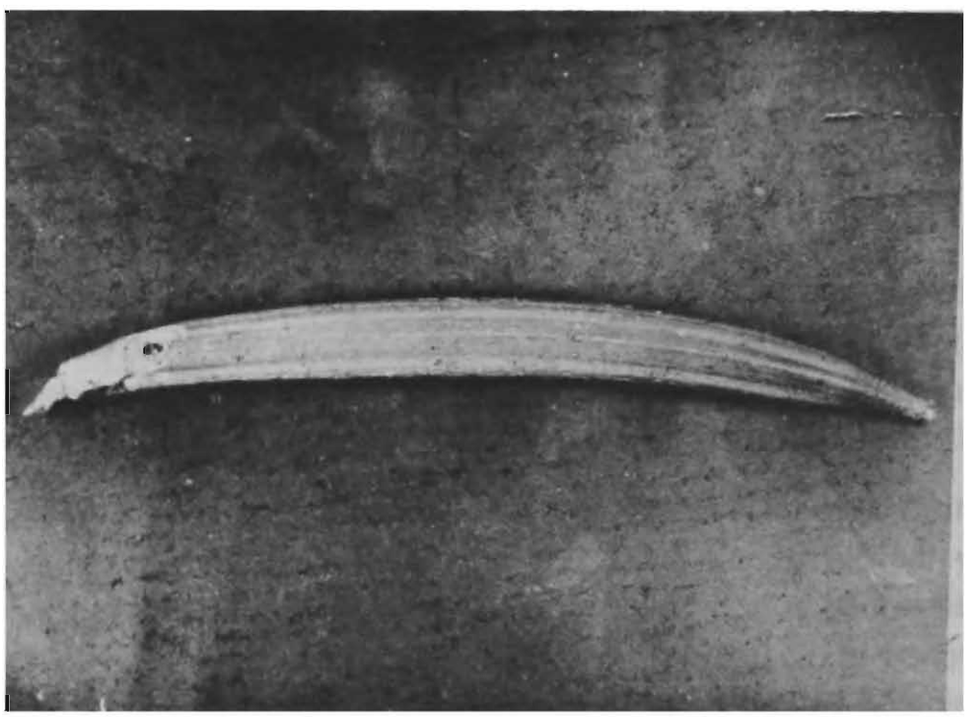


Fig. 86. A fruit of *Bruguiera gymnorhiza*, showing irregular exit hole of moth borer

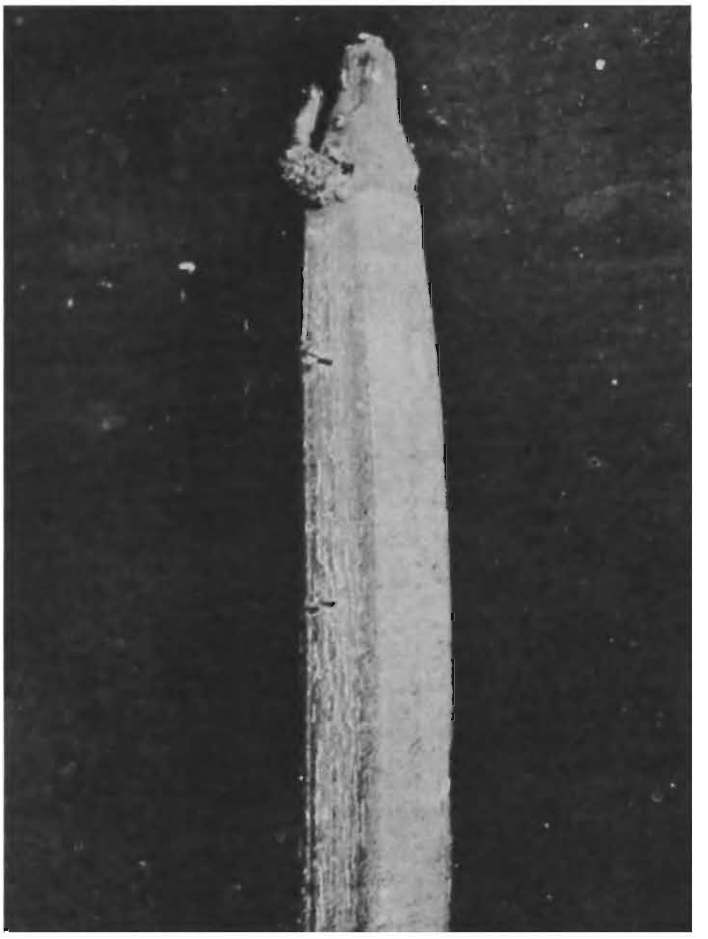


Fig. 87. A fruit of *Bruguiera gymnorhiza*, showing attachment of pupa of a moth borer by extraneous material

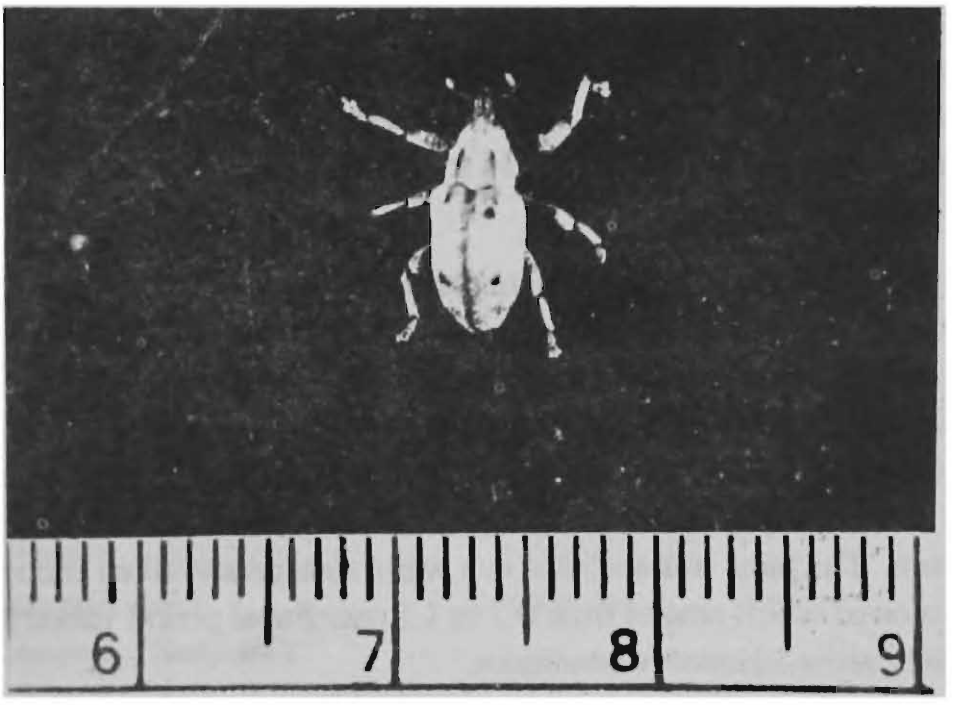



Fig. 88. *Camptorrhinus humeralis*, a fruit borer of *Heritiera littoralis*


Fig. 89. L.S. of a fruit of *Heritiera littoralis,* showing infestation with *Camptorrhinus humeralis*

In some places of South Andaman (namely, Chidyatapu and Bamboo-flat) ripe fruits of *Heritiera littoralis* were found to be heavily infested with larvae of the curculionid beetle, *Camptorrhinus humeralis* (Fig. 88). These larvae fed on the kernal portion and formed pupal chamber in the mesocarp of the fruits (Fig. 89). Size of the pupal chamber varied from 0.65 to 0.75 cm in length and 0.4 to 0.5 cm in width. In the laboratory pupal period ranged from 12 to 18 days. Adults emerged through the exit holes, the diameter of which varied from 0.35 to 0.4 cm. One to five exit holes per fruit were observed.

Fruits of *Heritiera littoralis* were also found to be infested with larvae of an unknown species belonging to family Pyralidae. These fruits were collected on the floor of the mangrove forest of Bambooflat (South Andaman). The identity of this moth is yet to be determined. The larvae were found to be covered with loosely packed frass material. The mature larva formed pupal chamber within those frass material and underwent pupation. The pupa was enclosed in a white transperant silken cocoon, the dimension of which ranged from 0.7 to 1.1 cm. Pupal period varied from 3 to 5 days under laboratory conditions.

Mention may be made here that in the Indian mainland, four species of insect borers - two moths namely, *Hymenoptychis sordida* and *Hypsipyla robusta* (Pyralidae : Lepidoptera) and two species of scolytid beetles, *Coccotrypes* (= *Thamnurgides*) *littoralis* and *T. nephellia* have been recorded as fruit bores of mangrove plants (Beeson, 1941, Mathuda, 1957). These insects affected the *Heritiera* sp, *Xylocarpus* (= *Carapa*) *moluccensis* and *Rhizophora mucronata.*

*Borers of germinating seedlings :* As stated earlier, Beeson (*loc. cit.*) reported the occurrence of *Cryphalus* (= *Epsips*) *littoralis* (Scolytidae : Coleoptera) as borers of the germinating seedlings of *Rhizophora mucronata* in Andaman. At Chidyatapu, Wandoor and Sippighat (South Andaman) we have found the germinating seedlings of *Rhizophora* spp to be infested by scolytid beetles, the specific identity of which is in progress.

List of insect borers of mangroves of Andaman islands has been given in Table 4.

Table 4. List of insect borers reported from the mangroves of Andaman and Nicobar islands.

| Sl. No. | Name of the borers | Plant species | Parts affected |
|---|---|---|---|
| 1. | *Aeolesthes holoserica* (Coleoptera : Cerambycidae) | *Rhizophora apiculata* | heartwood |
| 2. | *Cericium flavipes* (Coleoptera : Cerambycidae) | *Rhizophora* spp | heartwood |
| 3. | *Plocaederus obesus* (Coleoptera : Cerambycidae) | *Heritiera littoralis* | sapwood |
| 4. | *Megopis (Aeogosoma) sulcipennis* (Coleoptera : Cerabycidae) | *Sonneratia alba* | sapwood |
| 5. | *Cryphalus* (= *Epspis*) *littoralis* (Coleoptera : Scolytidae) | *Rhizophora mucronata* and other *Rhizophora* spp. | germinating seedlings |
| 6. | *Coccotrypes brevipilosus* (Coleoptera : Scolytidae) | *Rhisophora* spp *Bruguieria* spp | sapwood |
| 7. | *Coccotrypes fallax* (Coleoptera : Scolytidae) | *Bruguiera* sp | sapwood |

| Sl. No. | Name of the borers | Plant species | Parts affected |
|---|---|---|---|
| 8. | *Camptorrhinus humeralis* (Coleoptera : Curculionidae) | *Heritiera littoralis* | fruit |
| 9. | Scarabid beetles of unidentified species (Coleoptera) | *Rhizophora* sp | felled log |
| 10. | *Hypsipyla robusta* (Lepidoptera : Pyralidae) | *Xylocarpus granatum* | fruit |
| 11. | Moth of unidentified species (Lepidoptera : Pyralidae) | *Bruguiera gymnorhiza* | fruit |
| 12. | Moth of unidentified species | *Sonneratia alba* | fruit |
| 13. | Moth of unidentified species | *Acanthus ilicifolius* | stem |

I. *Galls :* Galls are malformations or abnormal developments of plant bodies, which arise as a result of association between the host plant and parasitic organisms. To be more specific, galls consist of "pathologically developed cells, tissues and organs" of plant parts. The deformities or malformations thus manifested on the plant body may be of simple type or of complicated structures. Information on gall-causing organisms of mangrove forest is very scanty. Lamb (1953) (*see* Chapman, 1976) recorded a mite, *Eriophyes avicenniae* to cause galls on young leaves of *Avicennia marina* var. *resinifera* in NewZealand. An almost identical gall was reported on leaves of *Avicennia officinalis* by Moldenke (1969) (*see* Chapman, 1976). A scrutiny of the literature reveals the record of only two galls each on *Heritiera littoralis* and *Avicennia officinalis* respectively from mangroves of mainland India (Mani, 1973).

Studies on gall-causing organisms from mangrove ecosystem of Andaman islands have been initiated very recently by Sharma *et. al.* (1983, 1984, 1985). Eleven zoocecidia have so far been recorded from four mangrove plant species of which two are of lepidopteran, three dipteran, one hemipteran (Homoptera), one hymenopteran, one of an unknown insect and the rest three are of mite origin (Table 5).

A noteworthy feature of the mangrove galls, hitherto studied, reveals that the galls are of very simple type and barring a single one, all are leaf galls. It may be noted that out of thirty seven plant species of mangroves

Table 5. List of mangrove galls of Andaman and Nicobar islands.

| Gall No. | Gall maker | Host | Part bearing gall |
|---|---|---|---|
| 1. | Unknown lepidoptera | *Avicennia marina* | leaf |
| 2. | *Eriophyes* sp. (Acarina : Eryophyidae) | *A. marina* | leaf |
| 3. | *Dasineura* sp. (Diptera : Cecidomyiidae) | *A. marina* | leaf |
| 4. | Unknown cecidomyiid (Diptera) | *A. marina* | leaf |
| 5. | *Keiferophyes* (=*Aceria*) *avicenniae* (Acarina : Eryophyidae) | *A. marina* | leaf |
| 6. | Unknown homoptera | *A. marina* | leaf |
| 7. | Unknown hymenoptera | *A. marina* | stem |
| 8. | *Dasineura* sp (Diptera : Cecidomyiidae) | *A. marina* | leaf |
| 9. | *Aceria* (=*Eriophyes*) *leptothrix* (Acarina : Eryophyidae) | *Dolichandrone spathacea* | leaf |
| 10. | Unknown insect | *Heritiera littoralis* | leaf |
| 11. | Unknown lepidoptera | *Sonneratia alba* | leaf |

and their associates occurring in Andaman and Nicobar islands, only four are known to bear galls. The occurrence of relatively less number of galls in mangales may be due to the high salt concentration in internal tissues of mangrove plant species which acts against the growth and development of insects as well as in their hatching mechanisma - as pointed out by Chapman (1976).

So far, from the mangroves belonging to the families Sonneratiaceae, Avicenniaceae, Bignoniaceae and Sterculiaceae galls have been observed. These are being dealt with under separate sub-heads as follows :

*Sonneratiaceae :* So far, only one gall has been recorded from *Sonneratia alba* (Sharma *et al,* 1983). The causative agent is an unknown lepidoptera. The galls of *Sonneratia alba* occur mostly on the lower surface of leaves (Fig. 90) but occasionally they may also be formed on the upper surface and also on the leaf margins. As many as four galls have been recorded on a single leaf. The galls of *Sonneratia alba* are simple, compressed, fleshy, devoid of hairs and are greenish-yellow in appearance.

Gall size varies from 10 to 12 mm in length and 3 to 4 mm in width. Each gall contains only one caterpillar. The larvae are whitish or greenish-

yellow and enclosed in gall-cavity. Pupation takes place inside the gall. Pupation lasts for 3 to 4 days. Mention may be made here that we have noted these galls on young plants as well as understorey of tall trees which remained submerged during the high tide at Chidyatapu and Lohabari (South Andaman). Even then, growth of the larvae does not seem to be adversely affected and galls have been found to occur throughout the year. Further, it was observed that the leaf-galls were concentrated in more numbers upto a height of two metres above the ground level. Above this, the upper storey of leaves becomes practically devoid of galls. In the course of present investigation, it has been observed that the lower storey of leaves which were more succulent than the upper canopy were actually susceptible to the gall insects.

*Avicenniaceae* : Eight different zoocecedia forming leaf and stem galls on *Avicennia marina* have so far been reported from the mangroves of South and Middle Andaman islands (Sharma *et al.* 1983, 1984). During the course of field investigation on the zoocecidea of mangroves of Andaman islands it has been found that this species of mangrove plant is highly susceptible to gall formation. Among the eight types of galls seven are leaf galls and one is a stem gall. Insects account for five types of galls (Diptera two, Lepidoptera, Hymenoptera and Hemiptera (Homoptera) one each) while mites are the causative agents of three types of galls. This is to mention here that there is no report so far on the gall of *A. marina* from mainland India although Mani (1973) has described one gall on *A. officinalis* from South India.

The following are the galls of *A. marina* from Bay islands the serial numbers of which are the same as described by Sharma and Das (1984).

*Gall No. 1.* Leaf gall (caused by unknown Lepidoptera)

These are sessile, solitary, glabrous, lenticular, discoid, visible equally from both sides of the leaf blade and form pouch galls. These galls are greenish in colour when young, indehiscent and persistent. Gall cavity is unilocular enclosing a single larva inside. Pupation takes place inside the gall itself. Ostiole is hypophyllous and single exit hole is seen in mature gall. Three to five galls have been recorded on a single leaf. Gall size ranges from 4 to 5 mm in diameter.

These galls have been collected from Phogibalu, Wandoor and Corbyn's Cove (South Andaman).

*Gall No. 2.* Leaf gall (caused by *Eriophyes* sp, Acarina : Eriophyidae)

These are sessile, solitary or agglomerate, subglobose, soft, fleshy, indehiscent, pouch galls, covered with fine, soft, closely crowded ashy hairs above (Fig. 91). Exit hole is epiphyllous, located in the middle of the gall and gall cavity unilocular. Galls are epihypophyllous and visible as small, discoid and discoloured depression from opposite side of the leaf blade. Gall size ranges from 2 to 5 mm in diameter.

Galls may occur throughout the leaf surface, sometimes on petiole and even along midrib at the lower surface as agglomerate masses.

These galls have been collected from the mangrove areas of Wandoor and Lohabari (South Andaman).

*Gall No. 3.* Leaf Gall (caused by *Dasineura* sp., Diptera : Cecidomyiidae)

These are sessile, solitary, globose to subglobose, solid, fleshy, glabrous pouch galls with flattened circular area above (Fig. 92). Galls are dehiscent, persistent and greenish yellow when young and turn brown to dark brown with age. Gall cavity is multilocular. Pupation takes place within the gall. Ostiole is epiphyllous; usually 1-3 exit holes are present in a mature gall. Size of the gall ranges from 5 to 8 mm in diameter and 2 to 3 mm in height on the lower surface of the leaf. Galls occur on leaf surface and their number per leaf varies from 1 to 3.

These galls have been collected from the mangrove areas of Wandoor, Bambooflat (South Andaman) and Bakultala (Middle Andaman).

*Gall No. 4.* Leaf gall (caused by unknown cecidomyiid : Diptera)

These are sessile, compressed, solitary or paired (but never agglomerate), rugose, glabrous pouch galls nearly equally visible from both sides of the leaf blade (Fig. 93). Galls are indehiscent, persistent and dark yellow in colour when young but turn copper red with age. Ostiole is hypophyllous and minute. usually 5-14 exit holes are seen on a mature gall. Gall cavity is unilocular containing many larvae inside. Pupation takes place inside the gall. Size of the gall ranges from 5 to 12 mm in diameter and number of galls per leaf varies from 1 to 4

These galls have been recorded from Lohabari (South Andaman).

*Gall No. 5.* Leaf gall (caused by *Keiferophyes* (= *Aceria*) *avicenniae* ; Acarina : Eriophyidae)

These are simple, sessile, glabrous and epihypophyllous galls visible from sides of the blades. Galls may occur both on upper and lower surfaces of leaves singly or in agglomerate masses. About 100 galls may occur on a single leaf (Fig. 94). Galls are greenish to pale yellowish in colour when young and turn light brown with age. Discoloured depressions at lower surface of the leaf blade, covered with very fine white hairs indicate the site of the gall. Ostiole is epihypophyllous. Gall cavity is unilocular without erineal hairs. Size of ten gall ranges from 1 to 3 mm in diameter.

This gall has been collected from Bambooflat (South Andaman).

*Gall No. 6.* Leaf gall (caused by unknown Homoptera)

These are simple, sessile, epihypophyllous, perfoliate, solid, glabrous, fleshy, pouch galls. These galls occur singly or at times two galls may join together but never agglomerate (Fig. 95). These are discoid and foveate on upper surface of the leaf and conical on lower surface. Galls are indehiscent, persistent and greenish yellow when young and dark brown with age. Ostiole is hypophyllous, operculate or open. Gall cavity is unilocular enclosing a single whitish nymph. Size of the gall varies 2-3 mm in diameter on upper surface. Galls may occur anywhere on the leaf surface and their number per leaf ranges from 2 to 15.

This type of gall has been collected from Phogibalu and Bambooflat (South Andaman).

*Gall No. 7.* Stem gall (caused by unknown Hymenoptera)

These are solitary, irregularly globose or subglobose, verrucose, solid, hard, woody, indehiscent, persistent, unilateral, cortical galls. They are light greenish brown when young and turn brown with age. Gall cavity is multichambered (Fig. 96), with a single larva in each chamber. Chambers are usually oval. Pupation takes place inside the gall. Size of the gall varies from 10 to 20 mm in diameter and 1-3 galls appear on a small tender branch. Usually 5-7 exit holes are seen on a mature gall.

This type of gall has been collected from Betapur (Middle Andaman).

*Gall No. 8.* Leaf gall (caused by *Dasineura* sp : Diptera : Cecidomyiidae).

These galls are elongated oval, irregular, solid, glabrous, epihypophyllous, and equally developed on both the surface of the leaf blade (Figs. 97-98). Size of the gall varies from 5 to 40 mm in length, and 2 to 5 mm in height above the leaf surface. Usually 1-3 galls may arise on the midrib of a single leaf.

Fig. 90. Leaf gall on *Sonneratia alba*, caused by unknown lepidoptera

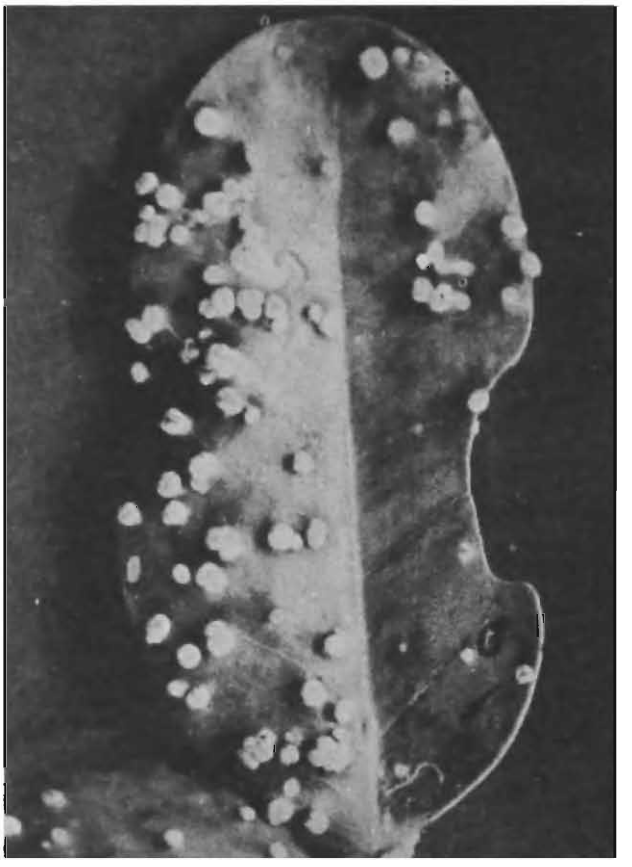


Fig. 91. Gall No. 2: Leaf gall on *Avicennia marina* caused by *Eriophyes* sp.

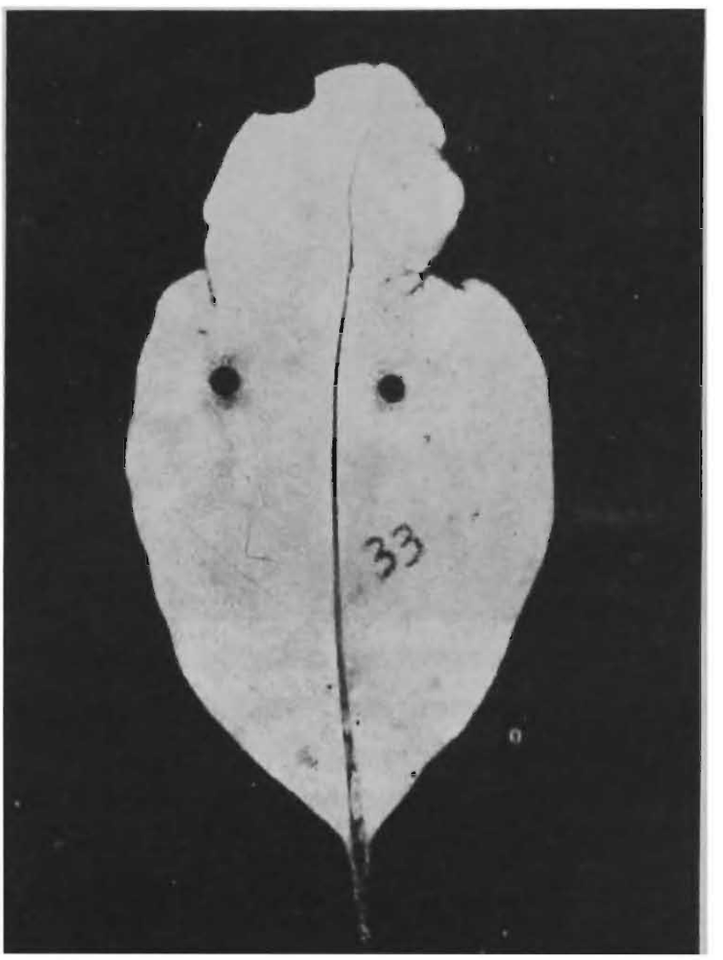



Fig. 92. Gall No. 3: Leaf gall on *Avicennia marina* caused by *Dasineura* sp.

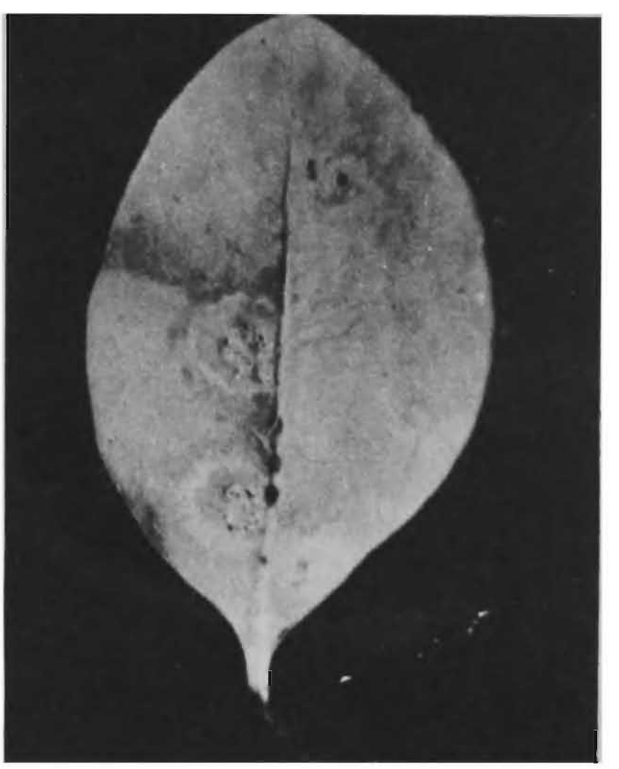


Fig. 93. Gall No. 4: Leaf gall on *Avicennia marina* caused by unknown Cecidomyiid.

Fig. 94. Gall No. 5: Leaf gall on *Avicennia marina* caused by *Keiferophyes avicenniae*

Fig. 95. Gall No. 6: Leaf gall on *Avicennia marina* caused by an unknown hemiptera

Fig. 96. Gall No. 7: Stem gall on *Avicennia marina* caused by an unknown hymenoptera

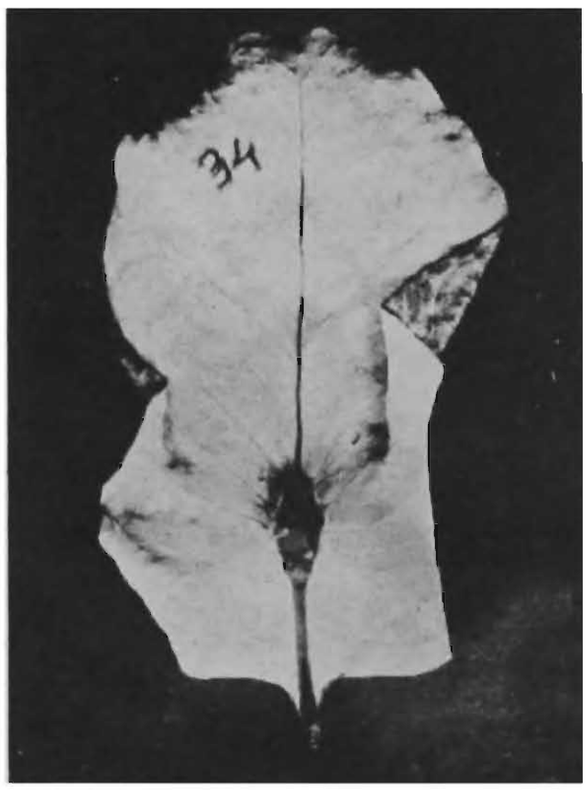



Fig. 97. Gall No. 8: Leaf gall on *Avicennia marina* caused by *Dasineura* sp.

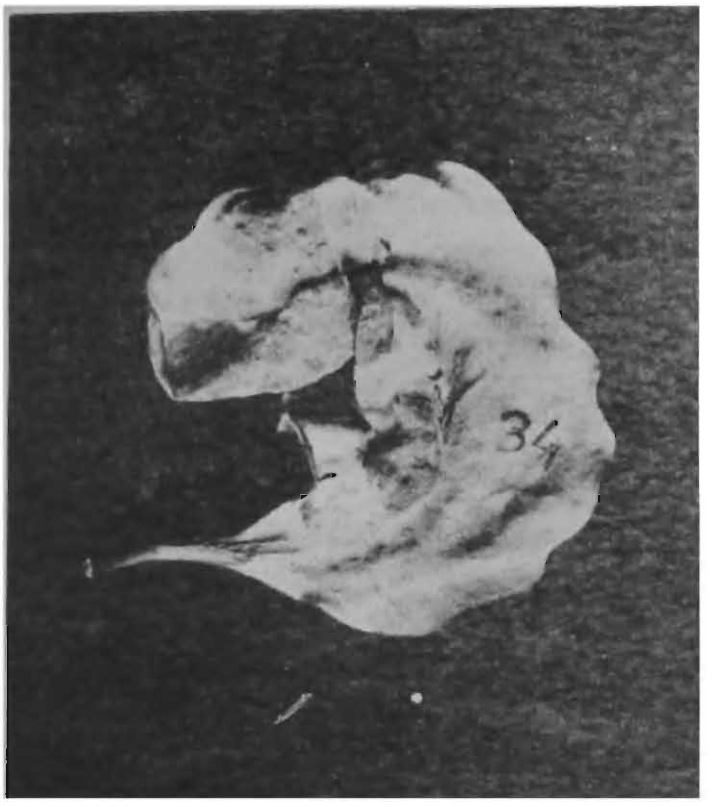


Fig. 98. Gall No. 8: Leaf gall on *Avicennia marina* caused by *Dasineura* sp.

Fig. 99. Leaf gall on *Dolichandrone spathacea* caused by *Aceria leptothrix*

*Sterculiaceae :* Galls of *Heritiera littoralis* occur mostly on the lower surface and very rarely on the upper surface of the leaf. The causative agent is an unknown insect. These galls are pustuloid, sessile, solitary, or at times two or three galls may unite at the base but never form any agglomerate mass. Galls are indehiscent, perisistent and light brown in colour when young and turn dark brown on ageing. Ostiole is hypophyllous and circular, and gall cavity unilocular. Size of the gall varies 2 to 3 mm in diameter. The galls occur throughout the unilocular surface even on stem. As many as 150 galls per leaf have been recorded.

This gall has been collected from Hut bay, Little Andaman.

This is to mention that, this gall is different from Gall No. 735 of Mani (1973), which he described on *Heritiera littoralis* from Sundarbans, West Bengal and from some regions of Coromandal coast.

*Bignoniaceae :* On the leaves of the plant species, *Dolichandrone spathacea* located in the mangrove areas of Corbyn's Cove (South Andaman) galls were observed during the present investigation. The galls are caused by the zoocecidia, *Aceria* (= *Eryophyes*) *leptothrix.* These galls are simple and solitary or paired. They occur on both sides of the leaf (Fig. 99). Swellings are found all along the mid rib or at the base of the lateral veins. Gall cavity is unilocular with erineal hairs. Ostiole is hypophyllous. Gall size measures 0.5 - 0.8 mm in diameter. Usually 5 - 20 galls are found per leaf. Almost every leaf was found to be studied with galls. These galls have been found to occur throughout the year. These are reddish brown and subglobose above and light yellow and bluntly conical below, indehiscent and persistent.

**Associates of mangrove galls**

(i) *Parasites :* For studying parasites of gall-causing organisms, mature galls were brought to the laboratory and kept in glass jars. The mouth of the glass-jars was tied with mulmul. Regular observations were made at least twice a day.

In the course of observations, it was revealed that the lepidopteran larvae causing galls on *Sonneratia alba* were subjected to be parasitized heavily by braconids and chalcids (Hymenoptera) (Sharma *et. al.,* 1983). Cecidomyiidae (Diptera) causing pouch galls on leaves of *Avicennia marina* were also found to be parasitized by chalcids (Sharma *et. al.,* 1984).

(ii) *Other gall associates :* The old deserted galls sometimes get occupied by secondary organisms like insects, mites, pseudoscorpions, etc. This secondarily invaded animals are known as successori. These successori do not have any role in gall formation. They occupy the empty hollow space of the gall after cecidozoa escapes and utilize it merely for shelter.

The succession of mangrove galls has not been properly studied. Sharma *et. al.* (1983) reported the occurrence of black ants in the lepidopteran leaf galls of *Sonneratia alba* after the escape of cecidozoa or parasites. Deserted stem galls caused by unknown Hymenoptera were also found to be occupied by ants (Sharma and Das, 1984).

**VII Centipedes and Pseudoscorpions :**

Centipedes are sometimes found in the underbark, crevices of live and dead mangrove tree and mangrove logs. Out of seventeen species of centipedes known to occur in Andaman and Nicobar islands (Tikader and Das, 1985), only three species, namely, *Rhysida nuda immarginata, Otostigmus scaber* and *O. simplex* have been collected from the live *Rhizophora* spp and *Bruguiera* spp at Sippighat and Wright Myo (South Andaman) above the high tide level.

A few examples of pseudoscorpions belonging to *Hormurus* sp have been collected under bark of the tree trunk of *Rhizophora stylosa* in Rutland Island (South Andaman).

## QUANTITATIVE STUDY

During the present investigation a monthly collection of crabs was made for the calender year, 1982 in the two mangrove areas of South Andaman, namely, Corbyn's Cove and Chidyatapu in order to estimate population density and population percentage of crabs occurring there. Further, benthic molluscs were also collected from a few mangrove areas of South Andaman for studying their population density.

In Corbyn's Cove following three stations were selected for the collection of crabs.

Station 1 ($S_1$) : Adjacent to *Rhizophora* thicket (not under shade); soil muddy, soft to semi fluviatile; water logging very rare; covered almost by all tides.

Station 2 ($S_2$) : Grassy; substratum quite hard, innundated during spring tides only.

Station 3 ($S_3$) : Mangrove trees cut and removed; soil composed of muddy sand; sand particles fine; black soil available at about 6 - 7 cm below the surface; covered by all tides; no water logging.

In Chidyatapu following five stations were selected for quantitative study of crabs.

Station 1 ($S_1$) : Open mud flat; *Rhizophora* thicket 3 - 5 m away; soil soft, black, muddy, usually water-logged; with $H_2S$ smell covered by all tides.

Station 2 ($S_2$) : Adjacent to the root-system of *Rhizophora* - thicket, soil composed of muddy sand, soil particles fine, no water logging and without $H_2S$ smell; covered by all tides.

Station 3 ($S_3$) : Open, pebbly bed around pneumatophores of *Sonneratia* sp; soil quite hard; water logging very rare; covered by all tides.

Station 4 ($S_4$) : Within sparse *Rhizophora* - thicket; sand coarse, mixed with mud, sometimes with conglomerated dead shells and corals; covered by all tides.

Station 5 ($S_5$) : Around a small channel; other condition similar to $S_1$

The crabs were collected from all the said stations after fixing 1 $m^2$ quadrate frame. The specimens were preserved in the field and brought to the laboratory where population percentage of different groups of crabs were calculated as shown in the following Tables.

*[*Abbreviations - 1: *Uca lactea lactea;* 2: *U. dussumieri spinata;* 3: *U. vocans;* 4: *U. tetragonon;* 5: *Ocypode* sp; 6: *Sesarma* spp; 7: Portunid crab; 8: *Macrophthalmus* sp; 9: Other crabs*]*

Table - Station 1: Corbyn's Cove

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | 100.00 | — | — | — | — | — | — | — | — |
| Feb. | 100.00 | — | — | — | — | — | — | — | — |
| Mar. | — | 66.67 | — | — | — | 33.33 | — | — | — |
| Apr. | — | 77.78 | — | — | — | — | — | — | 22.22 |
| May. | — | 100.00 | — | — | — | — | — | — | — |
| June | — | 77.78 | — | — | — | 22.22 | — | — | — |
| July | — | 88.23 | — | — | — | — | — | — | 11.77 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Aug. | — | 91.30 | — | — | — | 8.70 | — | — | — |
| Sept. | 12.50 | 75.00 | — | — | — | 12.50 | — | — | — |
| Oct. | — | 80.00 | — | — | — | 20.00 | — | — | — |
| Nov. | — | 92.40 | — | — | — | 7.60 | — | — | — |
| Dec. | 14.29 | 78.57 | — | — | 7.14 | — | — | — | — |

Table - Station 2: Corbyn's Cove

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | 68.00 | — | 16.00 | — | 8.00 | 4.00 | 4.00 | — | — |
| Feb. | 80.00 | — | — | — | 20.00 | — | — | — | — |
| Mar. | 84.62 | 7.69 | — | — | — | 7.69 | — | — | — |
| Apr. | 63.63 | — | — | — | 27.28 | 9.09 | — | — | — |
| May. | 77.78 | 11.11 | — | — | 11.11 | — | — | — | — |
| June | 85.71 | — | — | — | 9.52 | 4.77 | — | — | — |
| July | 76.20 | — | 2.38 | — | 19.04 | 2.38 | — | — | — |
| Aug. | 69.44 | — | — | — | 27.78 | 2.78 | — | — | — |
| Sept. | 50.00 | 10.00 | 20.00 | — | 20.00 | — | — | — | — |
| Oct. | 78.00 | — | — | — | 16.20 | 5.80 | — | — | — |
| Nov. | 90.90 | — | — | — | 9.10 | — | — | — | — |
| Dec. | 96.16 | — | — | — | 3.84 | — | — | — | — |

Table - Station 3: Corbyn's Cove

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | 60.00 | — | — | — | 30.00 | 10.00 | — | — | — |
| Feb. | 83.33 | — | — | — | — | 16.67 | — | — | — |
| Mar. | 18.89 | — | — | — | 81.81 | — | — | — | — |
| Apr. | 85.71 | — | — | — | — | 14.29 | — | — | — |
| May. | 50.00 | — | — | — | 50.00 | — | — | — | — |
| June | 75.00 | — | — | — | — | 25.00 | — | — | — |
| July | 75.00 | — | — | — | — | 25.00 | — | — | — |
| Aug. | 66.67 | — | — | — | 11.11 | 22.22 | — | — | — |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sept. | 83.33 | — | — | — | — | 16.67 | — | — | — |
| Oct. | 88.00 | — | — | — | 4.80 | 7.20 | — | — | — |
| Nov. | 93.93 | — | — | — | 6.07 | — | — | — | — |
| Dec. | 60.98 | — | — | — | 39.02 | — | — | — | — |

Table - Station 1: Chidyatapu

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | — | — | 100.00 | — | — | — | — | — | — |
| Feb. | — | — | 89.48 | — | — | — | — | 10.52 | — |
| Mar. | 4.56 | — | 90.90 | — | — | — | — | 4.54 | — |
| Apr. | 6.04 | — | 93.96 | — | — | — | — | — | — |
| May. | — | — | 94.88 | — | — | 2.56 | 2.56 | — | — |
| June | 7.14 | — | 92.86 | — | — | — | — | — | — |
| July | 22.22 | — | 77.78 | — | — | — | — | — | — |
| Aug. | — | — | 92.00 | — | — | 4.00 | — | 4.00 | — |
| Sept. | — | — | 100.00 | — | — | — | — | — | — |
| Oct. | — | — | 88.00 | — | — | 8.00 | 4.00 | — | — |
| Nov. | 10.53 | 10.53 | 78.94 | — | — | — | — | — | — |
| Dec. | 16.00 | 4.00 | 70.00 | — | — | 10.00 | — | — | — |

Table - Station 2: Chidyatapu

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | 87.50 | — | — | — | — | 12.50 | — | — | — |
| Feb. | 100.00 | — | — | — | — | — | — | — | — |
| Mar. | 100.00 | — | — | — | — | — | — | — | — |
| Apr. | 100.00 | — | — | — | — | — | — | — | — |
| May. | 100.00 | — | — | — | — | — | — | — | — |
| June | 100.00 | — | — | — | — | — | — | — | — |
| July | 100.00 | — | — | — | — | — | — | — | — |
| Aug. | 100.00 | — | — | — | — | — | — | — | — |
| Sept. | 100.00 | — | — | — | — | — | — | — | — |
| Oct. | 100.00 | — | — | — | — | — | — | — | — |
| Nov. | 100.00 | — | — | — | — | — | — | — | — |
| Dec. | 100.00 | — | — | — | — | — | — | — | — |

Table - Station 3: Chidyatapu

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | 20.00 | — | — | 80.00 | — | — | — | — | — |
| Feb. | — | — | — | 33.34 | — | 33.33 | 33.33 | — | — |
| Mar. | — | — | — | 100.00 | — | — | — | — | — |
| Apr. | 28.58 | — | — | 71.42 | — | — | — | — | — |
| May. | 12.50 | — | — | 87.50 | — | — | — | — | — |
| June | 12.50 | — | — | 87.50 | — | — | — | — | — |
| July | 14.29 | — | — | 85.71 | — | — | — | — | — |
| Aug. | — | — | — | 100.00 | — | — | — | — | — |
| Sept. | — | — | 25.00 | 75.00 | — | — | — | — | — |
| Oct. | 33.33 | — | — | 66.67 | — | — | — | — | — |
| Nov. | — | — | — | 76.00 | — | 15.70 | 8.30 | — | — |
| Dec. | — | — | — | 100.00 | — | — | — | — | — |

Table - Station 4: Chidyatapu

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | — | 88.89 | — | 11.11 | — | — | — | — | — |
| Feb. | 17.64 | 47.05 | 5.89 | 29.42 | — | — | — | — | — |
| Mar. | — | 60.00 | — | 40.00 | — | — | — | — | — |
| Apr. | 7.69 | 53.85 | — | 38.46 | — | — | — | — | — |
| June | 7.14 | 35.72 | 28.58 | 21.42 | — | — | — | — | 7.14 |
| July | 11.11 | 55.56 | — | 33.33 | — | — | — | — | — |
| Aug. | — | — | 33.33 | 66.67 | — | — | — | — | — |
| Sept. | — | 66.67 | — | 33.37 | — | — | — | — | — |
| Oct. | — | 80.00 | — | 20.00 | — | — | — | — | — |
| Nov. | 5.88 | 70.59 | — | 23.53 | — | — | — | — | — |
| Dec. | 8.33 | 58.34 | 8.33 | 25.00 | — | — | — | — | — |

*Data of May not taken

Table Station 5: Chidyatapu

| Month | Population percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Jan. | — | — | 100.00 | — | — | - | — | — | — |
| Feb. | — | — | 62.50 | — | — | - | — | — | 37.50 |
| Mar. | — | — | 100.00 | — | — | | — | — | — |
| Apr. | | 3.45 | 93.10 | — | — | — | — | 3.45 | — |
| May. | | 20.00 | 80.00 | — | — | — | — | — | — |
| June | | — | 100.00 | — | — | — | — | — | — |
| July | | 18.18 | 72.72 | — | — | — | — | — | 9.00 |
| Aug. | — | 16.67 | 75.00 | — | — | 8.38 | — | — | — |
| Sept. | | 75.00 | — | — | — | 25.00 | — | — | — |
| Oct. | | — | 100.00 | — | — | — | — | — | — |
| Nov. | | — | 100.00 | — | — | — | — | — | — |
| Dec. | — | — | 100.00 | — | — | — | — | — | — |

When population percentage of fiddler crabs in relation to other associated crabs are featured in histograms station-wise (Fig. 100-107), then zonation of different species of *Uca* becomes remarkably distinct. In all the three stations of Corbyn's Cove studied for the purpose, *Uca lactea lactea* was available at least in some seasons although this subspecies was most dominant in $S_2$ and $S_3$. *Uca dusumieri spinata* was found to be dominant in $S_1$ except in January and February. This subspecies was found to invade $S_2$ occasionally but never found in $S_3$ during the period under investigation (Figs. 100-102).

In the mangrove areas of Chidyatapu four species of fiddler crabs, namely, *Uca lactea lactea, U. dussumieri spinata, U. vocans* and *U. tetragonon* were available. Here, $S_2$ was the *lactea*-zone (Fig. 104) although this subspecies was found to occur in all the stations of Chidyatapu except in $S_5$. The dominant fiddler crabs of $S_1$ and $S_5$ were *U. vocans* (Figs. 103, 107) and those of $S_3$ and $S_4$ were *U. tetragonon* and *U. dussumieri* respectively (Figs. 105, 106). The notable feature of $S_4$ was the presence of three to four species of fiddler crabs at a time in most of the seasons.

Nature of substratum and tidal inundation seem to influence most the distribution of fiddler crabs in the different mangrove zones.

The average population density per $m^2$ of the mangrove crabs collected from the said stations are presented below.

| Sl. No. | Name of the species | Average size of carapace width (mm) | Average population density $m^2$ |
|---|---|---|---|
| 1. | *Uca lactea lactea* | 18 | 50 |
| 2. | *U. dussumieri spinata* | 30 | 12 |
| 3. | *U. vocans* | 20 | 34 |
| 4. | *U. tetragonon* | 21 | 7 |
| 5. | *Ocypode ceratophthalmus* | 45 | 7 |
| 6. | *Dotilla myctiroides* | 6 | 33 |
| 7. | *Metaplax crenulata* | 39 | 12 |
| 8. | *Scylla serrata* | 80 | 1 |
| 9. | *Sesarma taeniolata* | 42 | 3 |
| 10. | *Metasesarma rousseauxi* | 20 | 2 |
| 11. | *Baptozius vinosus* | 65 | 1 |
| 12. | *Macrophthalmus convexus* | 24 | 3 |

The following were the average density per $m^2$ of different species of molluscs in different mangrove areas of South Andaman.

| Species | Average density/$m^2$ | Species | Average density/$m^2$ |
|---|---|---|---|
| GASTROPODA | | | |
| 1. *Nerita albicilla* | 6 | 10. *Clypeomonas trailli* | 30 |
| 2. *N. chamaeleon* | 7 | 11. *Onchidium tigrinum* | 3 |
| 3. *N. planospira* | 3 | 12. *Assiminea brevicola* | 358 |
| 4. *N. polita* | 4 | 13. *Melampus striatus* | 6 |
| 5. *N. semirugosa* | 3 | BIVALVIA | |
| 6. *Neritina violacea* | 6 | 14. *Gafrarium tumidum* | 3 |
| 7. *Cerithidea quadrata* | 5 | 15. *Geloian galatheae* | 4 |
| 8. *Terebralia palustris* | 46 | 16. *Batissa inflata* | 3 |
| 9. *Cerithium corallinum* | 18 | 17. *Batissa similis* | 2 |

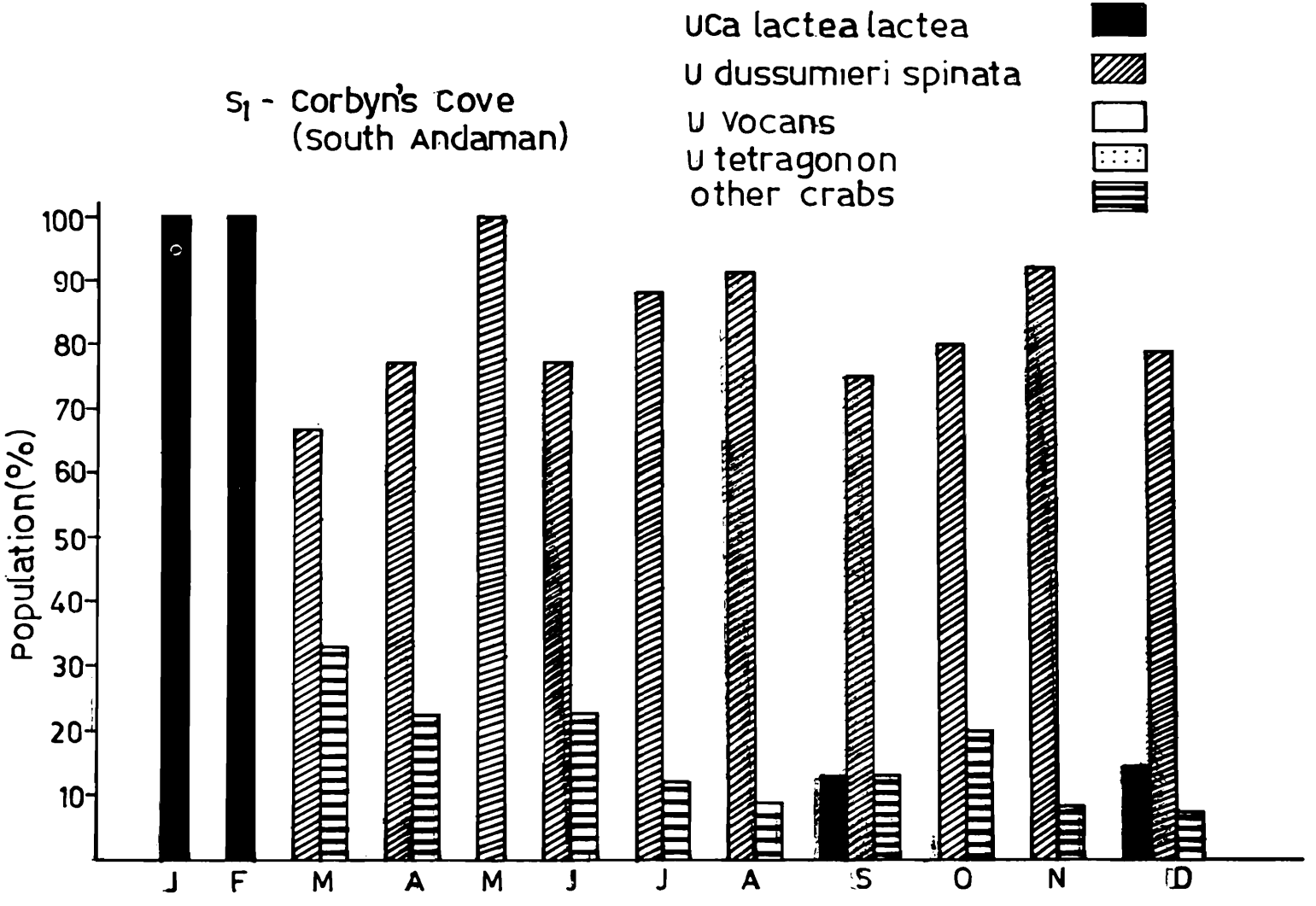



Fig. 100. Population percentage of fiddler crabs at $S_1$, Corbyn's cove.

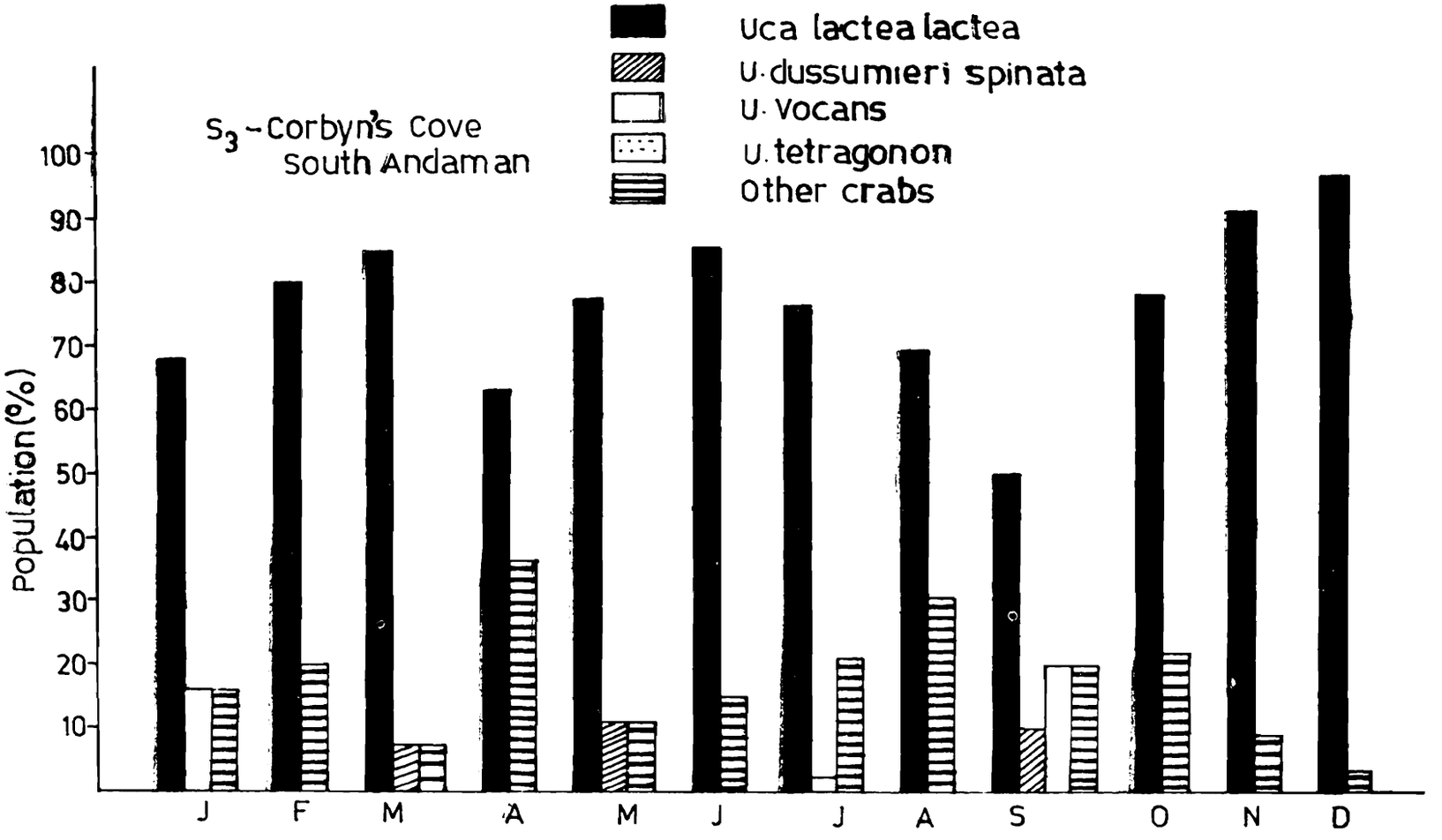



Fig. 101. Population percentage of fiddler crabs at $S_2$, Corbyn's cove.

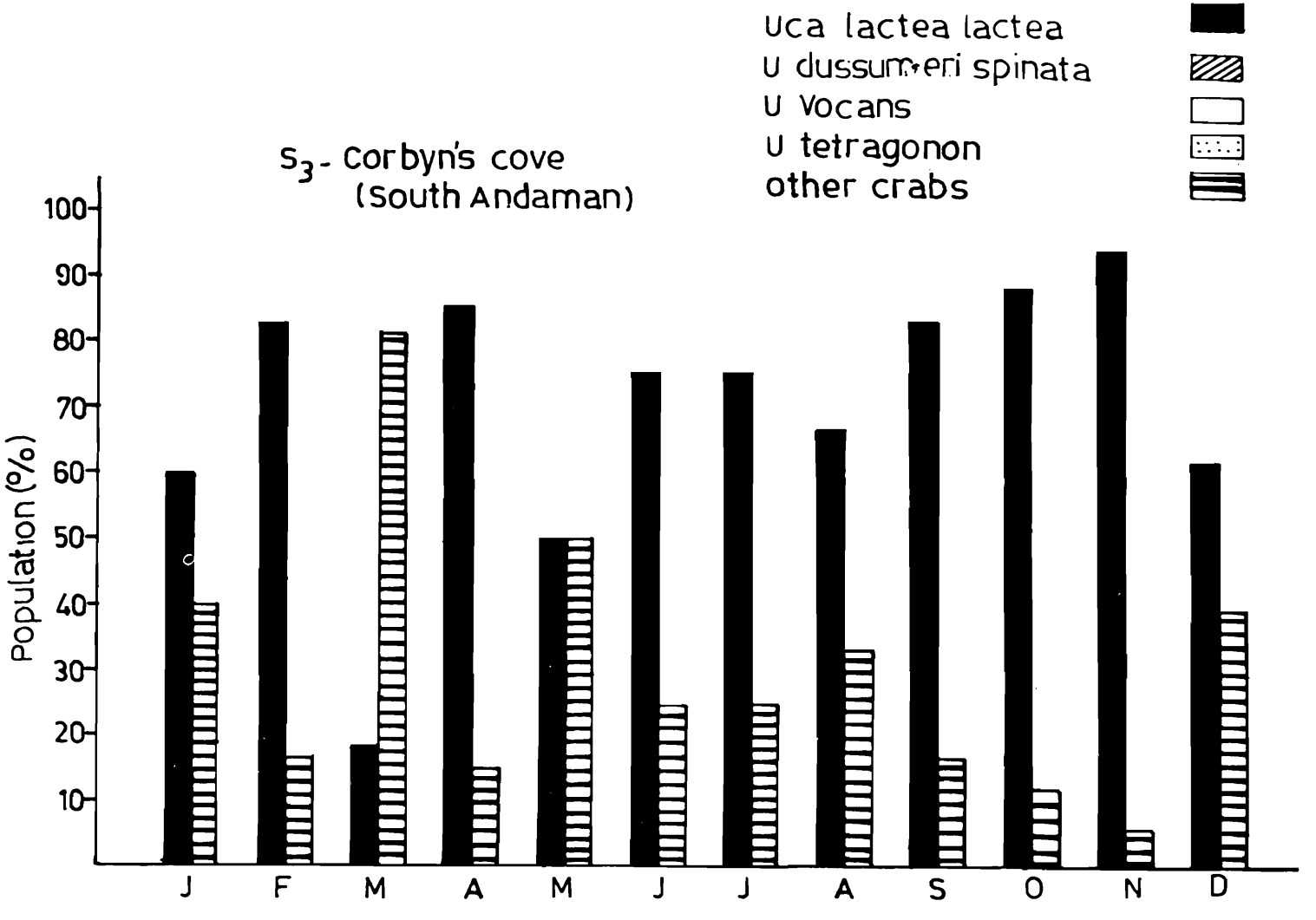



Fig. 102. Population percentage of fiddler crabs at $S_3$, Corbyn's cove.

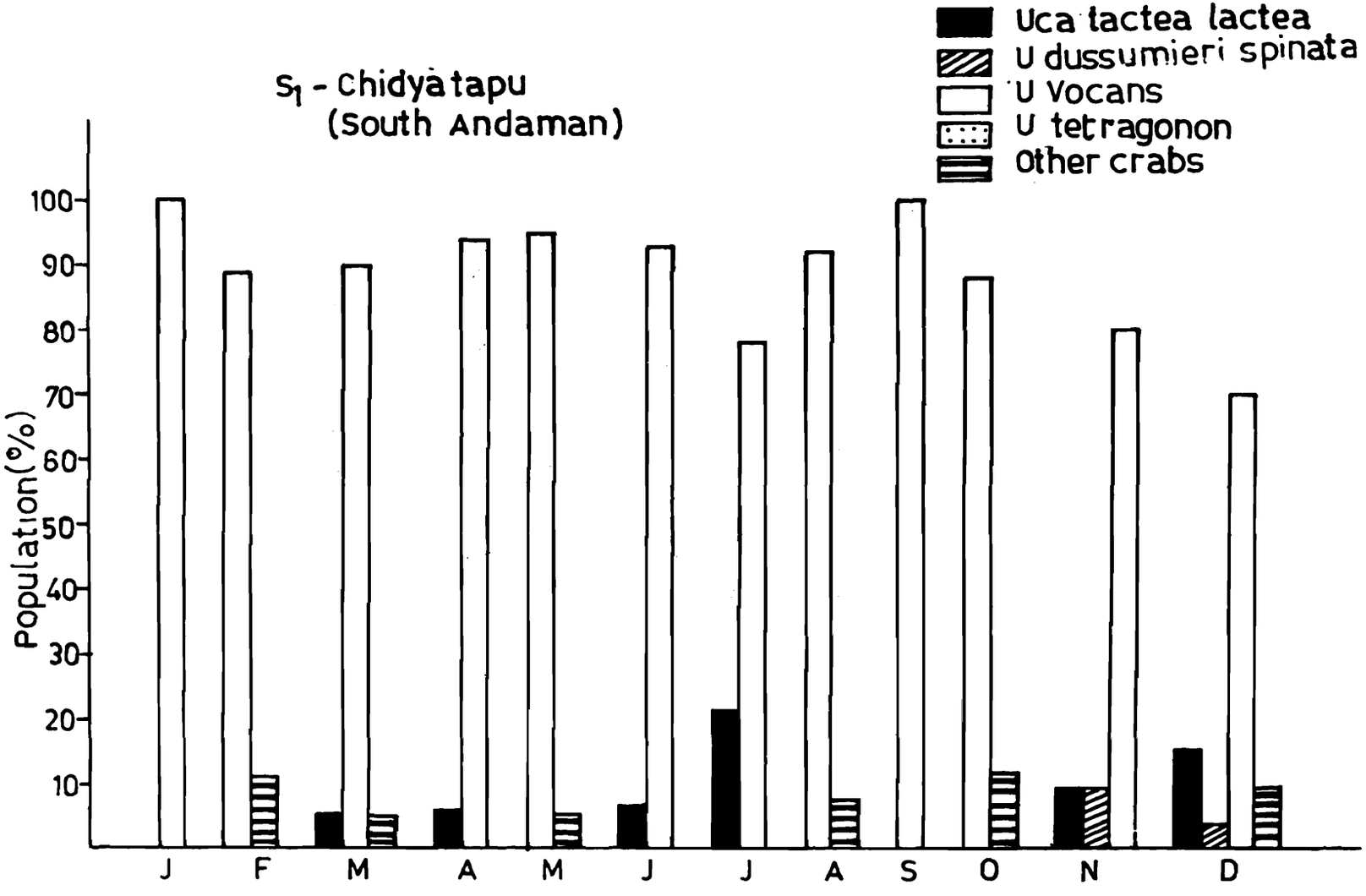



Fig. 103. Population percentage of fiddler crabs at $S_1$, Chidyatapu

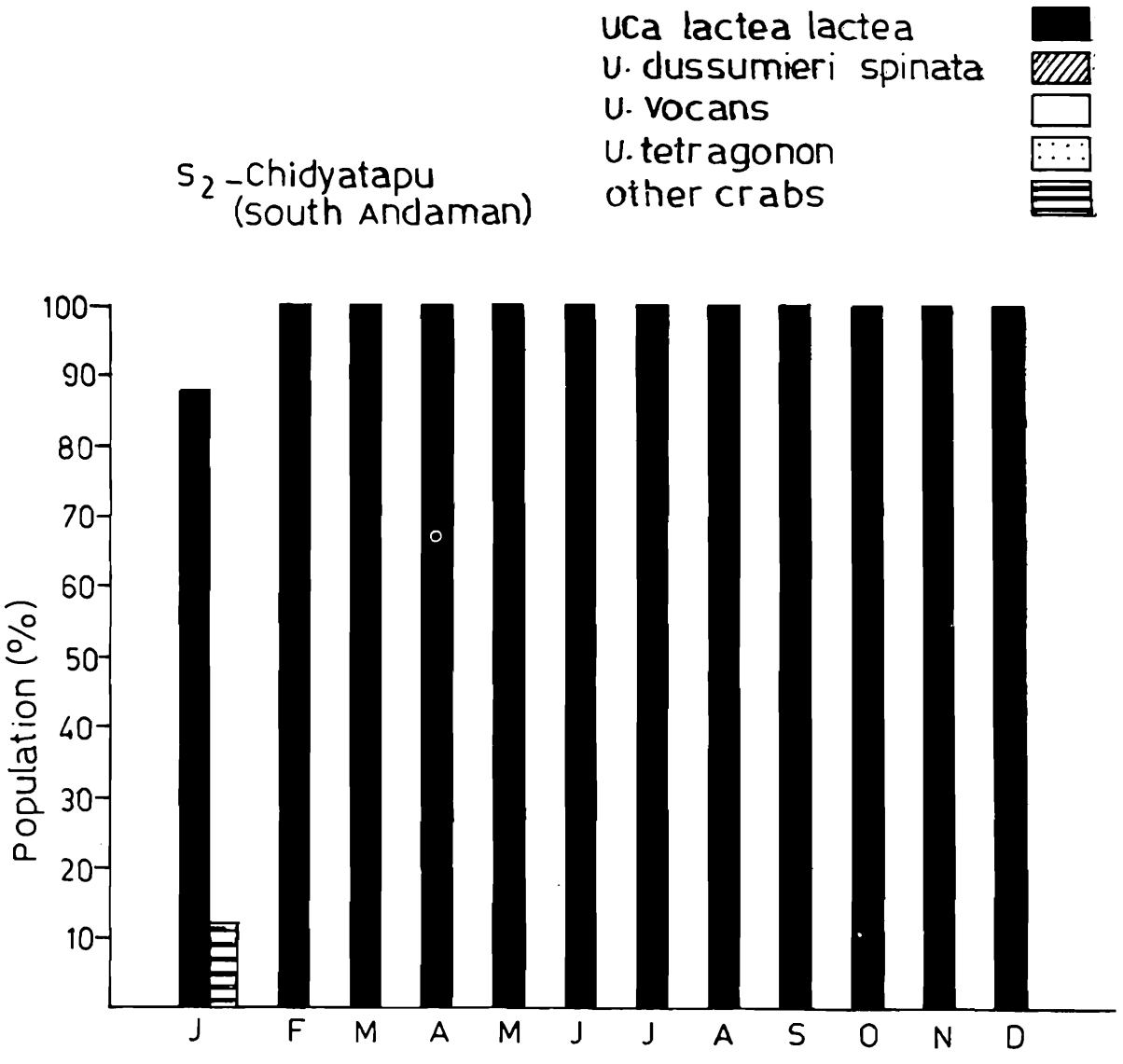



Fig. 104. Population percentage of fiddler crabs at $S_2$, Chidyatapu

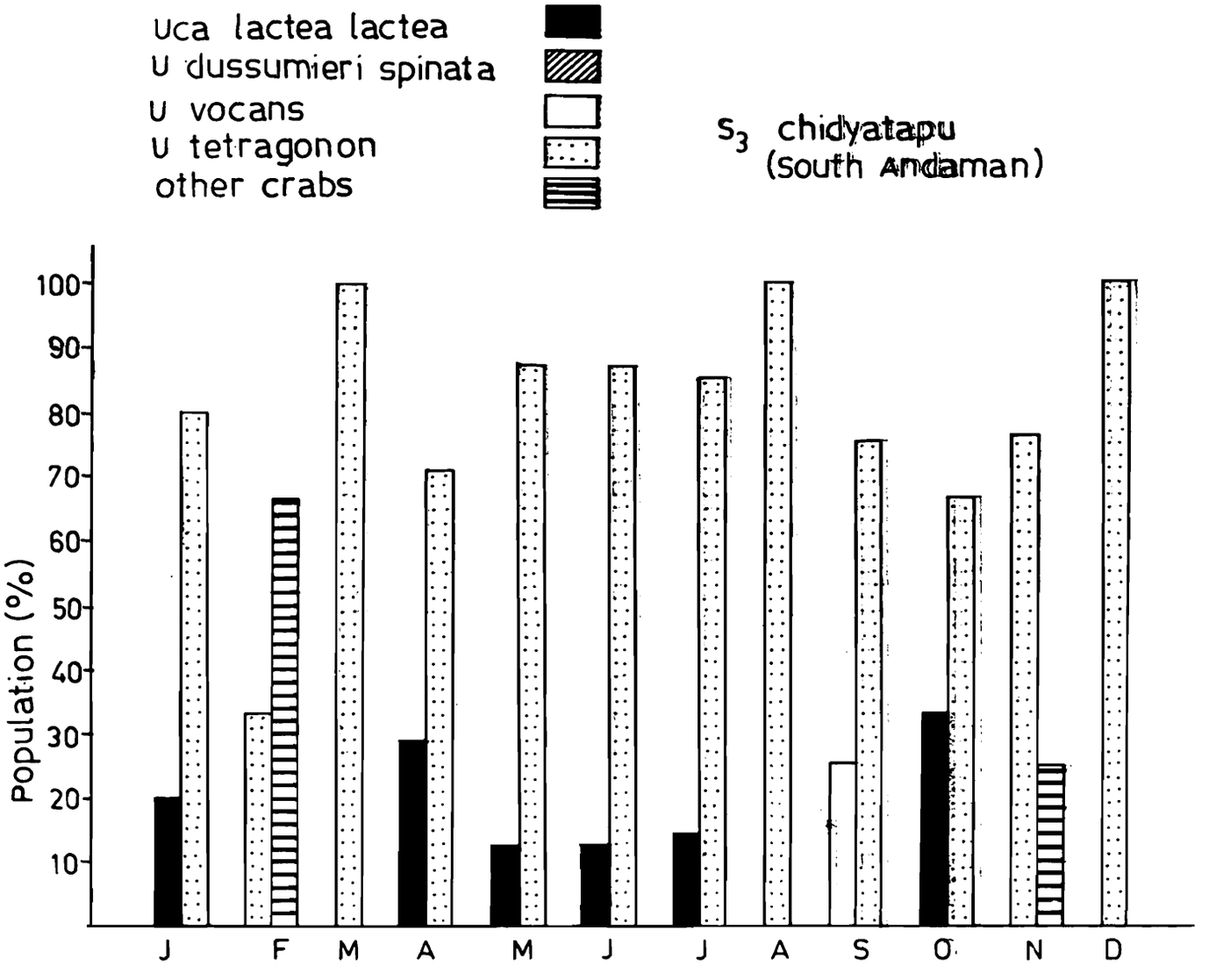



Fig. 105. Population percentage of fiddler crabs at $S_3$, Chidyatapu.

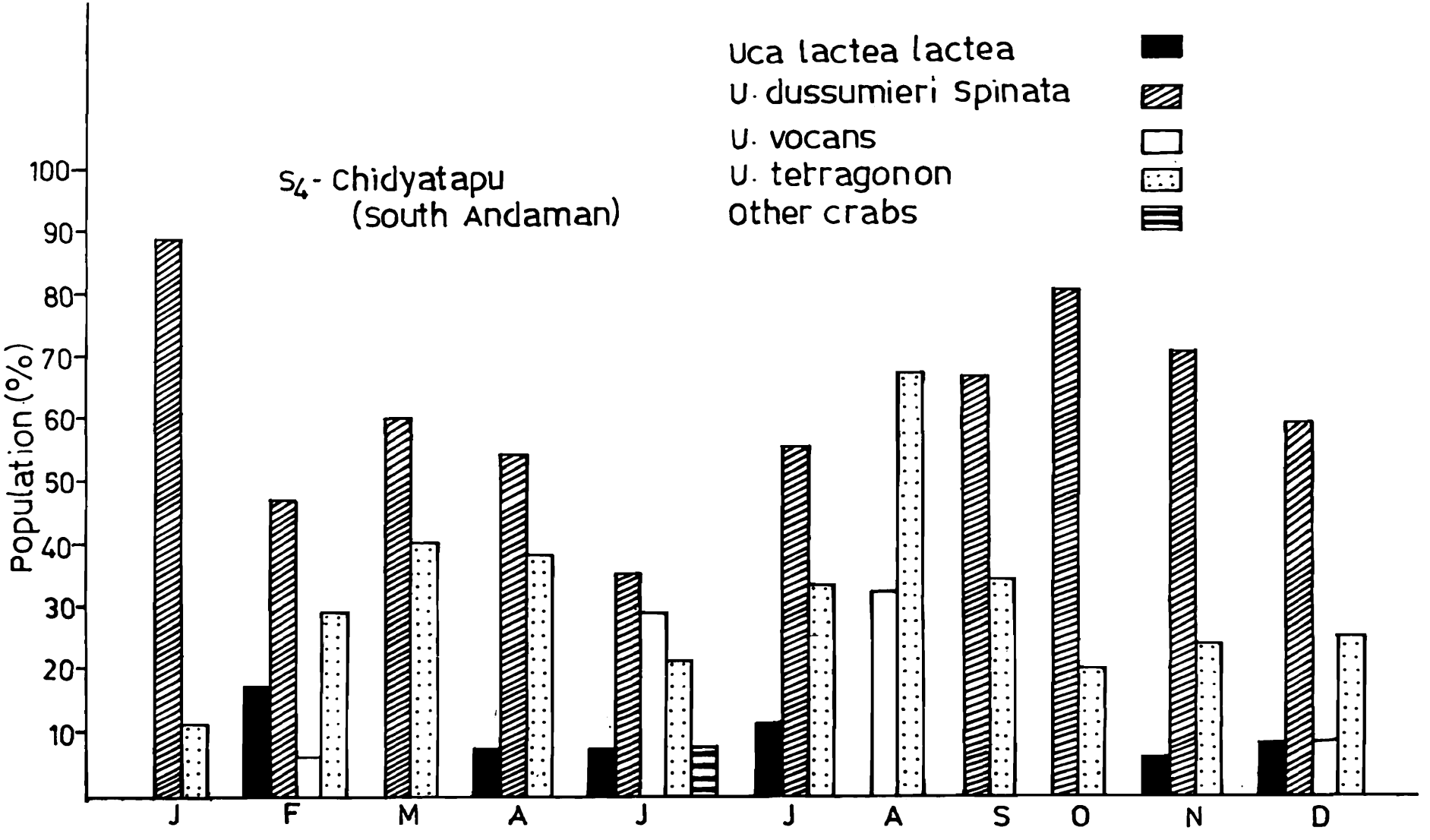



Fig. 106. Population percentage of fiddler crabs at $S_4$, Chidyatapu

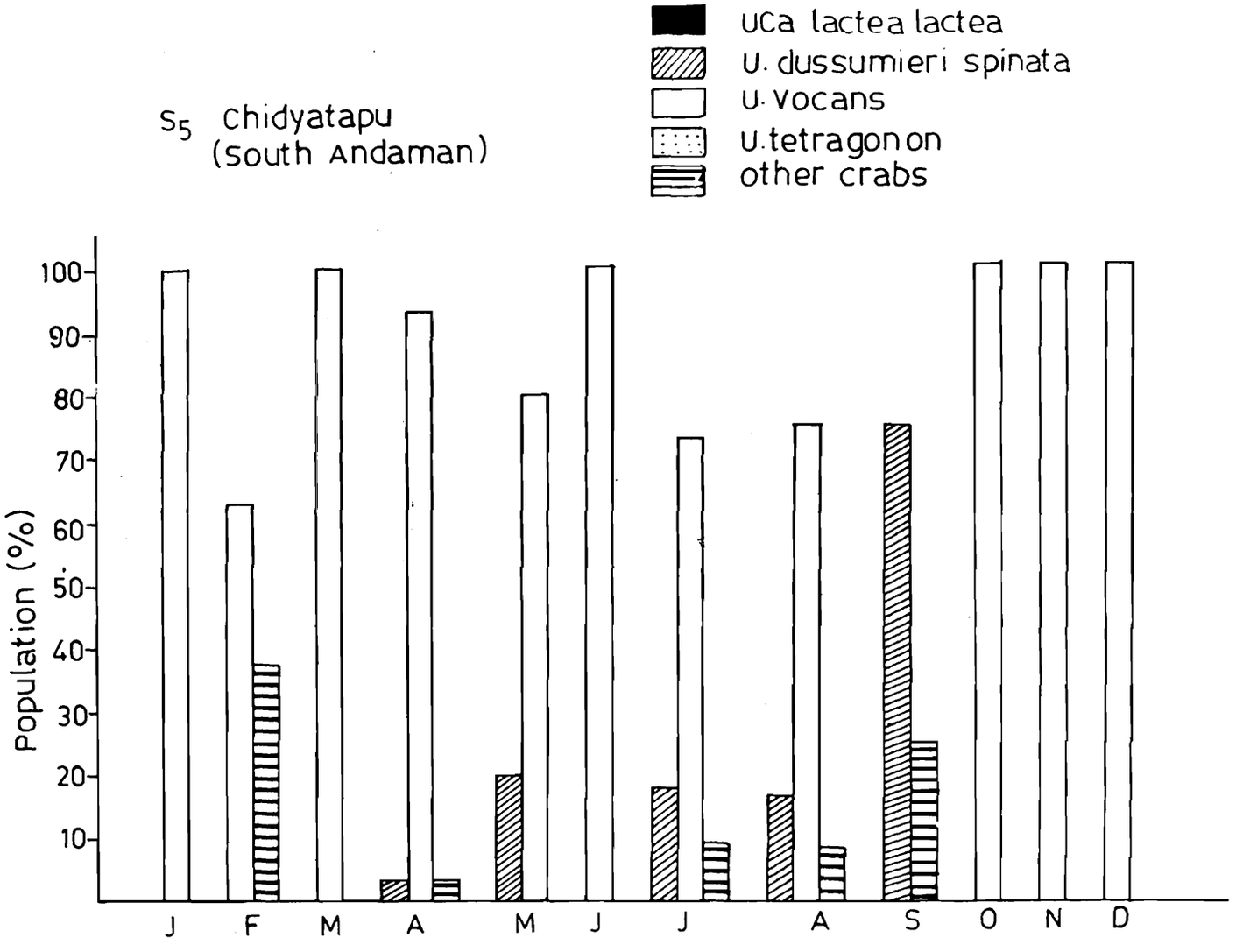



Fig. 107. Population percentage of fiddler crabs at $S_5$, Chidyatapu

## FAUNAL ZONATIONS

In addition to species composition one can differentiate various zones in mangroves in respect of flora and fauna. In the mangales of Andaman and Nicobar islands a dense curtain of *Rhizophora* - zone on either side of the channels followed by *Bruguiera* - zone may be demarcated in some places. But these mangrove tree zones are very narrow and are found to be devoid of any characteristic fauna. Therefore, faunal zonations based on mangrove tree zones as are reported from the mangroves of Indo Malaysia, Australia and New Zealand (Macnae, 1968, Chapman, 1976) are not tenable in the Bay islands. Verway (1930) proposed mangrove zonations in Indonesia based on dominant species of crabs that inhabit the area. He had identified five different sones: *Sesarma taeniolata* - zone, *Uca consobrinus* - zone, *Uca signatus* - zone, *Metaplax elegans* - zone and *Scylla serrata* - zone. In order to study vertical distribution of mangrove fauna Berry (1963) identified three zones, namely, High Tree zone, Lower Tree zone and Marginal zone. Faunal zonations made by Verway (*op. cit.*) cover the mangrove areas only partly and do not properly include vertical distribution of mangrove fauna in relation to tidal amplitude. Berry's zonations, on the other hand, do not satisfy the horizontal distribution of mangrove fauna in relation to tidal exposure.

For describing the vertical as well as horizontal distribution of mangrove fauna Macintosh (1984 b) recognised six zones - *Littorina* -zone, *Nerita* - zone, *Sesarmid* - zone, Fiddler crab-zone, Bivalve - zone and Burrower - zone. Since most of the bivalves of mangroves are either mud-burrower or wood-borers, the last two zones seem to be non-exclusive and confusing.

Dwivedi *et. al.* (1974) recognised five zones in the mangroves of Goa, namely, *Littorina* - zone, *Nerita* - zone, Barnacle - oyster zone, *Uca* - zone and Polychaete - zone. These zonations with little modification seem to be convenient for explaining the distribution of mangrove fauna of the Bay islands as discussed below.

1. *Littornia - zone :* This zone extends upward of Highest High Water Spring (H H W S) and corresponds with the High Tree zone of Berry. The dominant organism is the periwinkle gastropod, *Littornia scabra* and its important associate is *Cerithidea quadrata.* Horizontally, this zone is well above tidal influence. Here gecarcinid crab, *Cardisoma carnifex* and hermit crab, *Coenobita cavipes* also occur.

2. *Nerita - zone :* It corresponds with Lower Tree zone of Berry. In this zone dominant species are *Nerita semirugosa, N. articulata* and *N. planospra.* Upper and lower limits of this zone are bounded by H H W S and Mean Sea Level (M S L) respectively.

3. *Barnacle - oyster zone :* It extends between M S L and Mean Lower Low Water (M L L W). This zone is populated mainly by fouling organisms like *Balanus amphitrite, Saccostrea cucullata, Crassostrea* spp, *Isognomon ephippium, Modiolus striatulus,* etc. Brachyuran crabs, *Sesarma* spp are also found in this area. Hence, it corresponds Sesarmid-zone of Macintosh.

4. *Fiddler crab - Polychaete zone :* This zone lies below M L L W and corresponds with Berry's Marginal zone. It also includes last three zones of Macintosh (*op. cit.*) and last two zones of Dwivedi *et. al.* (op. cit.). In the mangroves of Andaman and Nicobar islands Polychaete - zone can not be demarcated singly.

Dominant animals of this zone are the fiddler crabs (*Uca* spp) excepting a very narrow area (10-15 m width) near Lowest Low Water Mark where Polychaetes are dominant. Important associates are gastropods (belonging to *Cerithidea* sp, *Cerithium* spp, *Terebralia palustris, Ellobium* sp, *Melampus* sp, *Cassidula* sp, etc.), mud burrowing bivalves, variety of crabs, mud lobster and gobiid fishes.

This is to be noted here that these faunal zonations pertain to aquatic and semi-aquatic elements and exclude terrestrial fauna of the mangrove ecosystem.

## GENERAL REMARKS

Mangroves of most of the places of Andaman and Nicobar islands are least disturbed mainly due to bottle- neck in communication. Perhaps due to this reason as well as insularity mangrove ecosystem of these islands sustains very rich and diversified faunal elements as is evident from our foregoing discussion. However, as a result of human settlement and other developmental activities some mangrove areas of Andaman islands suffer from denudation and encroachment of man and his domestic animals (Figs. 108-111).

The noteworthy feature of the mangrove fauna of Andaman and Nicobar islands is that amongst macrobenthic forms, especially molluscs and

Fig. 108. Coconut plantation within the mangrove areas at Sippighat (South Andaman)

Fig. 109. Mangrove trees cleared at Sippighat (South Andaman) for developmental activities

Fig. 110. Mangrove trees at Lohabari (South Andaman) used for fuel.

Fig. 111. Mangroves encroached by livestock of man

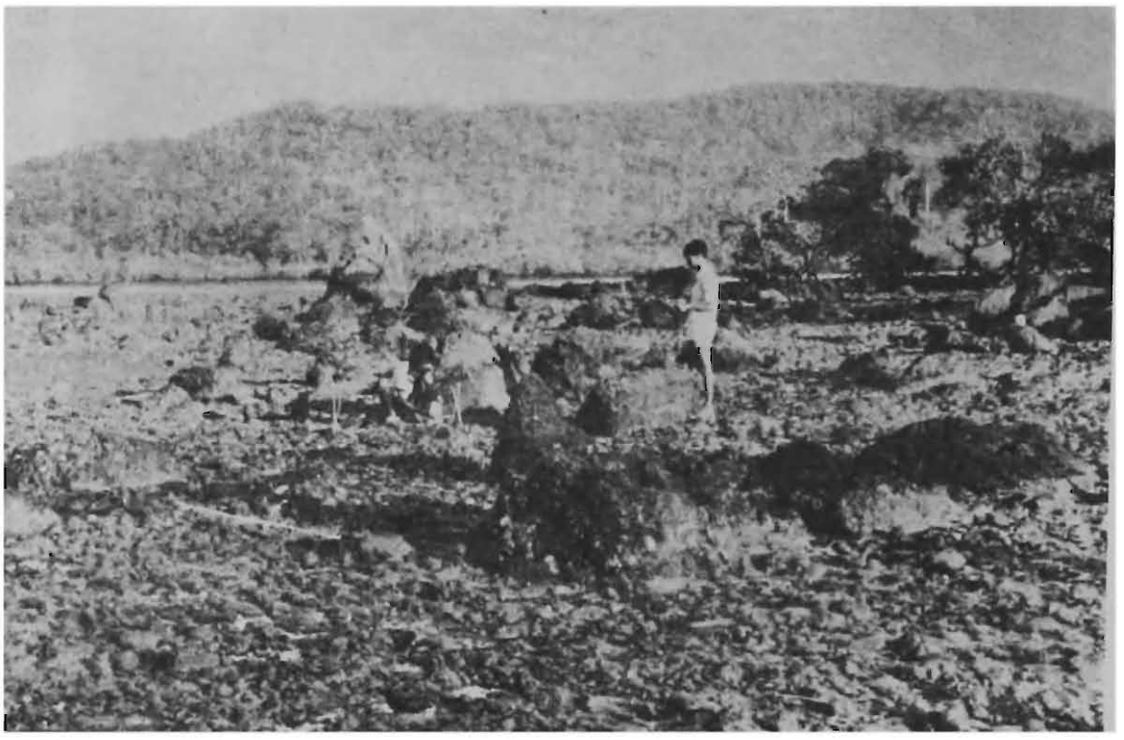


Fig. 112. Mangroves near wave swept rocky shore at Chidyatapu (South Andaman)

Fig. 113. Pneumatophores of mangrove trees emerging from pebbly bed in South Andaman

Fig. 114. Patchy mangroves near rocky shore of Peel island (Ritchie's archepelago)

Fig. 115. Mangroves near coral bed at Wandoor (South Andaman).

crustacea, marine faunal components are predominant. This may be due to the fact that true estuarine condition is practically absent in these islands except in some parts of Great Nicobar (Das, 1985) and that mangroves are most dominant on outer seaward fringe and between the creeks. Further, mangroves of these islands are found on or near the wave swept rocky shores (Figs. 112-114) and coral reefs (e.g. Wandoor and Chidyatapu) (Fig. 115). Therefore, molluscs and crustacean fauna of these areas are very rich and mostly marine as they invade the mangroves from the adjacent rocky habitats or coral reefs. For example, some molluscs like *Monodonta labio, Turbo porphyrites, Nerita costata, Planaxis sulcatus, Mauritia arabica, Mitra sulcata, Muricopsis bombayanus,* etc., which are common in coral reefs and rocky shores are sometimes available in the mangales of these islands.

In these islands epifauna form the main bulk of mangrove fauna. Commonest epifaunal forms are gastropods, bivalves mainly oysters, crustaceans represented by crabs, shrimps and barnacles, and fishes mainly mudskippers. These are mainly detritivores although oysters and barnacles are suspension feeders. Infauna, on the other hand, are either omnivores and/or deposit feeders. Infaunal forms are, however, few and are mainly represented by polychaetes, a few bivalves and wood-boring animals. In addition to sedentary fauna there are a number of species which utilise mangrove ecosystem only as a temporaty habitat, whether it be for spawning, for nursury, for breeding or only for shelter. Many economically important species of shrimps, crabs, molluscs and fishes are found in the mangroves of these islands as mentioned in Table - 6, of which some are mangrove dependant. Some of these molluscs may be used as a source of food, others are having ornamental value and the rest may be utilised as raw material for the manufacture of lime and cement. It is worth-while to mention that shrimp fisheries of Indonesia are strongly correlated to the distribution of mangrove forests (Soegiarto, 1984) as many shrimps have been shown to be mangrove dependent (Macnae, 1974, Unar, 1972).

Most of the bivalves and shrimps listed in Table 6 have aquacultural prospects. In this connection this is to mention that during 1979-81 Fisheries Department of Andaman and Nicobar Administration attempted to culture Green mussel (*Perna viridis*) and *Placuna placenta* in the mangrove areas of Sippighat, South Andaman. But that attempt was not successful. Recently Central Agricultural Research Institute of these islands has initiated Green mussel culture and brackish water prawn and fish culture

at Sippighat mangrove areas and its adjoining swamps. The growth, survival and production rate are still under study (C A R I, Port Blair-Annual Report, 1985).

In fine, this is to be noted that during the present investigation we have found only very few faunal elements (Table 7) which were non-exceptionally found to be associated with the mangroves of these islands in large number. These animals are also found in non-mangrove habitats, although less frequently. This finding corroborates that of Sandison and Hill (1966) and Macnae (1968). Majority of the faunal elements collected from the mangrove ecosystem of these islands are, however, loosely associated with the mangroves and are found in coral reefs and rocky shores and others sheltered shores away from mangroves.

Table 6. Economically important fauna of mangrove ecosystem of Andaman and Nicobar islands.

| MOLLUSCA | CRUSTACEA |
|---|---|
| Gastropods | Crabs |
| 1. *Strombus (Canarium) erythrinus* | 16. *Scylla serrata* |
| 2. *Strombus (Dolomena) variabilis* | 17. *Thalamita crenata* |
| 3. *Lambis (Lambis) lambis* | 18. *Thalamita prynma* |
| Bivalves | Shrimps |
| 4. *Geloina galatheae* | 19. *Penaeus semisulcatus* |
| 5. *Geloina siamica* | 20. *Penaeus indicus* |
| 6. *Batissa inflata* | 21. *Penaeus monodon* |
| 7. *Batissa similis* | 22. *Acetes* sp. |
| 8. *Codakia tigerina* | FISH |
| 9. *Paphia malabarica* | 23. *Anguilla bicolor* |
| 10. *Gafrarium tumidum* | 24. *Anguilla bengalensis* |
| 11. *Meretrix attenuata* | 25. *Sardinella* spp. |
| 12. *Donax cuneatus* | 26. *Liza macrolepis* |
| 13. *Donax lubricus* | 27. *Velamugil cunnesius* |
| 14. *Perna viridis* | 28. *Ambassis commersoni* |
| 15. *Placuna placenta* | 29. *Ambassis gymnocephalus* |

Table 7. List of faunal elements, always associated with the mangroves of Andaman and Nicobar islands.

| Name of the major group | Name of the species |
|---|---|
| Polychaeta | 1. *Marphysa mossambica* |
| | 2. *Eunice aphroditois* |
| | 3. *Eunice sp.* |
| Mollusca | 4. *Littorina (Littorinopsis) scabra* |
| | 5. *Cerithidea guadrata* |
| | 6. *Cerithidea alata* |
| | 7. *Naquetia capusina* |
| | 8. *Ellobium aurisjudae* |
| | 9. *Ellobium gangeticum* |
| | 10. *Cassidula aurisfelis* |
| | 11. *Nassarius (Zeuxis) taenia* |
| | 12. *Cerithium corallinum* |
| | 13. *Clypeomorus trailli* |
| | 14. *Terebralia palustris* |
| | 15. *Rhinoclavis vertagus* |
| | 16. *Rhinoclavis aspera* |
| | 17. *Neritina (Dostia) violacea* |
| | 18. *Clithon bicolor* |
| | 19. *Stenothyra hungerfordiana* |
| | 20. *Assiminea franceaiae* |
| | 21. *Assiminea brevicula* |
| | 22. *Assiminea woodmasonia* |
| | 23. *Isognomon ephippium* |
| Crustacea | 24. *Uca (Celuca) lactea lactea* |
| | 25. *Uca (Deltuca) dussumieri spinata* |
| | 26. *Uca (Thalassuca) vocans* |
| | 27. *Sesarma (Chiromantes) bidens* |
| | 28. *Macrophthalmus convexus* |
| Fish | 29. *Periophthalmus vulgaris* |
| | 30. *Periophthalmus dipus* |
| | 31. *Boliophthalmus boddarti* |

Table 8. Systematic list of mangrove fauna of Andaman and Nicobar Islands.

**Mammals**

Class Mammalia

Order Chiroptera

Family Pteropidae

1. *Pteropus melanotus* Blyth
2. *Pteropus giganteus* (Brunnich)
3. *Cynopterus sphinx* (Vahl)

Order Primates

Family Cercopithecidae

4. *Macaca fascicularis umbrosa* Miller

Family Tupaiidae

5. *Tupaia nicobarica nicobarica* (Zelebor)

Order Carnivora

Family Viverridae

6. *Paguma larvata tytleri* (Tytler)

Order Artiodactyla

Family Suidae

7. *Sus scrofa andamanensis* Blyth
8. *Sus scrofa nicobarica* Miller

**Birds**

Class Aves

Order Ciconiiformes

Family Ardeidae

1. *Ardea cinerea rectirostris* Gould
2. *Ardeola striatus spodiogaster* (Sharp)
3. *Egretta intermedia intermedia* (Wagler)
4. *Ixobrychus cinnamomeus* (Gmelin)
5. *Ixobrychus sinensis* (Gmelin)

Order Anseriformes

Family Anatidae

6. *Anas gibberifrons albogularis* (Hume)

Order Falconiformes

Family Accipitridae

7. *Accipiter virgatus gularis* (Temminck & Schlegel)
8. *Spizaetus cirrhatus andamanensis* Tytler
9. *Halieetus leucogaster* (Gamelin)
10. *Spilornis cheela davisoni* Hume

Order Gruiformes

Family Rallidae

11. *Amaurornis phoenicurus insularis* Sharpe

Order Charadriiformes

Family Charadriidae

12. *Pluvialis dominica fulva* (Gmelin)
13. *Tringa totanus* (Linnaeus)
14. *Tringa terek* (Latham)
15. *Charadrius dubius curonicus* Gmelin
16. *Numenius phaeopus phaeopus* (Linnaeus)
17. *Gallinago stenura* (Bonaparte)

Order Columbiformes

Family Columbidae

18. *Ducula aenea andamanica* Abdulali
19. *Ducula bicolor* (Scopoli)

Order Psittaciformes

Family Psittacidae

20. *Psittacula eupatria magnirostris* (Ball)
21. *Psittacula alexandri abbotti* (Oberholser)
22. *Psittacula longicauda tytleri* (Hume)
23. *Psittacula longicauda nicobarica* (Gould)
24. *Loriculus vernalis vernalis* (Sparrman)

Order Cuculiformes

Family Cuculidae

25. *Centropus andamanensis* Beavan

Order Caprimulgiformes

Family Caprimulgidae

26. *Caprimulgus macrurus andamanicus* Hume

Order Apodiformes

Family Apodidae

27. *Collocalia fuciphaga inexpectata* Hume

Order Coraciformes

Family Alcedinidae

28. *Alcedo meninting rufigaster* Walden
29. *Pelargopsis capensis osmastoni* (Baker)
30. *Pelargopsis capensis intermedia* Hume
31. *Halcyon coromanda mizorhina* (Oberholser)
32. *Halcyon smyrnensis saturatior* Hume
33. *Halcyon pileata* (Boddaert)
34. *Halcyon chloris davisoni* Sharpe
35. *Halcyon chloris occipitalis* (Blyth)

Order Piciformes

Family Picidae

36. *Dryocopus javensis hodgei* (Blyth)
37. *Picoides macei andamanensis* (Blyth)

Order Passeriformes

Family Laniidae

38. *Lanius cristatus* Linnaeus

Family Oriolidae

39. *Oriolus chinensis andamanensis* Tytler
40. *Oriolus xanthornus reubeni* Abdulali

Family Dicruridae

41. *Dicrurus paradiseus otiosus* (Richmond)

Family Artamidae

42. *Artamus leucorhynchus humei* Stresemann
43. *Acridotheres tristis tristis* (Linnaeus)

Family Corvidae

44. *Corvus macrorhynchus levaillanti* Lesson

Family Campephagidae

45. *Coracina striata dobsoni* (Ball)
46. *Pericrocatus cinnamomeus vividus* Baker

Family Muscicapidae

47. *Pachycephala grisola* (Blyth)
48. *Acrocephalus aedon aedon* (Pallas)
49. *Phylloscopus borealis borealis* (Blasius)

Family Motacillidae

50. *Motacilla flava beema* (Sykes)

Family Dicaeidae

51. *Nectarinia jugularis andamanica* (Hume)
52. *Nectarinia jugularis klossi* (Richmond)
53. *Nectarinia jugularis proselia* (Oberholser)

**Reptiles**

Class Reptilia

Order Crocodilia

Family Crocodilidae

1. *Crocodilus porosus* Schneider

Order Squamata

Family Agamidae

2. *Goniocephalus subcristatus* (Blyth)
3. *Calotes* sp.

Family Varanidae

4. *Varanus salvator andamanensis* Deraniyagala

Family Colubridae

5. *Cerberus rhynchops* (Schneider)

Family Hydrophiidae

6. *Laticauda* sp.

Family Viperidae

7. *Trimeresurus* sp.

**Amphibia**

Class Amphibia

Order Anura

Family Ranidae

1. *Rana limnocharis limnocharis* Wiegmann
2. *Rana limnocharis andamanensis* Stoliczka
3. *Rana cancrivora* Gravenhorst

**Fishes**

Class Chondrichthyes

Order Clupeiformes

Family Clupeidae

1. *Sardinella* spp

Order Anguilliformes

2. *Anguilla bicolor bicolor* Mc Clelland
3. *Anguilla bengalensis bengalensis* (Gray)

Order Atheriniformes

Family Oryziidae

4. *Oryzias melanostigma* (Mc Clelland)

Order Syngnathiformes

Family Syngnathidae

5. *Hippichthys spicifer* (Ruppell)

Order Scorpaeniformes

Family Platycephalidae

6. *Platycephalus indicus* (Linnaeus)

Order Perciformes

Family Ambassidae

7. *Ambassis commersoni* Cuvier
8. *Ambassis gymnocephalus* (Lacepede)

Family Leiognathidae

9. *Leiognathus equulus* (Forsskal)
10. *Gazza minuta* (Bloch)

Family Gerridae

11. *Gerres oblongus* Cuvier

Family Monodactylidae

12. *Monodactylus argenteus* (Linnaeus)

Family Mugilidae

13. *Liza macrolepis* (Smith)
14. *Liza melinoptera* (Valencinnes)
15. *Velamugil cunnesius* (Valencinnes)

Family Balenniidae

16. *Istioblennius dussumieri* (Valencinnes)
17. *Salarius fuscus* Ruppell

Family Eleotridae

18. *Eleotris fusca* (Bloch Schneider)
19. *Eleotris andamanensis* Herre
20. *Bunaka gyrinoides* (Bleeker)

Family Gobiidae

21. *Acentrogobius viridipunctatus* (Cuvier & Valencinnes)
22. *Callogobius hasselti* (Bleeker)
23. *Callogobius andamanensis* Menon & Chatterjee
24. *Pseudogobiopsis romeri* (M. Weber)

25. *Boleophthalmus boddarti* (Pallas)
26. *Periophthalmus vulgaris* Eggert
27. *Periophthalmus dipus* Bleeker
28. *Periophthalmus koelreuteri* (Pallas)
29. *Periophthalmus schlosseri* (Pallas)
30. *Butis gymnopomus* (Bleeker)
31. *Ophiocara aporos* (Bleeker)
32. *Oxyurichthys dasi* Talwar, Chatterjee & Dev Roy
33. *Quisquilius eugenius* Jodern & Evermann

Family Kraemeridae

34. *Kraemericus smithi* Menon & Talwar

Order Tetradontiformes

Family Tetradontidae

35. *Chelonodon fluviatilis* (Hamilton-Buchanan)

**Polychaetes**

Class Polychaeta

Family Amphiomidae

1. *Eurythoe complanata* (Pallas)
2. *Eurythoe parvecarunculata* Horst

Family Nereidae

3. *Namalycastis indica* (Southern)
4. *Perinereis nigropunctata* (Horst)
5. *Perinereis vancaurica* Ehlers

Family Eunicidae

6. *Eunice aphroditois* (Pallas)
7. *Eunice* sp
8. *Marphysa mossambica* Petters

**Sipunculids**

Class Sipunculidea

Order Sipunculiformes

Family Sipunculidae

1. *Sipunculus inclusus* Sluiter

Class Phascolosomatidea

Order Phascolosomatiformes

Family Phascolosomatidae

2. *Phascolosoma (Phascolosoma) arcuatum* (Gray)

**Molluscs**

Class Polyplacophora

Order Lepidopleurida

Family Ischnochitonidae

1. *Ischnochiton winckworthi* Leloup

Class Gastropoda

Order Archaeogastropoda

Family Trochidae

2. *Monodonta (Monodonta) labio* Linnaeus

Family Turbinidae

3. *Turbo (Lunella) porphyrites* (Martyn)

Family Neritidae

4. *Nerita (Theliostyla) planospira* Anton
5. *Nerita (Theliostyla) albicilla* Linnaeus
6. *Nerita (Theliostyla) costata* Linnaeus
7. *Nerita (Theliostyla) squamulata* Guillon
8. *Nerita (Theliostyla) insculpta* Recluz
9. *Nerita (Theliostyla) chamaeleon* Linnaeus
10. *Nerita (Ritena) semirugosa* Recluz
11. *Nerita (Amphinerita) articulata* Gould
12. *Nerita (Amphinerita) polita* Linnaeus
13. *Neritina (Dostia) violacea* (Gmelin)
14. *Neritina (Vittina) variegata* Lesson
15. *Neritina (Vittina) turrita* (Gmelin)
16. *Neritina (Neripteron) auriculata* (Lamarck)
17. *Clithon bicolor* (Recluz)

18. *Clithon corona* (Linnaeus)
19. *Pseudonerita sulculosa* (Von Marten)

Order Mesogastropoda

Family Littorinidae

20. *Littorina (Littorinopsis) scabra scabra* (Linnaeus)
21. *Littorina (Littoraria) undulata* Gray

Family Stenothyridae

22. *Stenothyra deltae* (Benson)
23. *Stenothyra hungerfordiana* Nevill

Family Assimineidae

24. *Assiminea brevicula* (Pfeiffer)
25. *Assiminea francesiae* (Gray)
26. *Assiminea woodmasonia* Nevill

Family Thiariidae

27. *Thiara (Melanoides) tuberculata* (Miller)

Family Planaxidae

28. *Planaxis sulcatus* (Born)

Family Potamididae

29. *Cerithidea alata* (Philippi)
30. *Cerithidea quadrata* Sowerby
31. *Terebralia palustris* (Bruguiere)

Family Cerithidae

32. *Cerithium corallinum* Sowerby
33. *Cerithium columna* Sowerby
34. *Clypeomorus trailli* (Sowerby)
35. *Rhinoclavis aspera* (Linnaeus)
36. *Rhinoclavis vertagus* (Linnaeus)

Family Vanikoridae

37. *Vanikora cancellata* (Lamarck)

Family Strombidae

38. *Lambis (Lambis) lambis* (Linnaeus)

39. *Strombus (Canarium) erythrinus* Dilwyn
40. *Strombus (Dolomena) variabilis* Swainson

Family Naticidae

41. *Polinices tumidus* (Swainson)

Family Cypraeidae

42. *Mauritia arabica* (Linnaeus)

Order Neogastropoda

Family Muricidae

43. *Chicoreus brunneus* (Link)
44. *Naquetia capucina* (Roeding)
45. *Muricopsis bombayanus* (Melvill)
46. *Thais hippocastanum* (Linnaeus)
47. *Cronia ochrostoma* (Blainville)
48. *Cronia (Ergalatax) contracta* (Reeve)
49. *Morula anaxeres* (Kiener)
50. *Drupa* sp

Family Buccinidae

51. *Engina alveolata* (Kiener)

Family Nassaridae

52. *Nassarius (Zeuxis) taenia* (Gmelin)
53. *Nassarius (Nassarius) immersa* Carpenter
54. *Nassarius (Plicarcularia) globosus* (Quoy and Gaimard)

Family Mitridae

55. *Mitra (Strigatella) scutulata* (Gmelin)
56. *Mitra (Strigatella) paupercula* (Linnaeus)

Order Basommatophora

Family Ellobidae

57. *Ellobium gangeticum* (Pfeiffer)
58. *Ellobium aurisjudae* (Linnaeus)
59. *Cassidula aurisfelis* (Bruguiere)
60. *Cassidula nucleus* (Gmelin)

61. *Pythia plicata* (Gray)
62. *Melampus caffer* Kuster
63. *Melampus caffeus* Linnaeus
64. *Melampus castaneus* (Muchlfeldt)
65. *Melampus striatus* (Pease)

Class Soleolifera

Family Onchidiidae

66. *Onchidium tigrinum* Stoliczka
67. *Onchidium verruculatum* Cuvier

Class Bivalvia

Order Arcoidea

Family Arcidae

68. *Anadara granosa* (Linnaeus)
69. *Arca* sp.
70. *Barbatia helblingii* (Bruguiere)

Order Mytiloidea

Family Mytilidae

71. *Modiolus striatulus* (Hanley)
72. *Perna virdis* (Linnaeus)

Order Pteroida

Family Isognomonidae

73. *Isognomon ephippium* (Linnaeus)

Family Annomiidae

74. *Placuna placenta* (Linnaeus)

Family Ostreidae

75. *Crassostrea madrassensis* (Preston)
76. *Crassostrea gryphoides* (Schlotheium)
77. *Saccostrea cucullata* (Born)

Order Veneroida

Family Lucinidae

78. *Codakia tigerina* (Linnaeus)

Family Donacidae

79. *Donax (Latona) cuneatus* Linnaeus
80. *Donax lubricus* Hanley

Family Veneridae

81. *Gafrarium tumidum* (Roeding)
82. *Paphia malabarica* (Schroeter)
83. *Dosinia (Asa) tumida* (Gray)
84. *Meretrix attenuata* (Dunker)

Order Myoida

Family Corbiculidae

85. *Geloina galatheae* (Morch)
86. *Geloina siamica* Prime
87. *Batissa inflata* Prime
88. *Batissa similis* Prime

Family Pholadidae

89. *Martesia striata* (Linnaeus)

Family Teredinidae

90. *Bactronophorus thoracites* (Gould)
91. *Bankia bipennata* (Turton)
92. *Bankia rochi* (Moll)
93. *Dicyathifer manni* (Wright)
94. *Lyrodus pedicellatus* (Quatrefages)
95. *Nausitora dunlopei* Wright
96. *Nausitora hedleyi* Schepman
97. *Nototeredo edax* (Hedley)
98. *Teredo furcifera* Von Martens
99. *Uperotus rehderi* (Nair)

Class Cephalopoda

Order Octopoda

Family Octopodidae

100. *Octopus* sp.

**Echinoderms**

Class Asteroidea

Order Valvatida

Family Asterinidae

1. *Patiriella pseudoexigua* (Lamarck)

Class Holothuroidea

Order Aspidochirotida

Family Holothuridae

2. *Actinopyga echinites* (Jaeger)

3. *Holothuria (Metriatyla) scabra* Jaeger

Family Stichopodidae

4. *Stichopus variegatus* Semper

Order Apodida

Family Synaptidae

5. *Synapta maculata* (Chamiso & Eysenhardt)

Family Chiridotidae

6. *Polycheira rufescens* (Brandt)

**Arthropods**

Class Crustacea

Order Thoracica

Family Balanidae

1. *Balanus amphitrite* Darwin

Order Decapoda

Family Penaeidae

2. *Penaeus semisulcatus* de Haan
3. *Penaeus indicus* Milne Edwards
4. *Metapenaeopsis coniger* (Wood Masson)
5. *Paenaeus canaliculatus* Olivier
6. *Paenaeus monoden* Fabricius
7. *Paenaeus merguiensis* De Man

8. *Metapenaeus dobsoni* Mien
9. *Metapenaeus affinis* (H. Milne-Edwards)
10. *Metapenaeus brevicornis* (Milne-Edwards)

Family Sergestidae

11. *Acetes* sp.

Section Caridea

Family Alpheidae

12. *Alpheus* sp.

Family Atyidae

13. *Caridina brachydactyla* de Man
14. *Caridina gracilivostris* de Haan

Family Palaemonidae

15. *Palaemon coneinnus* (Dana)
16. *Palaemon debilis* Dana

Section Stenopodidea

Family Thalassinidae

17. *Thalassina anomala* (Herbst)

Section Anomura

Family Coenobitidae

18. *Coenobita cavipes* Stimpson

Family Paguridae

19. *Clibanarius longitarsus* (de Haan)

Family Pylochelidae

20. *Pylocheles mierssi*

Family Porcellanidae

21. *Petrolisthes lamarckii* Leach

Section Brachyura

Family Portunidae

22. *Portunus sanguinolentus* (Herbst)
23. *Portunus pelagicus* (Linnaeus)
24. *Scylla serrata* (Forskal)

Family Portunidae

25. *Thalamita crenata* (Latreille)
26. *Thalamita prymna* (Herbst)
27. *Charybdis (Charybdis) orientalis* (Dana)

Family Grapsidae

28. *Grapsus strigosus* (Herbst)
29. *Metopograpsus messor* (Forskal)
30. *Sesarma (Chiromantes) bidens* (de Haan)
31. *Sesarma (Sesarma) longipes* Krauss
32. *Sesarma (Sesarma) taeniolata* White
33. *Sesarma tetragonum* (Fabricius)
34. *Sesarma latifemur* Alcock
35. *Sesarma (Sesarma) quadrata* (Fabricius)
36. *Sesarma andersoni* De Man
37. *Sesarma (Sesarma) intermedium* (De Hann)
38. *Metasesarma rousseauxii* Edward
39. *Metaplax elegans* De Man
40. *Metaplax crenulata* Gerstaecker

Family Ocypodidae

41. *Ocypode ceratophthalmus* (Pallas)
42. *Uca (Celuca) lactea lactea* (De Haan)
43. *Uca (Deltuca) dussumieri spinata* Crane
44. *Uca (Thalassuca) vocans* (Linnaeus)
45. *Uca (Thalassuca) tetragonon* (Herbst)
46. *Dotilla myctiroides* (Milne-Edwards)
47. *Macrophthalmus convexus* Stimpson

Family Mictyridae

48. *Mictyris longicarpus* (Milne-Edwards)

Family Xanthidae

49. *Epixanthus frontalis* (Milne-Edwards)
50. *Baptozius vinosus* (Edwards)
51. *Pilumnus cursor* Milne-Edwards

Family Gecarcinidae

52. *Cardisoma carnifex* (Herbst)

Order Stomatopoda

Family Gonodactylidae

53. *Gonodactylus chiragra* Fabricius
54. *Gonodactylus* sp.

Order Isopoda

Family Sphaeromidae

55. *Sphaeroma terebrans* Bate
56. *Sphaeroma triste* Heller

Family Eurydicidae

57. *Cirolana parva* Hanson
58. *Cirolana elongata* Edwards

Order Amphipoda

Family Gammaridae

59. *Melita zeylanica* Stebbing

Class Insecta

Order Isoptera

Family Kalotermitidae

60. *Neotermes andamanensis* Synder

Family Rhinotermitidae

61. *Coptotermes heimi* (Wasmann)
62. *Coptotermes travians* Haviland

Family Termitidae

63. *Prorhinotermes flavus* (Bugion & Popoff)
64. *Microcerotermes danieli* Roonwal & Bose

65. *Microcerotermes nicobarensis* Roonwal & Bose

66. *Nasutitermes metangeninformes* (Holongren)

67. *Hospitalitermes blaire* Roonwal & Sen Sharma

Order Coleoptera

Family Cerambycidae

68. *Aeolesthes holoserica* (Fabricius)

69. *Cerecium flavipes* (Fabricius)

70. *Plocaederus obesus* Gahan

71. *Megopis (Aegosoma) sulcipennis* White

Family Scolytidae

72. *Cryphalus* (= *Epsips*) *littoralis* (Beeson)

73. *Coccotrypes brevipilosus* (Beeson)

74. *Coccotrypes fallax* (Eggers)

75. *Xyleborus bidentatus*

Family Curculionidae

76. *Camptorrhinus humeralis* Chev.

Family Bupestridae

77. *Chrysobothris andamana*

Family Lampyridae

78. *Pteroptyx* sp.

Family Coccinellidae

79. *Verania discolor*

Family Chrysomelidae

80. *Philopona* sp.

Family Oedomeridae

81. *Xanthorca* sp.

Order Diptera

Family Cecidomyiidae

82. *Dasineura* sp.

Order Lepidoptera

Family Pyralidae

83. *Hypsipyla robusta* Moore

Family Lycaenidae

84. *Spalgis epeus nubilius* Moore

Family Hisperidae

85. *Celaenorrhinus andamanica* Wood-Masson

Order Orthoptera

Family Gryllidae

86. *Parendacustes sanyali* Bhowmik

Order Hymenoptera

Family Formicidae

87. *Sima rufonigra* Jerdon

88. *Iridomyrmex cordatus* Fabr.

89. *Formica* spp.

90. *Camptonotus* spp.

90a. *Oecophylla smaragdina* Fabr.

Family Apidae

91. *Apis (Megapis) dorsata* Fabricius

**Mites**

Order Acariformes

Family Eriophyidae

92. *Keiferophyes avicenniae* Mohan Sundaram

93. *Aceria (=Eriophyes) leptothrix* (Nalepa)

**Centipedes**

Order Scolopendromorpha

Family Scolopendridae

94. *Rhysida nuda immarginata* (Porret)

95. *Otostigmus scaber* Porret

96. *Otostigmus simplex*

**Pseudoscorpion**

Order Scorpianida

Family Ischnuridae

97. *Hormurus* sp.

Table 9. List of meiofauna reported from mangrove sediments of South Andaman

NEMATODA

1. *Anticoma arctica* Steiner
2. *Camacolaimus* sp.
3. *Chromadora* sp.
4. *Curvolaimus wieseri* Timm
5. *Desmodora brevicollis* Cobb
6. *Desmodora* sp.
7. *Dichromadora* sp.
8. *Halalaimus filicollis* Timm
9. *Halalaimus setosus* Timm
10. *Halalaimus* sp.
11. *Halichoanolaimus longissimicauda* Timm
12. *Linhomoeus* sp.
13. *Metachromadora* sp.
14. *Metalinhomoeus* sp.
15. *Monhystera* sp.
16. *Oncholaimellus* sp.
17. *Oxystomina elongata* (Butschli)
18. *Oxystomina* sp.
19. *Paralinhomoeus dubius* Timm
20. *Sabatiera jubata* Cobb
21. *Sabatiera* spp
22. *Southerniella simplex* Allgen
23. *Sphaerolaimus pacificus* Allgen
24. *Terschellingia viridis* Timm

25. *Terschellingia* sp.
26. *Theristus tortuosa* Gerlach
27. *Theristus* sp.
28. *Viscosia* sp
29. *Wieseria longicauda* Timm

## COPEPODA

30. *Amphiascopsis cinetus* (Claus)
31. *Brianola hamondi* Wells & Rao
32. *Canuellina* sp.
33. *Enhydrosoma pectinatum* Wells & Rao
34. *Halectinosoma* sp.
35. *Laubiera* sp.
36. *Mites holothuriae* (Edwards)
37. *Nitocra* sp.
38. *Paralaophonte brevirostris* Claus
39. *Peltidium* sp.
40. *Pseudostenhelia* sp.
41. *Robertsonia adduensis* (Sewell)
42. *Robertsonia* sp.
43. *Stenhelia breviseta* Wells & Rao
44. *Stenhelia* sp.

## GASTROTRICHA

45. *Chaetonotus* spp.

## KINORHYNCHA

46. *Echinoderes* sp.

## ARCHIANNELIDA

47. *Protodrilus* sp.

## POLYCHAETA

48. *Armandia* sp.
49. *Dorvillea* sp.

50. *Goniadides* sp.

51. *Hesionides* spp.

52. *Sphaerosyllis* sp.

## OSTRACODA

53. *Polycope* spp.

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## SUMMARY

1. This monograph gives a general account of the faunal components available in the mangrove ecosystem of Andaman and Nicobar islands.

2. Mangrove fauna of the islands have been dealt with under two broad subheads - the terrestrial component, and the aquatic and semiaquatic components.

3. Terrestrial components mainly include mammals, birds, reptiles, insects, mites, centipedes, pseudoscorpions, etc. Some reptiles, namely, marine snake (*Laticauda* sp) and saltwater crocodile (*Crocodilus porosus*) are, however, aquatic components.

4. *Rana cancrivora* and *Rana limnocharis* are the amphibians found in Andaman mangales in the areas where salinity is very low ranging from 0.6°/oo to 10°/oo.

5. Mangrove associated insects mainly include mosquitoes, biting midges, ants, beetles, termites and bees. Coccids and gall-causing insects are also frequently seen. Some cerambycid, scolytid, curculionid and scarabid betles and moths bore into dead and dying trees, fruits and germinating seedlings of mangroves in these islands.

6. Aquatic and semiaquatic fauna of the mangroves mainly include polychaetes, molluscs, crustaceans, echinoderms, sipunculids and fishes (mostly gobiids).

7. Macrobenthic community of Andaman mangroves, more particularly mangrove borers and crabs have been investigated in some detail. Quantitative studies of mangrove crabs have also been made in two mangrove areas of South Andaman (*viz.* Chidyatapu and Corbyn's Cove) for one calender year.

8. A complete systematic list of the fauna available in the mangrov areas of the Bay islands has been appended in a separate table which clearl reveals that major aquatic components of the mangrove fauna of thes islands are, in fact, the fauna of sheltered marine shores and not the estuarir one.

## REFERENCES

ABDULALI, H. 1964. Birds of the Andaman and Nicobar Islands. *J. Bombay nat. Hist. Soc.*, **61**: 483-571.

ALCOCK, A. 1905. *Catalogue of the Indian Decapod crustacea in the collection of the Indian Museum. Part II. Anomura Fasciculus* I *Pagurides :* I + IX + 1 - 197.

ANONYMOUS, 1981. Annual General Report of Andaman and Nicobar Administration.

ANNONYMOUS, 1985. Annual Report of Central Agricultural Research Institute, Andaman and Nicobar Islands, Port Blair.

BANERJI, J. 1954. The mangrove forests of the Andamans. *Wld. For. Congr.* : 3.

BANERJI, J. 1958. The mangrove forests of the Andamans. *Wld. For. Congr.* : 425-430.

BEESON, C.F.C. 1941. *The ecology and control of the forest insects of India and neighbouring countries:* 1-767, Govt. of India, Dehra Dun.

BERRY, A.J. 1963. Faunal zonation in mangrove swamps. *Bull. Nat. Mus. Singapur,* **32**: 90-98.

BHOWMIK, H.K. 1970. The Gryllid fauna (Orthoptera : Insecta) of the Great Nicobar Island, India. *J. zool. Soc. India,* **22**: 69-86.

BLASCO, F. 1977. Outlines of ecology, botany and forestry of the mangales of the Indian subcontinent. In *West Coastal Ecosystem :* 241-260. Ed. Chapman, V.J.

CHAKRABORTY, S.K. and CHOUDHURY, A. 1985. Distribution of fiddler crabs in Sundarbans mangrove estuarine complex, India. *Proc. Nat. Symp. Biol. Util. Cons. Mangrove:* Nov. 1985, Kohlapur, India: 467-472.

CHAPMAN, V.J. 1976. *Mangrove Vegetation* : i-viii + 1-447. Ed. J. Cramer.

CHENGAPPA, B.S. 1944. Andaman forests and their regeneration. *Indian For.,* **70**: 207-304; 339-351.

COLLINS, P.J., BERKELHOMER, R.C. and MESLER, M. 1977. Notes on the natural history of the mangrove, *Pellicera rhizophorae* Tr. and Pl., (Theaceae). *Brenesia,* 10/11: 17-29.

DANIEL, A. and RAJAGOPAL, A.S. 1974. Molluscs of economic value from Great Nicobar island. *J. Bombay nat. Hist. Soc.,* **70**: 394-398.

DAS, A.K. 1985. Estuarine fauna of Andaman and Nicobar islands. *State of Art Report : Estuarine Biology, zool. Surv. India, Paper No. 12 :* 1-12.

DAS, A.K. and DEV ROY, M.K. 1980. On the wood-boring molluscs of South Andaman, India. *Rec. zool. Surv. India.* **77**: 179-187.

DAS, A.K. and DEV ROY, M.K. 1981. On the teredinid borers of mangroves of Camorta Island, Nicobar, India. *Bull. zool. Surv. India,* **4(3)** : 391-393.

DAS, A.K. and DEV ROY, M.K. 1982. On a fruit borer of mangroves of Andaman Islands. *Geobios New Report,* **1(2)** : 131.

DAS, A.K. and DEV ROY, M.K. 1984a. Marine borers of mangroves of Little Andaman, India. *Bull. zool. Surv. India,* **6**: 95-98.

DAS, A.K. and DEV ROY, M.K. 1984b. Report on the marine wood borers from the mangroves of Neil, Havelock and Peel Island, Ritchie's Archipelago, Andaman, India. *Bull. zool. Surv. India,* **6**: 327-329.

DAS, A.K., DEV ROY, M.K. and MITRA, B. (in press). Some moth borers of mangroves in Andaman islands. *J. Andaman Sci. Assoc.*

DAS, A.K., DEV ROY, M.K. and MITRA, B. (in press). Insect borers of mangroves of Andaman and Nicobar islands, India. *J. Andaman Sci. Assoc.*

DEV, ROY, M.K. and DAS, A.K. 1985. Marine wood-borers from the mangrove ecosystem of Great Nicobar Island, India. *Bull. zool. Surv. India,* **7** (2-3): 251-254.

DEV, ROY, M.K., MITRA, B. and DAS, A.K. 1984. Studies on the insect borers of mangroves of Andaman and Nicobar Islands. *Proc. III Oriental Entomological Congress Symp. Univ. Kerala, India :* 15.

DEV, ROY, M.K., MITRA, B. and DAS, A.K. (in press). On some insect borers of mangroves of Andaman Islands, India. *Bull. zool. Surv. India.*

DHARMARAJ, K. and NAIR, N.B. 1981. Timber-boring animals of Talapady mangroves and adjoining areas with a record of *Martesia* sp. (Bivalvia : Pholadidae) boring into living trees. *Mahasagar Bull. natn. Inst. Oceanogr.*, **14**: 159-162.

DWIVEDI, S.N., PARULEKAR, A.H., GOSWAMI, S.C. and UNTAWALE, A.G. 1974. Ecology of mangrove swamps of the Mandovi estuary, Goa, India. *Symp. on Biology and Management of Mangroves. East West Centre, Honolulu, Hawai.*, 115-125.

EDMUNDS, G.L. 1964. Eolid mollusca from Jamaica, with descriptions of two new genera and three new species. *Bull. mar. Sci. Gulf. Caribb.* **14**: 1-32.

FERRAR, M.L. 1947. The butterflies of Andaman and Nicobars. *J. Bombay nat. Hist. Soc.*, **47**: 470-491.

GANAPATI, P.N. and RAO, M.L.V. 1959. Incidence of marine borers in the mangroves of the Godavari estuary. *Curr. Sci.*, **28**(8): 332.

HALDAR, B.P. 1977. *Sipunculus inclusus* Shitor (Sipunculidae Sipuncula) a new record from the Indian Ocean. *Newsl. zool. Surv. India*, 3(3): 120-123.

HUGHES, D.A. 1966. Behavioural and ecological investigations of the crab *Ocypode ceratophthalmus* (Crustacea : Ocypodidae). *J. Zool. Lond.*, **150**: 129-143.

HUXLEY, C. 1976. The ant plants Hydnophytum and Myrmecodia (Family: Rubiaceae) and the ants which inhabit them. *M. Sc. thesis, University of Papua*, New Guinea.

HUXLEY, C. 1980. Symbiosis between ants and epiphytes. *Biol. Rev.*, **55**: 321-340.

JOHN, P.A. 1955. Studies on *Melita zeylanica*, an amphipod destructive to submerged timber. *Bull. Centr. Res. Inst. Trivandrum, IV, I.C.* 117-126.

KARANDE, A.A. 1978. Marine fouling and timber deteriotion in sub-oceanic islands of Andamans. *Indian J. mar. Sci.*, 7: 39-43.

KASINATHAN, R. and SHANMUGAM, R. 1985. Molluscan fauna of Pichavaram mangroves, Tamil Nadu. *Proc. Nat. Symp. Biol. Util. Cons. Mangroves:* Nov. 1985, Kolhapur, India: 438-443.

KERWIN, J.A. 1971. Distribution of fiddler crabs (*Uca minax*) in relation to marsh plants within a Virginia coast. *Chesapeake Sci.*, **12**: 180-183.

KHAN, AJMAL and NATARAJAN, R. 1981. Laboratory rearing of larval stages of the estuarine hermit crab, *Clibanarius longitarsus* (De Haan) (Decapoda : Anomura). *Indian J. mar. Sci.*, **10**: 74-81.

KHAN, M.A.R. 1986. Wild life in Bangladesh mangrove ecosystem. *J. Bombay nat. Hist. Soc.*, **83**: 32-48.

KHAN, T.N. and MAITY, P.K. 1983. Studies on the biotaxonomy, biology and ecology of some longicorn beetle borers (Coleoptera : Cerambycidae) of the Andaman islands, India. *Occ. paper* No. 45, *zool. Surv. India* : 1-100.

KLOSS, BODEN, 1903. *In the Andamans and Nicobars* : 1-373., John Marray, London.

KRISHNAMURTHY, K. 1985. The changing landscape of the Indian mangroves. *Proc. Symp. Biol. Util. Cons. Mangroves :* Nov. 1985, Kohlapur, India : 119-126.

MACINTOSH, D.J. 1977. Some responses of tropical mangrove fiddler crabs (*Uca* spp) to high environmental temperatures. In : *Proc. 12th Europ. mar. biol. Symp.* pp. 49-56. Eds. D.S. Mc Lusky and A.J. Berry. Pergamon Press : Oxford.

MACINTOSH, D.J. 1982. Ecological comparisons of mangrove swamp and salt marsh fiddler crabs. In : *Proc. 1st International Wetland Conference.* pp. 243-257. Eds. National Institute of Ecology, Jaipur & International Scientific Publication, Jaipur.

MACINTOSH, D.J. 1984a. Ecology and productivity of Malaysian mangrove crab populations (Decapoda : Brachyura). *Proc. As. Symp. Mangr. Env. - Res. & Manag. :* 354-377.

MACINTOSH, D.J. 1984b. Mangrove animal communities. In : *Second Introductory Training Course on Mangrove Ecosystem : Nov. 1-25, 1984: Goa, India :* 183-191.

MACNAE, W. 1968. A general account of the fauna and flora of mangrove swamps and forests in the Indo West Pacific region. In : *Adv. mar. Biol.*, **6**: 73-270. Eds. F.S. Russel & M. Younge.

MACNAE, W. 1974. Mangrove forests and fisheries. FAO/IOFC/DEV/74/34/FAO, Rome : 1-35.

MALL, L.P., SING, V.P., GARGE, A., PATHAK, S.M. 1985. Mangrove forest of Andamans and some aspects of its ecology. *Proc. Nat. Symp., Biol. Util. Cons. Mangroves:* Nov. 1985, Kohlapur, India: 438-443.

MANDAL, A.K. and MISRA, A. 1985. Mudflats of lower Bengal with special reference to macrobenthic fauna. *Proc. Nat. Symp. Biol. Util. Cons. Mangroves:* Nov. 1985, Kohlapur, India: 425-431.

MANI, M.S. 1973. *Plant galls of India* : 1-354, Macmillan, India.

MATHUDA, G.S. 1957. The mangrove forests of India. *Proc. Mangrove Symp.* ; Oct. 16-19, 1957, Calcutta : 66-87.

MC LUSKY, S.D. 1971. *Ecology of estuaries :* 1-VIII + 1-144.

MC NEIL, A.F. 1932. Crustacean boring pests. *Publication Sydney Harbour Trust,* 1932.

MENON, A.G.K. and TALWAR, P.K. 1972. Fishes of the Great Nicobar Expedition, 1966 with description of a new goboid fish of the family Kraemeriidae. *Rec. zool. Surv. India,* **66**: 35-61.

MILLER, K.G. and MAURER, D. 1973. Distribution of the fiddler crabs, *Uca pugnax* and *Uca minax,* in relation to salinity in Dilawara rivers. *Chesapeake Sci.,* **14**: 219-221.

MISRA, A. and CHOUDHURY, A. 1985. Polychaetous annelids from the mangrove swamps of Sundarbans, India. *Proc. Nat. Symp. Biol. Util. Cons. Mangroves:* Nov. 1985, Kolhapur, India : 448-452.

MOLL, F. 1939. Die Teredinides in Congo museum zu Tervuren. *Revue de zoologie et de botanique africanines,* **32**: 368-375.

MUKHERJE, A.K. 1975. The Sundarban of India and its biota. *J. Bombay nat. Hist. Soc.,* **72**: 2-20.

MURTY, A.S. and BALAPARAMESWARA RAO, M. 1977. Studies on the ecology of molluscs in a South Indian mangrove swamp. *J. Moll. Stud.,* **43**: 223-229.

MYERS, A.A. 1985. Shallow water, coral reef and mangrove amphipoda (Gammaridea) of Fiji. *Rec. Austr. Mus. Suppl.* **5**: 1-143.

NAIR, N.B. and DHARAMARAJ, K. 1980a. Wood-boring molluscs of the Palk Bay and the Gulf of Mannar. *Mahasagar Bull. natn. Inst. Oceanogr.* 13(3): 249-260.

NAIR, N.B. and DHARAMARAJ, K. 1980b. Incidence of timber-boring animals in the Vellar-Coleroon estuarine system. *Curr. Sci.,* **49**: 486-487.

NAIR, N.B. and SARASWATHY, M. 1971. The biology of the wood-boring teredinid molluscs. In: *Adv. mar. Biol.,* **9**: 335-509 Eds. F.S. Russel and M. Yonge.

NEIL, W.T. 1946. An unusual habitat for frogs and lizards. *Copeia,* **4**: 258.

OSMASTON, B.B. 1906. Notes on Andaman birds with accounts of nidification of several species whose nests and eggs have not been hitherto described. *J. Bombay nat. Hist. Soc,* **17**: 156-173.

PEARSE, A.S. 1911. Concerning the development of frog tadpoles in seawater. *Philipp. J. Sci., D.* **6**: 213-217.

PARULEKAR, A. 1984. Fauna of the mangrove ecosystem. *Second Introductory Training Course on Mangrove Ecosystem* : Nov. 1-25, 1984: Goa, India : 53-62.

PILLAI, N.K. 1967. The role of crustacea in the destruction of submerged timber. *Proc. Symposium on Crustacea* IV. *Mar. biol. Assoc. India:* 1274-1283.

PILLAI, C.S.G. and APPUKUTTAN, K.K. 1980. Distribution of molluscs in and around the coral reefs of the Southeastern coast in India. *J. Bombay nat. Hist. Soc.,* **77**(1): 26-48.

RADHAKRISHNA, Y and GANAPATI, P.N. 1969. Fauna of the Kakinada Bay. *Bull. natn. Inst. Sci. India,* **38**: 689-699.

RADHAKRISHNA, Y and JANAKIRAM, 1975. The mangrove molluscs of Godavari and Krishna estuaries. In: *Recent Researches in Estuarine Biology,* R. Natarajan, 177-184. Hindustan Publishing Corporation (L), Delhi, India.

RAJAGOPALAIENGAR, A.S. 1961. Fuller description of a recently described species of the marine borer *Bankia* (*Neobankia*) *roonwali* Rajagopalaiengar from West Bengal, India *Rec. Indian Mus.,* Delhi, **59**(4): 305-495.

RAJAGOPALAIENGAR, A.S. 1964a. Two new species of marine borers of the genus *Nausitora* (Mollusca : Teredinidae) from West Bengal, India. *J. Bombay nat. Hist. Soc.,* **61**(1): 108-118.

RAJAGOPALAIENGAR, A.S. 1964b. Field ecology of some marine borers (Mollusca : Teredinidae) of mangroves in Sundarbans, India. *Rec. zool. Surv. India,* **62**(1 & 2): 21-27.

RAMBABU, A.V.S., PRASAD, B.V. and BALAPARAMESWARA RAO, M. 1985. Incidence of wood-borers in the Krishna estuarine mangales. *Abstract No. 35, Second National Seminar on Marine Intertidal Ecology,* Feb. 14-16, 1985 : *Deptt. Zoology, Andhra University,* Waltair, India.

RAO, G.C. 1980. On the zoogeography of the interstitial meiofauna of the Andaman and Nicobar islands, Indian Ocean. *Rec. zool. Surv. India,* 77: 153-178.

RAO, G.C. 1986. Meiofauna of the mangrove sediments in South Andaman. *J. Andaman Sci. Assoc.,* 2: 23-32.

RAO, M.V.L. 1986. Notes on the wood borers from the mangroves of the Godavari estuary, India. In: *Indian Ocean: Biology of benthic marine organisms :* 579-588: Eds. Thompson et al. Oxford & IBH Publishing Co, New Delhi, Calcutta and Bombay.

ROONWAL, M.L. 1954a. *Bactronophonus thoracites* (Gould) as a pest of living trees in the Sundarbans, Bengal (Mollusca : Teredinidae). *Curr. Sci.* 23: 301.

ROONWAL, M.L. 1954b. The marine borer *Bactonophorus thoracites* (Gould) (Mollusca, Eulamellibranchiata, Teredinidae), as a pest of living trees in the mangrove forests of Sunderbans, Bengal, India. *Proc. zool. Soc., Calcutta,* 7: 91-105.

ROONWAL, M.L. 1959. Biology and ecology of oriental termites (Isoptera) No. 4. The dry wood termite, *Coptotermes heimi* (Wasm.) in India. *J. Bombay nat. Hist. Soc.,* 56: 511-523.

ROONWAL, M.L. 1966. Wood-boring Teredinid shipworms (Mollusca) of mangroves in the Sunderbans (West Bengal). *Proceedings* of *Dacca Symposium* on *Scientific Problems* of the *Humid tropical zone deltas and their implication,* 1964, Paris (UNESCO): 277-283.

SAHANY, K.C. 1957. Mangrove forest in the Andaman and Nicobar Islands. *Proc. Mangrove Symposium, Calcutta,* Oct. 16-19, 1957: 114-123.

SAMANT, J.S. 1985. Avifauna of the mangroves around Ratnagiri, Maharashtra. *Proc. Nat. Symp. Bio Util. Cons. Mangroves* Nov.1985: Kolhapur, India: 456-466.

SANDISON, E.E. and HILL, M.B. 1966. The distribution of *Balanus pallidus stutsburi* Darwin, *Gryphaea gasar* (Adanson) Doutzenberg, *Merci-erella enigmatica* Fauvel and *Hydroides uncinata* Phillipi, in relation to salinity in Lagos harbour and adjacent creeks. *Journal* of *Animal Ecology,* 35: 235-250

SANKOLLI, K.N. 1966. On the Porcellanidae (Crustacea : Anomura) of Ratnagiri along the west coast of India. *Proc. Symp. Crustacea, Part I, Series 2. Mar. biol. assoc. India,:* 295-313.

SANTHAKUMARAN, L.N. 1983. Incidence of marine wood-borers in mangroves in the vicinity of Panaji coast, Goa. *Mahasagar - Bull. natn. Inst.* of *Oceanogr.* 16(3): 229-307.

SANTHAKUMARAN, L.N. 1985a. Destruction of mangrove vegetation by marine wood borers along Goa coast, with notes on their distribution in mangroves along the Indian coast. *Proc. Nat. Symp. Biol. Util. Cons. Mangroves:* Nov. 1985, Kolhapur, India: 492-498.

SANTHAKUMARAN, L.N. 1985b. Marine wood borers of India, an annotated bibliography : 1-147 (Mimio). Wood Preservation Centre (Marine), *nat. Inst. Oceanogr.,* Goa.

SANTHAKUMARAN, L.N. and PILLAI, S.R.M. 1974. Incidence of marine wood borers in mangroves in the vicinity of Bombay harbour. *J. Timb. Dev. Assoc. India,* 20: 18-20.

SASEKUMAR, A. 1974. Distribution of macrofauna on a Malayan mangrove shore. *J. Anim. Ecol,* 43: 51-69.

SHARMA, R.M. and DAS, A.K. 1984. Further contribution to the knowledge of zoocecidia of the mangrove, *Avicennia marina* (Fosk.) Vier. *Rec. zool. Surv. India,* 81: 123-126.

SHARMA, R.M., DEV ROY, M.K. and DAS, A.K. 1983. New records of zoocecidia from mangroves of Andaman Islands, India. *Geobios New Reports,* 2 (2): 139-141.

SHARMA, R.M., DEV ROY., M.K., MITRA, B. and DAS, A.K. 1984. New records of zoocecidia on *Avicennia marina* (Forsk.) Vier. from Andaman Islands, India. *Geobios New Reports,* 3: 46-48.

SHARMA, R.M. and DEV ROY, M.K. 1985. On a small col'ection of plant galls from Great Nicobar, India. *Geobios New Reports,* 4: 72-73.

SILAS, E.G. and SANKARANKUTTY, C. 1960. On the castle-building habit of the crab, *Cardiosoma carnifex* (Herbst) (Family : Gecarcinidae) of the Andaman Islands. *J. mar. biol. Assoc. India,* 2: 237-240.

SIVICKS, P.B. 1928. New Philippine shipworms. *Philippine Journal* of *Science,* 37(3): 285-298.

SOEGIARTO, A. 1984. The mangrove ecosystem in Indonesia, its problem and management. In: *Physiology and management of mangroves.* Ed. H.J. Teas, Dr. W. Junk Publishers, The Hague.

SRIPATHI, K, AJMAL KHAN, S. and NATARAJAN, R. 1977. Shell selection by land crab, *Coenobita cavipes* Stimpson. *Ind. J. mar. Sci.,* 6: 163-165.

SRINIVASAN, V.V. and CHANDRAMOHAN, K. 1973. Notes on a collection of teredines infesting wooden structures from south east coast of India. *J. Timb. Dev. Assoc. India,* 19: 17-20.

SUBBA RAO, N.V. 1986. Report on a collection of wood-boring molluscs from Mahanadi estuary, India. *Proc. Symp. on Mollusca,* Part I; *Mar. biol. Assoc. India:* 85-93.

SUBBA RAO, N.V. and MUKHERJEE, H.P. 1969. On a collection of molluscs from the Mahanadi estuary, Orissa. *Recent Researches in Estuarine Biology.* Ed. B. Natarajan, Marine Biological Association of India, Pt. I: 85-93.

SUBBA RAO, N.V., DEY, A. and BARUA, S. 1983. Studies on the malacofauna of Muriganga estuary, India. *Proc. Symposium* on *Mollusca,* Part I, *Mar. biol. Assoc. India,* 85-93.

TALWAR, P.K., CHATTERJEE, T.K. and DEV ROY, M.K. 1982. *Oxyuricthys dasi,* a new gobid (Pisces : Gobiidae) from the Andaman Islands. *Rec. zool. Surv. India,* 79: 483-487.

TALWAR, P.K. and KACKER, R.K. 1984. *Commercial sea fishes of India. Handbook Zoological Survey of India* (4), pp. Lii + 1-997.

TEAL, J.M. 1958. Distribution of fiddler crabs in Georgia salt marshes. *Ecology,* 39: 185-193.

TIKADER, B.K. and DAS, A.K. 1985. *Glimpses of Animal Life of Andaman and Nicobar Islands. Spl. Publ. zool. Surv. India, Calcutta* : 1-XII + 1-170.

TIWARI, K.K., DAS, A.K., DEV ROY, M.K. and KHAN, T.N. 1980. On the wood-borers of mangroves of Andaman and Nicobar Islands, with a note on the gallery pattern of some insect borers. *Rec. zool. Surv. India,* **77**: 357-362.

TWEEDIE, M.W.F. 1935. Two new species of *Squilla* from Malayan waters. *Bull. Raffles. Mus.,* **10**: 45-52.

UNAR, M. 1972. Review of the Indonesian shrimp fishery and its present development. *Publ. mar. Fish. Inst.* (LPPL) 1/72: 1-26.

VASUDEVA RAO, M.K. 1986. A preliminary report on the angiosperms of Andaman-Nicobar islands. *J. Econ. Tax. Bot.,* **8**(1): 107-184.

VERWEY, J. 1930. Einiges uber die Biologie Ost-Indischer Mangrove-krabben. *Treubia,* **12**: 169-261.

WILSON, E.O. 1969. The species equilibrium. In: *Diversity and Stability in Ecological Systems. Brookharen Symposium* in *Biology* No. **22**: 38-47.

WATSON, J.C. 1928. Mangrove forests of the Malay Peninsula. *Malay Forest Rec.,* **6**: 275.

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