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PALK BAY**

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KOTAPALLI SATYANARAYANA RAO *and* K. S. SUNDARAM

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ECOLOGY OF INTERTIDAL MOLLUSCS OF GULF OF MANNAR AND PALK BAY

by KOTAPALLI SATYANARAYANA RAO and K. S. SUNDARAM, *Central Marine Fisheries Research Institute, Marine Fisheries P. O.-623520, Mandapam Camp*

The distribution of fauna in the intertidal zone in different stations in the Gulf of Mannar and Palk Bay in the vicinity of Mandapam Camp has been studied. Distinct zonation has been observed in the occurrence of the fauna and three sub-zones the supralittoral fringe, midlittoral zone and infralittoral fringe were recognized in the intertidal region. In the Gulf of Mannar, *Littorina scabra*, *L. undulata*, *Tectarius* spp, *Crassostrea cucullata* and *Chthamalus stellatus stellatus* have been recorded in the supralittoral fringe. In the midlittoral zone, *C. stellatus stellatus* is usually abundant along with some *Cellana radiata*, *Modiolus striatula*, *Tectarius* spp, *Donax* spp and *Prianospio* sp. In the Infralittoral fringe, tubicolous Vermetid gastropods, prosobranchs like *Trochus radiatus* and *Turbo intercostalis*, sponges and sea-anemones have been recorded. In Palk Bay the supralittoral fringe is mostly sandy and on some dead coral stones a few *Littorina scabra* and *Tectarius* spp are found. The midlittoral zone fauna includes *Planaxis sulcatus*, *Nerita maura*, *Crassostrea cucullata*, a few *Littorina* spp. and *Tectarius* spp on coral stones. In the infralittoral fringe prosobranchs like *Cerithium* spp, *Rissoina bertholleti* and *Pyrene diminuta*, bivalves (*Arca* spp, *Isognomon* spp, etc.), sponges, hydroids, polyzoans, polychaetes, isopods, amphipods and crabs occur. The probable factors influencing the variations in abundance of the fauna, particularly the molluscs in different stations and the habits of the molluscs in relation to low and high tides, temperature, etc. have been discussed.

INTRODUCTION

The zonation of intertidal fauna of the British, African, American and Australian coasts and elsewhere has been studied by several workers (Colman 1933; Evans 1974 a, b; Southward and Crisp 1954; Lewis 1953, 1955, 1961, 1964; Crisp and Southward 1958; Stephenson 1939, 1943, 1944, 1947; Lawson 1956; Stephenson and Stephenson 1949, 1950, 1952; Doty 1946, 1957; Dakin *et al.* 1948; Womersley and Edmonds 1952; Chapman 1943; Guiler 1950). Similar studies have received only scant attention in regard to the fauna of the Indian coasts except for a few papers (Ganapati and Lakshmana Rao 1962; Rao and Rao 1962; Nagabushanam and Rao 1969). In the present work the molluscan fauna in the intertidal region in the Gulf of Mannar and Palk Bay in the vicinity of Mandapam Camp has been investigated to find out if there is zonation in its distribution. The factors influencing the variations in abundance of fauna in different areas and the habits of the molluscs in relation to low and high tides, temperature etc. have been dealt with.

MATERIALS AND METHODS

The fauna has been studied at four stations in the Gulf of Mannar: I—the Central Marine Fisheries Research Institute's jetty and a pier closeby (Fig. 1) II—by

the side of the Catholic Church 3/4 km away from station I, III—at the eastern extremity of the Quarantine Camp, IV—on the concrete construction east of station III, and V in Palk Bay near Manakad. The range of the tide at Mandapam Camp is about one metre. In dividing the intertidal zone into sub-zones the procedure of Stephenson and Stephenson (1949) was followed and three subzones viz., supralittoral fringe, midlittoral zone and infralittoral fringe were distinguished. The sub-zones were delimited as follows; (i) Supralittoral fringe—from the mean high water mark of spring tides (0.7 m. C.D.) to E. H. W. S., (ii) Midlittoral zone—between the mean high water mark of spring tides (0.7 m C.D.) and mean low water mark of neap tides (near 0.4 m C.D.), and (iii) Infralittoral fringe between the mean low water mark of neap tides (near 0.4 m. C.D.) and extreme low water mark exposed at the ebb of spring tides about one and half days after the new moon and full moon. The different stations although situated in close proximity are dealt with separately as they vary in physical environmental conditions.

In the supralittoral fringe and midlittoral zone of station III in the Gulf of Mannar and the infralittoral fringe in Palk Bay the number of individuals of different species of molluscs present in three half metre squares has been determined during the period between October, 1969 and January, 1970. The animals living below the sand were also examined after digging up to 15 cm. The counts of individuals in the squares in different areas recognized by making marks on rocks in the neighbourhood with synthetic enamel paint, were taken at low and high tides to see if there is dispersal or aggregation of individuals of different species during the course of the day. The habits and food of the molluscs were also observed.

Data on air and water temperature and salinity at low and high tides have been recorded between October, 1969 and January, 1970.

RESULTS

Station I. (C. M. F. R. I. Jetty)

The jetty (Fig. 1, I a) is a cement concrete construction located in a sandy area. The pier (Fig. 1, I b) is also a concrete structure located near it.

Supralittoral fringe—On the pillars of the jetty the prosobranch gastropods *Littorina scabra*, *Tectarius granularis* and *T. malaccanus* are present. Among these, *Tectarius* spp are in good numbers (Fig. 2). *Tectarius malaccanus* is abundant in the upper portions of the pillars in the sub-zone. The barnacle *Chthamalus stellatus stellatus* which is found in large numbers in the sub-zone below extends into this sub-zone and exists in much smaller numbers.

Midlittoral zone—Below the supralittoral fringe the barnacle *Chthamalus stellatus stellatus* are abundant (Table I) and form a band 0.25–0.30 metre in height on the seaward and shoreward sides of the pillars (Fig. 2). The rock oyster *Crassostrea cucullata*, the limpet *Cellana radiata* and *Littorina scabra* are found in small numbers and *Tectarius granularis* in good numbers. On the seaward pillars the barnacles are much more abundant than on those shoreward.

Infralittoral fringe—In this sub-zone an unidentified Vermetid gastropod with a straight, narrow, tubular, brown shell the terminal portions of which project above the substratum, occurs in large numbers close together forming a continuous band

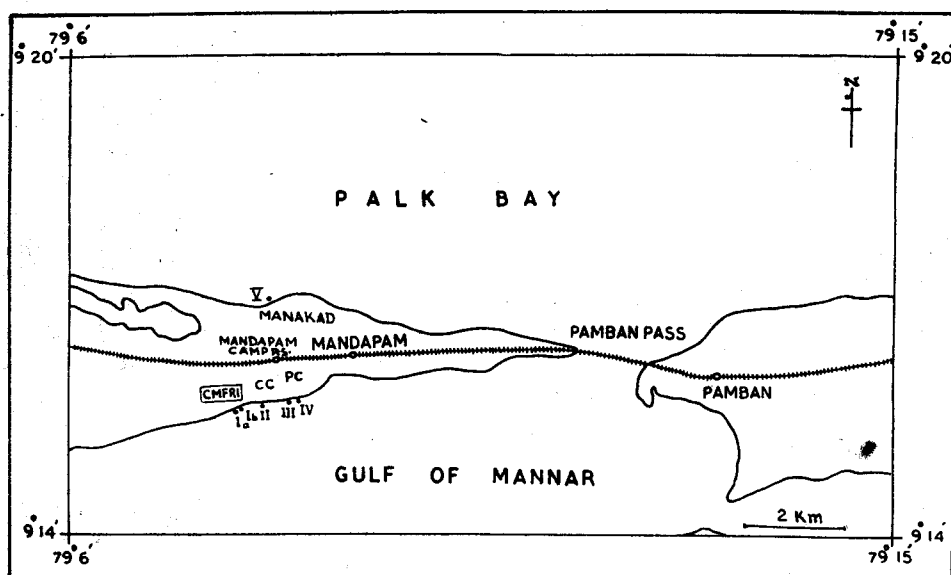


FIG. 1. Showing the location of stations in the Gulf of Mannar and Palk Bay where the intertidal fauna has been studied. CMFRI—Central Marine Fisheries Research Institute; CC, Catholic Church, PC, Protestant Church.

(Fig. 2). The alga *Gracilaria pucillum* grows in the lower part of this subzone. Young ones of the pearl oyster *Pinctada anomioides*, the boring bivalve *Petricola lithophaga*, *Modiolus striatula*, *Onchidium verraculatum* and isopods are the others represented on the pillars. The infralittoral fringe is not represented on the landward pillars as they are covered by sand at the bottom.

On the sides of the concrete pier near the C. M. F. R. I. jetty in the supralittoral fringe under exposed conditions *Littorina scabra* occurs in small numbers. *Tectarius malaccanus* and *T. granularis* are in moderate numbers in contrast to what has been observed on the pillars of the jetty. A few individuals of *C. stellatus stellatus* are also present in the subzone. There are loose granite stones below and before the pier in the midlittoral zone. *C. stellatus stellatus* is found in good numbers here on exposed granite but the abundance is much lower than on the protected surfaces of pillars of the jetty. Amidst the stones *Drupa tuberculata* and *Thais rudolphi* have been recorded. On the undersurface of stones sea anemones, amphipods, isopods (*Ligia* sp.), crabs (*Medaesus* sp.), opisthobranchs (*Smaragdinella* sp.) and ascidians are found.

In the infralittoral fringe *Trochus radiatus*, *Drupa tuberculata*, *Conus ebraeus*, *Discodoris rubra* and *Ligia* sp. have been recorded amidst stones near the pier.

Station II (By the side of the Catholic Church)

The intertidal region is sandy with exposed boulders having inclined surfaces on the shoreward side. There are large, flat, exposed boulders in the middle and

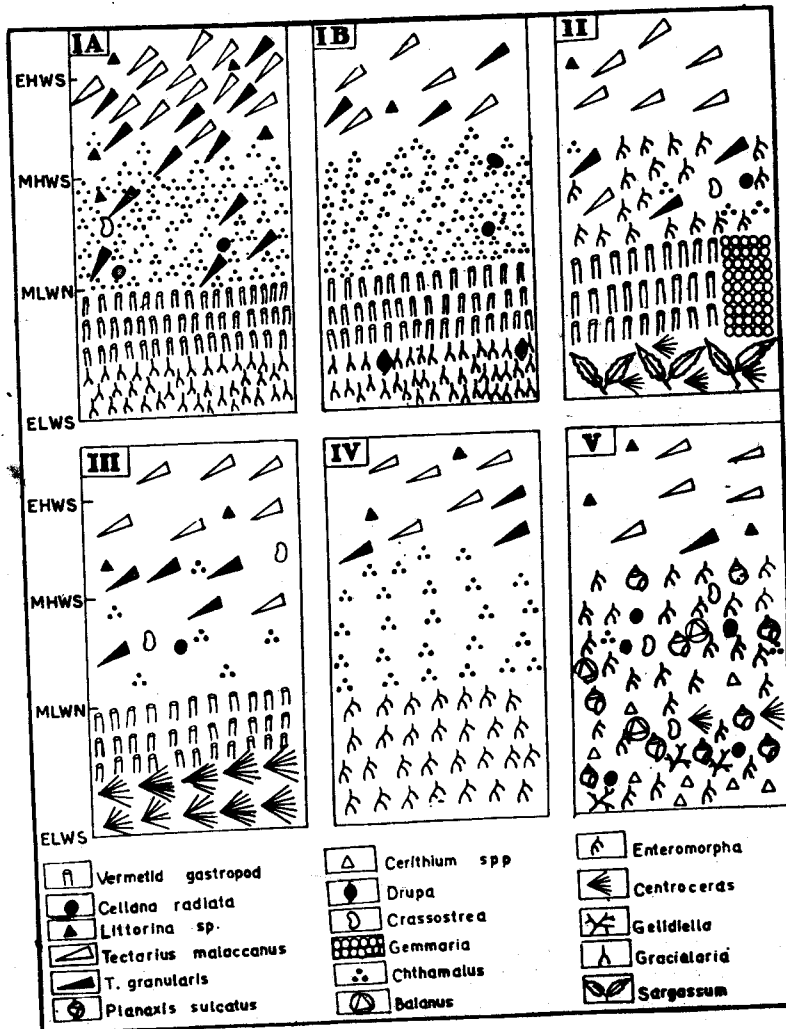


FIG. 2. Zonation of fauna and flora in the different stations in Gulf of Mannar and Palk Bay.

seaward portions. A few sheltered boulders are also present in the seaward portion. *Supralittoral fringe*—*Tectarius malaccanus* and *Littorina scabra* are found on the surface of sandstone boulders.

Midlittoral zone—*C. stellatus stellatus* occurs on the surface of the flat boulders. The intensity of occurrence of the barnacle is very much lower than that on the jetty and pier (Table I). *Tectarius malaccanus* and *T. granularis* are also represented but in small numbers. A few *Cellana radiata* and *Crassostrea cucullata* also are found. On boulders with encrusting remains of dead calcareous algae the barnacles are in low numbers the substratum appearing to be not suitable for the settlement of cirripedes. On many of the boulders in the lower portions of the zone there is a growth of the

TABLE I
Animals found in a 25 cm square in the three subzones of the intertidal zone at the five different stations

Station	Supralittoral fringe	Midlittoral zone	Infralittoral fringe
Ia. C.M.F.R.I. Jetty	<i>Littorina scabra</i> 1 <i>Tectarius granularis</i> 36 <i>C. stellatus stellatus</i> 16	<i>C. stellatus stellatus</i> 919 <i>Littorina scabra</i> 1 <i>Tectarius granularis</i> 10 <i>Cellana radiata</i> 1 <i>Crassostrea cucullata</i> 1	Vermetid gastropods 619
Ib. Pier near the C.M.F.R.I. Jetty	<i>Littorina scabra</i> 3 <i>Tectarius malaccanus</i> 17 <i>Tectarius granularis</i> 9 <i>C. stellatus stellatus</i> 1	<i>C. stellatus stellatus</i> 698	Vermetid gastropods 1585 <i>Drupa tuberculata</i> 16 <i>Thais rudolphi</i> 1
II. By the side of Catholic Church	<i>Tectarius malaccanus</i> 156	<i>C. stellatus stellatus</i> 84 <i>Tectarius malaccanus</i> 7 <i>Tectarius granularis</i> 43 <i>Cellana radiata</i> 1 <i>Modiolus striatula</i> 16	Vermetid gastropods 1421 <i>Cellana radiata</i> 1 <i>Modiolus striatula</i> 2
III. At the eastern extremity of Quarantine camp	<i>Littorina scabra</i> 2 <i>Littorina undulata</i> 1 <i>Tectarius granularis</i> 25 <i>Tectarius malaccanus</i> 33	<i>C. stellatus stellatus</i> 5 <i>Cellana radiata</i> 1 <i>Tectarius granularis</i> 3 <i>Tectarius malaccanus</i> 4 <i>Crassostrea cucullata</i> 1 <i>Modiolus striatula</i> 1	Vermetid gastropods 958 <i>Petricola lithophaga</i> 1
IV. Concrete construction near Centre III	<i>Littorina scabra</i> 5 <i>Tectarius malaccanus</i> 1 <i>Tectarius granularis</i> 15 <i>C. stellatus stellatus</i> 64	<i>C. stellatus stellatus</i> 146 <i>Crassostrea cucullata</i> 1	<i>Thais rudolphi</i> 1 Amphipods 6 Isopods 12
V. Near Manakad, Palk Bay	<i>Littorina scabra</i> 1 <i>Tectarius malaccanus</i> 1	<i>Littorina scabra</i> 2 <i>Tectarius malaccanus</i> 2 <i>Planaxis sulcatus</i> 67	<i>Planaxis sulcatus</i> 2 <i>Cerithium trailli</i> 2 <i>Cerithium clypeomorus</i> 1 <i>Cerithium splendens</i> 4 <i>Balanus amphitrite communis</i> 10

alga *Enteromorpha compressa*. The interstitial areas between the boulders are sandy and there is no molluscan fauna here.

Infralittoral fringe—The prosobranchs *Thais rudolphi*, *Pyrene zebra*, *Trochus radiatus*, *Turbo intercostalis* and *Conus coronatus* are present in moderate numbers on the surface of the sandstone boulders. The Vermetid gastropods found on the jetty are represented here also in large numbers in patches. A few individuals of *Petricola lithophaga* are also found boring into soft sandstone. The sponges *Sigmodocea pumila* and *Haliclona tenuiramosa* are present in large patches in a few places on the top and sheltered sides of boulders. The colonial anthozoan *Gemmaria* sp. has been recorded on the protected vertical surfaces. Besides the above fauna, there is a good growth of algae like *Centroceras* sp., *Amphiroa* sp., *Sargassum wightii*, *Gracilaria corticata* and *Caulerpa racemosa*.

Station III (At the eastern extremity of Quarantine Camp)

In this area the intertidal region is mostly sandy with large sandstone boulders on the landward edge. There are a few, small, flat boulders in the middle part and bigger ones on the seaward side.

Supralittoral fringe—*Littorina scabra* and *L. undulata* are found on the surface of the sandstone boulders in moderate numbers. Some of the littorinids occur in groups in shady places of the boulders. *Tectarius granularis* and *T. malaccanus* are found in very large numbers. *T. malaccanus* is usually more abundant in the upper portions of the subzone while *T. granularis* is in maximum numbers in lower portions of the subzone which are covered with water at M. H. W. S. The bivalves *Crassostrea cucullata* and *Modiolus striatula* are represented in small numbers. Stray individuals of *C. stellatus stellatus* also occur on a few boulders.

Midlittoral zone—The midlittoral zone is mostly sandy with a certain amount of coral sand, mud and small quantity of organic detritus. *Donax cuneatus*, *D. faba*, polychaetes of *Prionospio* sp. and crabs of *Philyra* sp. have been recorded in small numbers in this subzone. *C. stellatus stellatus* occurs in very much smaller density as compared to at stations I, II and III on the boulders of this zone. *T. granularis*, *Cellana radiata* and *Modiolus striatula* are also found.

Infralittoral fringe—The Vermetid gastropods are found in this station also in large numbers closely packed together on some sandstone boulders. The others represented in this subzone are the prosobranch gastropods *Trochus radiatus* and *Turbo intercostalis*.

Station IV (On the concrete construction east of Station III)

The concrete construction is a tall wall built with granite stones and cement.

Supralittoral fringe—*Littorina scabra* is found in moderate numbers and *T. malaccanus* and *T. granularis* in small numbers. *C. stellatus stellatus* characteristic of midlittoral zone is found in some numbers on parts of the wall in this subzone.

Midlittoral zone—The bottommost 0.3 metre portion of the concrete construction and some sandy region before it constitute this zone. On the former *C. stellatus*

stellatus is found in large numbers but their abundance is not as much as on the pillars of the jetty.

Infralittoral fringe—The prosobranch gastropod *Thais rudolphi* is found in small numbers. A few isopods and amphipods live on the undersurface of stones scattered in the sand. *Enteromorpha compressa* is present in this subzone.

Station V (In Palk Bay near Manakad)

The landward part of the intertidal region is sandy with coral stones scattered in the area. The seaward portion of the intertidal region has a good amount of coral sand, mud and organic detritus with small, dead coral pieces all over the place.

Supralittoral fringe—On the large dead coral stones a few *Littorina scabra*, *Tectarius malaccanus* and *T. granularis* are found. The very low density of *Tectarius* spp. in Palk Bay as compared to the Gulf of Mannar is a striking difference. The probable reason for this is not clear.

Midlittoral zone—*L. scabra* occurs on the coral stones but in very small numbers. Only a few *Tectarius malaccanus* are found on the coral stones. The dominant species in this subzone is *Planaxis sulcatus* which occurs in large numbers. It is a gregarious form found in groups. A few barnacles of the species *Balanus amphitrite communis* are present on dead coral. The others which occur sporadically in the subzone are *Cerithium trailli*, *Nerita maura*, *Cellana radiata* and *Crassostrea cucullata*. *Enteromorpha compressa* is represented.

Infralittoral fringe—Members belonging to various taxonomic groups occur in this subzone on dead coral stones and in the muddy sand below. On the coral stones the prosobranchs *Planaxis sulcatus*, *Cerithium trailli*, *C. clypeomorus* and *C. splendens* are common. *Cerithium* spp. are also found on the undersurface of stones in good numbers and a few on the muddy sand bed. On the coral stones *Cellana radiata* occurs in small to moderate numbers and the chiton *Ischnochiton comptus* and the oyster *Crassostrea cucullata* in small numbers. The prosobranchs *Rissoina bertholleti* and *Pyrene diminuta* are present in small to appreciable numbers on the undersurface of stones. *Onchidium verraclatum* is represented on the undersurface of coral stones. The opisthobranchs *Dendrodoris rubra* and *Discodoris concinna* and the bivalves *Arca avellana* and *A. fusca* occur on the upper and lower surfaces of stones. The opisthobranch *Haminoea tenera* is found on the alga *Gelidiella acerosa*. Stray individuals of *Isognomon isognomum* var. *canina*, *I. isognomum* var. *norma* and *Modiolus striatula* are present in crevices of stones. The Vermetid gastropods which are abundant in the infralittoral fringe in Gulf of Mannar are absent here. The reason for their absence is not known. The sponges *Spongia officinalis* var. *ceylonensis*, *Callyspongia diffusa*, *Hyatella cribriformis*, *Tedania nigrescens*, hydroids, polyzoans and *Balanus amphitrite communis* and *Crassostrea cucullata* are present on the protected and exposed surfaces of coral stones. A few bivalves *Gafrarium tumidum*, *G. pectinatum* and *G. dispar* and small numbers of the polychaetes *Nereis* sp., *Eunice antennata*, *Prionospio* sp. and Terebellids are found in the muddy sand of the subzone amidst coral debris. Good numbers of isopods (*Ligia exotica*) and amphipods are found on the upper and lower surfaces of stones. Moderate numbers of crabs *Metapograpsus thukhur*, *Grapsus strigosus*, *Medaesus* sp., *Thalamita crenata* and *Scylla*

serrata have also been recorded in this subzone. The crabs feed on the prosobranch molluscs *Cerithium* spp. in the subzone. The algae *Enteromorpha compressa* and *Gelidiella acerosa* are common in this sub-zone and *Centroceras* sp. *Chaetomorpha*, *Cladophora* and *Sphacellaria* are also found.

Habits of Intertidal Molluscs

The bivalves *Donax cuneatus*, *Crassostrea cucullata*, *Arca* spp., *Gafrarium* spp., and *Modiolus striatula* are suspension feeders feeding on fine suspended organic materials in the sea water. The prosobranch gastropods *Littorina scabra*, *L. undulata*, *Planaxis sulcatus*, *Cerithium* spp. and *Cellana radiata* have been found to feed on algae like *Chaetomorpha* and *Enteromorpha compressa*. Feeding was more intensive at noon and in the afternoons as compared to morning and has not been observed at the time of storms. *P. sulcatus*, *Cerithium* spp., *Rissoina bertholleti*, *Pyrene diminuta* and *Cellana radiata* have been found to feed on organic detritus. In Gulf of Mannar, *Turbo intercostalis* feeds on the algae *Caulerpa racemosa*, *Gracilaria* and *Centroceras*, *Trochus radiatus* on *Centroceras* and *Trochus pustulosus* on *Chaetomorpha* and organic detritus; *Conus coronatus* is carnivorous and eats Terebellid polychaetes. *Onchidium verruculatum* subsists on organic detritus present in the muddy sand.

Prasad (1957) has studied the variations in air and surface temperatures close to the shore in the Gulf of Mannar and found that surface temperature follows very closely the atmospheric temperature though it has not always been so. He has observed that water temperature increases between January and April and again between August and October and falls in the periods June–July and November–December. In the present work also during the period October–January the air temperature and surface water temperature in the intertidal zone in the intertidal zone in the Gulf of Mannar and Palk Bay have shown similar trends but for some exceptions which may be ascribed to the prevalence of strong winds during the monsoon as mentioned by Prasad (*loc. cit.*). In the present study the water temperature in the intertidal region has varied between 26° and 31°C in the Gulf of Mannar and between 24.8° and 35.8°C in Palk Bay (readings taken at different periods of the day included). The extent of increase in water temperature in the intertidal zone during daytime is more marked in Palk Bay (2.8–7°) than in the Gulf of Mannar (1.5–2.8°). This is explained by the fact that in Palk Bay the intertidal region is shallow as compared to the Gulf of Mannar. *Planaxis sulcatus*, *Cerithium trailli*, *Trochus* spp., *Rissoina bertholleti*, *Pyrene zebra*, *Pyrene diminuta* and *Cellana radiata* are more active towards noon and in the afternoon and feed intensively as the water temperature increases. However, even on cloudy days when there was no appreciable increase in temperature there been greater activity of these gastropods towards noon. It is of interest to note that on days when there is a depression in the bay followed by rough sea and rains and chill weather the above gastropods have shown little movement and feeding has not been observed. When the water temperature is low on stormy days *Planaxis sulcatus* cling firmly in large numbers on the stones above water level to where they are transported by wave action.

The salinity of the sea-water varied between 29.9 and 34.99 ‰ in the Gulf of Mannar and between 22.28 and 35.82 ‰ in the period October–January in

- Palk Bay. The minimum value in Palk Bay is much lower than that in the Gulf of Mannar. As mentioned by Jayaraman (1954) in the case of inshore waters of this area there has been a fall in salinity in the period December-January. No well-defined differences have been observed in salinity at low and high tides. Crisp and Southward (1958) working on the intertidal fauna of the English Channel have pointed out that shore organisms are exposed to wide changes in salinity through rainfall and stream water. The marked decrease in salinity in Palk Bay in January does not appear to affect the density of the molluscan fauna.

At low tide *Littorina scabra* and *L. undulata* are mostly passive and at high tide they move actively when splashed by waves. These movements are feeding migrations in search of food. The counts of *L. scabra* and *L. undulata* taken at fixed areas at successive low tides and high tides showed that changes occurred in numbers following movement of the periwinkles. Such changes take place in other mobile forms like *Tectarius* spp., *Planaxis sulcatus*, *Cerithium* spp., *Trochus pustulosus* and *Cellana radiata* also. However, the fluctuations are irregular.

Vertical migration was not perceptible in *Littorina* spp. in relation to tides. Such a migration has been observed in the case of *Planaxis sulcatus* which descended by a height of 0.14 metre between high tide and low tide. Like *Littorina* spp., *Planaxis sulcatus*, *Cerithium trilli*, *C. clypeomorus* and *Onchidium* fed actively at high tide as the waves splashed. *Cellana radiata*, *Pyrene diminuta* and *Rissoina bertholleti* also showed similar habits.

DISCUSSION

The results obtained in this work clearly show that there is distinct zonation in the occurrence of fauna in the intertidal region in Gulf of Mannar and Palk Bay which is primarily influenced by tides. The three subzones recognized by Stephenson and Stephenson (1949) are discernible in the Mandapam area. In the Gulf of Mannar *Littorina* spp. and *Tectarius* spp. characterize the supralittoral fringe, *Chthamalus stellatus stellatus*, *Cellana radiata* and *Crassostrea cucullata* the midlittoral zone and Vermetid gastropods, sponges, and the prosobranchs *Drupa tuberculata*, *Trochus radiatus* and *Turbo intercostalis* along with a good growth of different species of algae *Centroceras* sp., *Amphiroa* sp., *Gracilaria corticata*, *Sargassum wightii* and *Caulerpa recemosa* the infralittoral fringe. In the Palk Bay *Littorina* and *Tectarius* are the indicator organisms in the supralittoral fringe, *Planaxis sulcatus*, *Crassostrea cucullata* and *Cellana radiata* in the midlittoral zone and *Trochus* sp., *Cerithium* spp., *Rissoina* sp., *Pyrene* sp., and bivalves (*Gafrarium* sp., and *Arca* sp.) in the infralittoral fringe.

In a few places the rock oyster *Crassostrea cucullata* a member of the midlittoral zone is found in small numbers in the supralittoral fringe. This is due to the existence of suitable substratum (sandstone boulders) which is an important factor in distribution. Chapman (1943) has termed this factor the presence or absence factors. The same explanation will hold for the midlittoral zone form, *Chthamalus stellatus stellatus* occurring in the supralittoral fringe on the pillars of the jetty and station IV concrete construction in the Gulf of Mannar. The lower portions of the supralittoral fringe here receive splash and water spray at high tide which enables the barnacles to thrive there.

Stephenson and Stephenson (1952) have further subdivided the midlittoral zone at Marineland into two subzones (an upper one with barnacles, limpets, bivalves and some algae and a lower one with a luxuriant growth of algae) and in Beaufort region into three subzones (*Chthamalus*, oyster and muddy zones). On the Waltair coast, Rao and Rao (1962) have distinguished three subzones in the midlittoral zone viz. (i) the upper littoral including *Littorina*, *Ostrea*, *Chthamalus* and *Chaetomorpha*, (ii) the midlittoral with *Chthamalus*, *Cellana*, *Thais*, *Drupa*, *Ulva*, *Jania* and *Caulerpa* and (iii) the lower littoral with *Gemmaria*, *Balanus tintinnabulum*, *Drupa*, *Nerita*, *Cerithium*, *Stomopneustes*, *Gracilaria* and *Sargassum*. However, Umamaheswararao and Sreeramulu (1964) have held that the midlittoral zone of Waltair coast is not further divisible into subzones. In the Mandapam area the midlittoral zone is very narrow and inhabited by *C. stellatus stellatus*, *Cellana*, *Tectarius* spp., *Modiolus*, *Crassostrea* and *Chaetomorpha* in the Gulf of Mannar and *Planaxis sulcatus*, *Littorina* sp., *Tectarius* sp., *Nerita*, *Cellana* and *Enteromorpha* in Palk Bay. There is no vertical stratification in the occurrence of these forms and hence subdivision of the zone is not possible.

The density of the population in any habitat is determined by the prevalence of favourable conditions. The restricted density of *Littorina* spp. in supralittoral fringe in Gulf of Mannar area may be ascribed to the unfavourable conditions under which they live, the substratum (sandstone boulders) getting heated up very much on most days during day time. In Palk Bay there is very little scope for the species to multiply due to the scantiness of the substratum well above water level. The abundance of *Tectarius* spp in Gulf of Mannar can be ascribed to the ability of the species which have a shell thicker than *Littorina* to withstand desiccation, and absence of predators. The extreme abundance of the barnacle *Chthamalus stellatus stellatus* on the pillars of C. M. F. R. I. jetty could be ascribed to good wave action which is known (Southward and Orton 1954) to highly favour settlement of large numbers of *C. stellatus* on exposed surfaces. Near the pier by the side of the jetty *C. stellatus stellatus* are found in good numbers on granite stones but in lesser density than on the cement concrete jetty. The rough and uneven surface of the granite stones do not facilitate settlement and survival of the barnacles as much as the smooth cement surface of the pillars of the jetty. For the same reason the barnacles are found in moderate numbers in station IV. The poor numbers of *C. stellatus stellatus* in station III and the moderate intensity in station II could be ascribed to the movement of interstitial sand over the flat boulders on which the barnacles are present causing mortality. Dead barnacles have been observed in a fixed area in station III (in Gulf of Mannar) examined at periodical intervals.

While *C. stellatus stellatus* is represented in the intertidal region in the Gulf of Mannar in small or large numbers, it has been found only very rarely in the Palk Bay. *Balanus amphitrite communis* is the barnacle which is seen in Palk Bay and it occurs generally in small numbers. The factors responsible for the sporadic occurrence of the barnacles in this area is not quite clear. The soft nature of the dead coral stones which are only available for the settlement of barnacles may not be conducive for their survival. The high content of organic and inorganic suspended matter in the area over muddy sand may also be inimical to barnacles.

Stephenson and Stephenson (1949, 1952) have recorded that oysters and limpets are abundant in the midlittoral zone in Florida Keys and north Florida. Under tropical conditions in Gulf of Mannar *Crassostrea cucullata* and *Cellana radiata* are represented only in small numbers. The striking difference is understood when it is realized that in Mandapam area the oysters and limpets live under very unfavourable conditions, being exposed to intense heat during day time and the conditions are worse in summer in tropical areas as pointed out in the case of the South African coasts by Stephenson (1943).

The prosobranchs *Trochus radiatus* and *Turbo intereostalis* are present in Gulf of Mannar in the infralittoral fringe where there is excellent growth of the algae *Centroceras*, *Amphiroa* and *Caulerpa racemosa* which constitute their food. The occurrence of large populations of *Planaxis sulcatus*, *Cerithium trilli*, *C. clypeomorus*, and *C. splendens* in Palk Bay is favoured by the availability of their food, the algae like *Chaetomorpha*, *Enteromorpha compressa*, *Gelidiella*, *Cladophora* and *Sphacelaria* and organic detritus. However, it may be stated that the density of various species is determined not by just a single factor or a set of a few individual factors but by quite a variety of biotic and abiotic factors constantly tending to alter the ecosystem. Mutual competition of the organisms constituting the ecosystem may bring about drastic changes in its composition and the picture may vary with seasons. In this paper the factors which are of prime importance in the colonization of different subzones of the intertidal region by different organisms are mentioned.

The observations on the habits of intertidal molluscs show that they are influenced by factors like light, geotaxis, high tide, wave action and water temperature changes. *Littorina* spp. and *Tectarius* spp. are usually found in the supralittoral fringe being well-adapted for aerial respiration but they extend into the midlittoral zone also when there is a suitable substratum. Atapattu (1969) has also recorded *Nodilittorina* (*Tectarius*) *granularis* in midlittoral zone on Ceylon coast. *Littorina* spp. and *Tectarius* spp. exhibit negative phototaxis preferring shady crevices. For feeding purposes, however, they come out of crevices. *Littorina* sp. and *Tectarius malaccanus* keep above water level except when feeding exhibiting what Mitsukuri (1901) has described as negative hydrotaxis in *Littorina exigua*.

Littorina spp. and *Tectarius* spp. are mostly inactive at low tide and actively feed when splashed by waves at high tide. *Planaxis sulcatus*, *Cerithium trilli*, *C. clypeomorus*, *Trochus radiatus*, *T. pustulosus* and *Cellana radiata* also exhibit a similar behaviour. *Patella vulgaris* is known (Fretter and Graham, 1962) to occur from the highest portions of the intertidal region down to M.L.W.S. and the occurrence of the limpet has been stated to be determined by the extent of water splash. Wave action appears to similarly restrict the distribution of *Cellana radiata* and *Planaxis sulcatus* in Palk Bay between the midlittoral zone and landward portions of the infralittoral fringe.

There is evidence to show that increase in water temperature during daytime is followed by active locomotion and feeding in *Planaxis sulcatus*, *Cerithium trilli*, *Trochus* spp., *Cellana* and some other species. Even on cloudy days when there has been no increase in water temperature these molluscs have been more active towards noon and in the afternoons as compared to mornings. This is suggestive of the existence also of an internal rhythm in the organisms that results in active locomotion

and feeding at particular periods in the day. Weather conditions have been observed to have profound influence on the intertidal molluscs. On days when there is a depression in the bay, and rough sea accompanied by rain the water temperature is low (22.8° to 24.8°C compared to a temperature of 28–31°C on days with fair weather), *Littorina* spp. and *Planaxis sulcatus* drifted to big stones along with waves and were attached firmly to the top surfaces of the stones. At such periods feeding does not take place or is very scanty in these species. *Cerithium* spp. *Cellana* and *Onchidium* sp. and some other gastropods also have showed similar behaviour. These observations recall those of Newell (1958) who has observed that *Littorina littorea* become inactive and cease to feed or move about at about 8°C on north Kent coast due to low temperature.

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