

STUDIES ON THE MARINE INTERTIDAL ECOLOGY OF THE ORISSA COAST

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The ecological distribution of the intertidal fauna observed during a marine faunistic survey of the Orissa coast in December, 1966, is described. A fairly dense and highly varied micro-and macro-fauna has been reported on. Over 480 species have been recorded.

Dense populations of diatoms occurred in vast sheets near mid-water level. Whereas the microfauna was fairly rich, the density of the macrofauna inhabiting the intertidal sands was relatively poor; due to the strong wave-action over the beaches there appeared to be a consequent deficiency of organic matter.

The zonal distribution of animals in the intertidal sandy habitat of the Orissa region was found to be more or less similar to that described by Ganapati and Lakshmana Rao (1962) for the Andhra coast.

INTRODUCTION

In recent years, while there has been much attention paid to the study of the marine intertidal ecology of temperate zones, our knowledge for tropical coasts is relatively poor. This is specially the case for Indian coasts. However, McIntyre (1968) dealt with the meiofauna and macrofauna of some tropical beaches near the Marine Biological Station, Porto Novo, south of Madras; Ganapati and Lakshmana Rao (1962) and Ganapati and Chandrasekhara Rao (1962) dealt with the ecology of the intertidal sands of the Visakhapatnam coast; and, Nagabhushanam and Chandrasekhara Rao (1969) made some preliminary observations on the shore-fauna of the Orissa coast.

The present paper is based on the collections made by the Zoological Survey of India during a marine faunistic survey of the Orissa coast in December, 1966. An attempt has been made to recognize major ecological niches, and to correlate the present data with the observations made by McIntyre (1968) and Ganapati and Lakshmana Rao (1962) for the two locations (over 1000 and 500 miles respectively) further to the south along the Bay of Bengal coastline.

AREA INVESTIGATED

The investigations were made at five stations along the Puri and Konarak coast (Fig. 1). The area investigated was completely sandy, being composed of sand-grains varying from 150 μ to 600 μ in diameter, without any pebbles or rocky outcrops. The organic detritus of the Puri beaches appeared rich in the finer substrates; while at Konarak the organic content of the sands was low, possibly due to their larger particulate size; at both places, the beaches slope gently down to the low-water mark (LWM) exposing a wide intertidal belt during low tides.

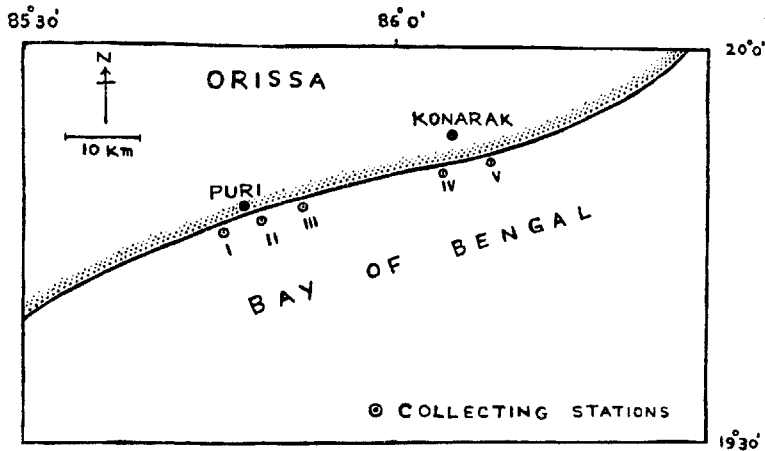


FIG. 1. Chart of the Orissa coast, showing stations where collections of micro - and macro - fauna were made.

MATERIALS AND METHODS

The interstitial fauna was studied by examining sand samples extracted from several localities along mid-water mark (MWM) in the intertidal belt, from top to a depth of 50 cm below surface. The samples were washed with sea-water and the animals were picked up with a pipette under a binocular microscope; examination of the specimens was made in a fresh condition, since it was found that preservation destroyed these delicate forms.

Surface scrappings were made of the diatom film, which covered the intertidal belt along MWM in vast sheets, for further detailed examination and identification.

The intertidal macrofauna was collected from $\frac{1}{4}$ metre square areas from LWM to HWM along each station transect to a depth of 50 cm.; the material was brought to the laboratory in a preserved condition for further processing.

OBSERVATIONS

Diatom films—Dense populations of diatoms occurred in vast sheets near MWM, and these were chiefly composed of the following species : *Asterionella japonica* Cleve and Moler, *Biddulphia* spp, *Chaetoceros affine* Lauder, *C. diversum* Cleve, *Coscinodiscus centralis* Ehrenberg, *Hemidiscus* sp., *Nitzschia seriata* Cleve, *Pleurosigma elongatum* Smith, *P. aestuarii* Smith, *Rhizosolenia* spp, and *Thalassionema nitzschoides* Grunow.

The diatom film showed great uniformity as regards population-composition for the different localities surveyed. But a large number of other diatomaceous species were identified, though their distribution and numerical contribution to the film population appeared to be relatively poorer. A full check-list of the diatoms encountered appears elsewhere (Nagabhushanam and Rao 1969).

THE INTERSTITIAL MICROFAUNA

While a large number of interstitial-dwelling forms have been identified, the following species made up the bulk of the populations observed at different stations, occurring at three or more stations (unless otherwise indicated, when they occurred in large enough numbers to form a dominant component of the interstitial community).

PROTOZOA : Foraminifera—*Discorbis versicularis* Lam., *Rotalia pulchella* d'Orb.; Dinoflagellata—*Amphidinium pellucidum* Herdman *Gymnodinium splendens* Lebour; Ciliata: Holotricha—*Coleps* spp; Spirotricha : *Diophrys appendiculata* (Ehrenberg), *Epiclintes ambiguus* (O. F. Müller) Bütschli, *Euplotes moebusi* Kahl, *Metopus* sp.

COELENTERATA : *Halammohydra octopodides* Remane.

TURBELLARIA : *Baltoplana magna* Karling, *Macrostomum* sp., *Otoplana* sp.

NEMATODA : Enoploidea—*Anticoma arctica* Steiner, *Enoploides* sp.; Chromodo-roidea—*Desmoscolex bengalensis* Timm, *Metepsilonema* sp; Axonolaimoidea—*Camacolaimus* sp.; Monhysteroidea—*Rhynchonema cinctum* Cobb; *Theristus tortuosa* Timm.

GASTROTRICHA : Macrodasyoidea—*Dactylopodalia* sp., *Mesodasys* sp., *Pseudostomella roscovita* Swedmark, *Tetrarhynchoderma* spp.; Chaetonotoidea—*Chaetonotus* sp., *Xenotrichula velox* Remane.

KINORHYNCHA : *Cateria styx* Gerlach.

NEMERTINEA : *Ototyphlonemertes* sp.

ROTIFERA : *Encentrum* sp. (at two stations only)

ANNELIDA : Archiannelida—*Diurodrilus benazzii* Gerlach, *Protodrillus indicus* Aiyar and Alikunhi, *P. pierantonii* Aiyar and Alikunhi; Polychaeta *Hesionides arenarius* Friedrich, *H. gohari* Hartmann Schröder, *Petitita amphophthalma* Siewing, *Pisone complexa* Alikunhi; Oligochaeta—*Michaelsena* sp., *Propappus* sp.

CRUSTACEA : Ostracoda—*Loxoconcha* sp., *Microcythere subterranea* Hartmann, *Polycope* sp., *Xestoleberis* sp., Copepoda—*Amiera trisetosa* Krishnaswamy, *Arenopontia indica* Rao, *A. subterranea* Künz, *Arenosetella germanica*, Künz, *Paramesochra wilsoni* Krishnaswamy, *Pararenosetella* sp., *Sewellina raductus* Krishnaswamy, *Stigmatidium arenosetelloides* Noodt; Isopoda—*Angellera phreaticola* Chappuis and Delamare, *Microcerberus predatoris* (Gnanamuthu)

ARACHNIDA : Tardigrada—*Stygarctus bradypus* Schulz; Acarina—*Copidognathus* sp., *Halacarus anomalus* Trouessart, *Rhombdogasthus* sp.

MOLLUSCA : *Microhedyle* sp., *Pseudovermis salamanarops* Marcus—at two stations only.

A full check-list of the various microfauna identified (over 160 species) has been given elsewhere (Nagabhushanam and Rao 1969). An examination of the interstitial microfauna revealed an amazing similarity for the various locations sampled, and

the majority of the microfauna live in sands of medium size 10–30 cm below the surface near MWM where they appear to find optimum climatic and biotic environment. Fine grades of sand yielded very poor interstitial fauna, possibly due to paucity of interstitial spaces and/or the blocking of the interstices by organic matter.

THE INTERTIDAL MACROFAUNA

The sandy intertidal belt is characterized by the occurrence of the following species which either live burrowed just under the surface during low water (emerging only when their environment is covered with the incoming tide, or else move actively around on the sand even when the tide is out).

ARACHNIDA : Archiannelida—*Polygordius madrasensis* Aiyer and Alikunhi; Polychaeta—*Nereis* sp.; *Glycera lancadivae* Schmarda; *G. alba* Rathke

CRUSTACEA : *Ocyropa platytarsis* Milne-Edwards, *Calappa* sp., *Philyra scabruiscula* (Fabr.), *P. corallicola* Alcock, *Clibnarius arethusa* de Man, *Emerita asiatica* Milne-Edwards.

MOLLUSCA : Gastropoda—*Bullia vittata* (L.), *Oliva gibbosa* (Born), *Conus striatus* L.; Bivalvia—*Sunetta scripta* (L.), *Donax cuneatus* (L.), *Meretrix casta* (Chemnitz); *Gafrarium* spp., *Solen corneus* Lam., *Siliqua readiata* L.

PISCES : (at one station only)—*Ophichthys orientalis* Günther

As the study on macrofauna progressed, it became apparent that the intertidal belt could be roughly divided into two ecological nichés, viz., the LWM-MWM niché and the MWM-HWM niché; a brief account of these nichés is given below :

The LWM-MWM niché—Of the organisms named above, it was observed that while the archiannelids like *Polygordius* were common in the coarser substrates mixed with fine shell gravel between LWM and MWM, other sand-worms like the errant polychaetes occurred chiefly nearer LWM; polychaetes like *Glycera* commonly occurred in fine or medium sandy substrates near MWM, while *Nereis* preferred the coarse sand grades near LWM; due to the strong wave-action which resulted in energetic scouring of the intertidal belt, very few of the more delicate tubicolous polychaetes were met with.

Beside the polychaetes, the animal community in this niché appeared to be dominated by the hippid crab *Emerita asiatica* and the cockle *Gafrarium* spp; the density of these two species was 10 individuals of each species per sq. metre. The other prominent members of this niché included the decapod crabs (other than *Ocyropa*) and the molluscs (other than *Bullia*, *Oliva* and *Conus*).

This niché yielded the bulk of the fauna collected in the intertidal belt as a whole, and its very richness in macrofauna set it apart from the relatively poorer MWM-HWM niché.

Ophichthys orientalis—burrows near LWM, and it eludes capture by burrowing so swiftly that the present capture-record at one station only does not indicate that it is rare; on the other hand, it was often seen in this niché.

The MWM-HWM niché—This niché includes the upper levels of the intertidal belt and is completely dominated by the ocyropid crab *Ocyropa platytarsis*;

this crab was found to live in burrows at all levels of this niché, and observations made on its habits are in agreement with those made at Porto Novo (McIntyre, 1968). Eight ocypodid burrows occurred per sq. m. Lower down, nearer MWM, the ocypodids form part of a larger faunal complex which includes the gastropods *Bullia*, *Oliva* and *Conus*. The niché is remarkably poor, relative to the LWM-MWM niché.

While these nichés have certain aspects which make them fairly discreet ecological units, yet there are quite a few forms, e.g., the hermit-crabs (*Clibnarius*), *Glycera* and the mollusc *Donax*, which appear to freely move up and down the intertidal belt at times when the belt is flooded with the tide-water. It is felt, however, that these two ecological nichés would serve for all practical purposes, as a basis for further studies on in-living macrofauna.

A full check-list of identified macrofauna (over 320 species) is given elsewhere (Nagabhushanam and Rao 1969).

DISCUSSION

The present study revealed an amazing uniformity in population-composition for the diatom-films which covered vast tracts of the intertidal belt near MWM. The same observation was made for the interstitial-living microfauna; the richest yields of microfauna (4706 individuals per sq. m) occurred near MWM, and it would appear at first sight that there may be an association possible between the diatom film on the surface and the rich microfaunal element 10-30 cm below surface. As yet we know very little about the migratory characteristics of the microfauna in the vertical plane. Only further detailed study will support or reject this hypothesis of an association of the surface diatom-film and the underlying microfauna.

There is a great similarity between the macrofauna recorded for sandy beaches in the Orissa, Visakhapatnam and Porto Novo zones of the Bay of Bengal coast (Table I). As might be expected for areas widely separated geographically, there are differences in the certain species found dominant in one zone were either not found at all, or else were quite insignificant relatively in the other, e.g., in the Orissa Zone *Bullia* was prominent in the MWM-HWM niché, possibly this is due to the fact that the Orissa beach slopes gently down to the water-level, ensuring quick coverage by the incoming tide and this has perhaps helped this species to populate the upper niché in the intertidal belt; *Bullia* was absent from this niché for the two zones further to the south, and in Porto Novo, McIntyre (1968) recorded that the upper levels of the sandy intertidal belt were very poorly populated. Table I attempts to arrange the macro-faunal element for the two nichés and it will be noted that there are many forms which move up and down the intertidal belt from LWM to HWM almost, for foraging on the 'resident' population of the nichés.

During the present study data was collected on the numbers of 'total' fauna, i.e., counts of all animals found occurring in a given area, and this data for the two nichés and for the microfauna and macrofauna separately, are given in Table II; the Table also gives a comparative set of values for the Visakhapatnam and Porto Novo zones. It will be seen that the Orissa zone and Visakhapatnam zone are appreciably poorer than the Porto Novo one, where McIntyre (1968) has had counts

TABLE I

The dominant macrofauna recorded for sandy beaches in the Orissa, Visakhapatnam and Porto Novo zones of the Bay of Bengal coast. (The data for the two last-named zones have been rearranged for comparative study according to the two ecological nichés)

Zone (area studied)	Niché : LWM-MWM	Niché : MWM-HWM	Migrants	Authority
Orissa (19° 50' N; 86° E approx.)	<i>Polygordius madrasensis</i> ,	<i>Ocyropa platytarsis</i> ,	<i>Clibnarius</i> ,	This paper
	<i>Glycera lancadivae</i> ,	<i>Bullia vittata</i> ,	Decapod crabs,	
Visakhapatnam (17° 38' N; 83° 16' E approx.)	<i>G. alba</i> , <i>Nereis</i> spp.,	<i>Oliva gibbosa</i> ,	<i>Donax cuneatus</i> ,	Ganapati and Lakshmana Rao (1962)
	<i>Emerita asiatica</i> ,	<i>Conus striatus</i>	<i>Glycera</i>	
	<i>Gafrarium</i> spp, <i>Ophichthys orientalis</i>			
	<i>Prionospio krusadensis</i> Fauvel,	<i>Nerine cirratulus</i>	<i>Emerita asiatica</i> ,	
	<i>Aricia</i> sp.,	Delle Chiaje,	Lamellibranchs,	
	<i>Eunice tentaculata</i> Quatrefages,	Some talitrids,	<i>Donaxcuneatus</i>	
	<i>Harpinta</i> sp.,	<i>Ocyropa platytarsis</i> ,		
	<i>Gastrosaccus spinifer</i> (Goes),	<i>O. macrocera</i> M.—Edw		
	<i>Bullia vittata</i> ,			
	<i>Ophichthys orientalis</i>			
Porto Novo (11° 40' N; 79° 38' E approx.)	<i>Donax</i> sp. juv.,	<i>Ocyropa platytarsis</i> ,	<i>Emerita asiatica</i>	McIntyre (1968)
	<i>Nerine cirratulus</i> ,	<i>Nerine cirratulus</i> ,	Mysids	
	<i>Glycera alba</i> ,	Lamellibranch spp. juv	<i>Oliva</i> sp.	
	Isopoda, Amphipoda		<i>Umbonium</i> sp.	

as high as 1,960,000 individuals per sq m. at MWM. The data for the Orissa and Visakhapatnam zones, as regards the microfauna, more or less agree in density of populations at all levels of the intertidal except LWM where the Orissa zone appears richer.

TABLE II

A comparison of numbers/sq. m of the micro-and macro-fauna components of the intertidal fauna inhabiting sandy beaches of three zones along the Bay of Bengal coast of India

Zone	Period studied	Microfauna	Macrofauna	Authority
Orissa	Dec. '66	*LWM : 3252 MWM : 4706 HWM : 2048	LWM-MWM : 406 MWM-HWM : 184	Present paper
Visakhapatnam	1953-54	No comparable data	No data for 'total' fauna	Ganapati and Lakshmana Rao (1962)
„	1961	+LWM : 2068 *MWM : 2284 +HWM : 1832	No data	Ganapati and Chandrasekhara Rao ((1962)
Porto Novo	Jan.-Feb '66	LWM : 992,000 MWM : 1960,000 HWM : 968,000	LWM : 368 MWM : 128 HWM : 128	McIntyre (1968)

*indicates data (some unpublished) made available by Dr. G. Chandrasekhara Rao

While there is no 'total' fauna data available for the Visakhapatnam zone, Table II indicates that the Orissa zone is comparatively richer in the macro-faunal component than the Porto Novo zone.

However, it must be pointed out that unless we know whether there are large fluctuations in the composition of the micro—and macro—faunal components with seasonal changes through the year, such comparisons of numerical densities of populations have only limited value. The fluid and unstable nature of the sandy intertidal belt makes it one of the most fascinating marine faunal realms for research.

Again, it is obvious that it is cubic metres of sand, etc. that are being examined for the contained fauna, whereas so far all workers have been mentioning "sq. metres" in their tables. There is need to standardize the term so as to prevent confusion for future workers. However, in the present paper, as pointed out earlier, since most of the fauna was found limited to 50 cm below surface, it was thought expedient (for ease of comparison with earlier data) to speak in terms of "sq metres". Whereas the calculations are based on surface markings of 1 square metre, the depth penetrated was only 50 cms.

ACKNOWLEDGEMENTS

I am indebted to my colleague Dr. G. Chandrasekhara Rao, who formed part of the Orissa Marine Survey, 1966, and who has kindly placed at my disposal his

data (some unpublished, and incorporated in Table II of this paper) on the microfaunal component. It is a pleasure to record the help given by members of the Z.S.I. during the field-collections. Thanks are due to the Director, Zoological Survey of India, Calcutta, for affording me the opportunity of conducting the Orissa Marine Survey, 1966.

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ABSTRACTS OF PAPERS ACCEPTED FOR PUBLICATION

THE INTERTIDAL FAUNA OF THE SANDY BEACHES OF COCHIN

by K. P. PHILIP

The paper presents the results of the preliminary observations on the intertidal macrofauna of the sandy beaches of Cochin made during 1968-1969. Observations were made at Fort Cochin and Narackal — two exposed areas on the south-west coast of India, with moderate wave action. Environmental factors such as wave action, grain size, temperature and salinity were also studied. Beach changes were observed by measuring the beach profiles. It was found that the salinity varies considerably owing to the heavy rainfall during the south-west monsoon.

All animals of size 1 mm and above were separated and studied in detail. The major components of the fauna, constituted by the bivalves *Donax spiculum* and *Donax incarnatus* and the sand crab *Emerita asiatica* occupy the mid-tide and low-tide levels. Crabs of the genus *Ocypoda* are common at the high-tide level. The pattern of distribution and the seasonal abundance of different intertidal species were studied. A typical tropical study shore zonation very similar to the one proposed by Erik Dahl has been observed in the region under investigation.

STUDIES ON THE SEA-ANEMONE *ANTHOPLEURA NIGRESCENS* (VERRILL)

by KURUVILA MATHEW

A general behaviour and ecology of the sea-anemone *A. nigrescens* was studied. The tolerance of the anemone to different grades of salinity was observed in the laboratory.

RESISTANCE OF THE LIMPET *CELLANA RADIATA* (BORN) TO VARIATIONS IN TEMPERATURE, SALINITY AND DESICCATION

by M. BALAPARAMESWARA RAO and P. N. GANAPATI

Tolerance limits of *Cellana radiata* to high and low temperatures, to salinities above and below the ambient conditions and to desiccation were studied with a view to ascertain the influence of these parameters on the vertical distribution of the animal.

The experimental studies have shown that the limpet is temporarily tolerant to both high and low temperatures and to salinities above and below the ambient conditions. The lethal temperature of the limpet was found to be 42°C. Salinities above 37‰ and below 20‰ appear to be critical to the animals. No marked differences were observed in the tolerance of the limpets collected from the high and low water zones.

ABSTRACTS OF PAPERS

The desiccation experiments showed that the animals living at the higher levels are more tolerant to dry air than those living at the lower levels. It has also been shown that the limpets living at the higher levels are more resistant to higher temperatures in dry air than those at lower levels. The rate at which water is lost is related to the weight and the vertical position of the limpets. In both the high and low water limpets the total water-loss in the smaller animals is less than that of the larger ones, but the weight specific water loss in the smaller animals is always greater. When compared at the same body weight the low water limpets are found to lose water at a greater rate than those at higher levels. Further, the limpets living at the higher levels are found to withstand greater water-loss than those living at lower levels. The results are discussed and compared with those of the other workers on the limpets from temperate regions.

SALINITY TOLERANCE OF A LITTORAL OLIGOCHAETE, *PONTODRILUS BERMUDENSIS* BEDDARD

by P. N. GANAPATI and B. V. S. S. R. SUBBA RAO

Pontodrilus bermudensis Beddard, a littoral oligochaete, occurs in large numbers along with the polychaetes, *Lycastis indica* and *Marphysa gravelyi* and a sipunculid worm *Siphonosoma australe* in Southern Lighter Channel at Visakhapatnam harbour, where there are wide fluctuations in salinity (6 S‰ to 33 S‰). The present paper reports the effect of sudden changes of salinities on the worm when subjected to wide range of experimental media of varying salinities, from 30 S‰ to 2.5 S‰, under laboratory conditions. The mortality rates in each tested salinity were noted at the end of every 24 hr for a period of 4 days. The rate of mortality in an experimental medium of 25 S‰ was the lowest (3 per cent at the end of 24 hr). The highest rates of mortality were recorded once in 2.5 S‰ (60 per cent at the end of 24 hr) and for a second time in 30 S‰ (14 per cent at the end of 24 hr). It is, therefore, possible to conclude that for *P. bermudensis* a salinity regimen of 25 S‰ may perhaps represent the optimum salinity concentration. Also the trend of mortality increases both with increasing and decreasing salinities with reference to this optimum salinity.

OXYGEN CONSUMPTION AND METABOLIC RATE IN RELATION TO BODY SIZE IN THE INTERTIDAL GASTROPOD *TURBO INTERCOSTALIS* (MENKE)

by P. N. GANAPATI and R. V. RAMASASTRY

There have been many reports on the respiratory metabolism in relation to body size of several marine poikilotherms from arctic and temperate waters. In the present paper the results of the experiments conducted on the oxygen consumption and metabolic rate in relation to body size in the intertidal gastropod, *Turbo intercostalis* (Menke) are given. This animal is abundant on the rocky substrata of the Waltair coast at the region of the Mean Sea Level.

ABSTRACTS OF PAPERS

The oxygen consumption measurements were made on 100 animals of different sizes ranging from 0.295 to 10.436 g. wet weight using Winkler's method of determining the dissolved oxygen. The temperature and salinity were kept constant at 25°C and 30‰ respectively and the pH of the sea-water used did not vary much during different experiments.

The oxygen consumption of different size groups of *Turbo intercostalis* under constant temperature and salinity increased with the increase in body weight. The metabolic rate or weight specific oxygen consumption, i.e. O₂ uptake/g body-weight/hr showed a decrease with the increasing body-weight. Using the equation $Y=ax^b$; 'b' was calculated by the statistical method of least squares and a value of 0.548 obtained. The results are discussed with those of other authors.

OBSERVATIONS ON THE ASSOCIATES OF CRINOIDS AT WALT AIR COAST WITH SPECIAL REFERENCE TO MYZOSTOMES

by K. HANUMANTHA RAO and R. SOWBHAGYAVATHI

The associates of the crinoid *Tropiometra encrinus* Clark of Waltair coast have been enumerated and notes on protective colouration mentioned. Among these the anomuran *Galathea elegans* Adams and White, the apherodite *Scalissetosus longicirrus* Schmarda, and several molluscs and myzostomes show striking adaptation in colour harmony.

Myzostoma gopali Subramaniam, 1938 on *T. encrinus* and *M. striata* George, 1950 on *Lamprometra palmata* Clark have been encountered and the occurrence of strict host specificity in these interesting ectoparasites has been suggested. By a battery of histochemical tests it has been discovered that the myzostomes possess a significant laminated wall of collagen fibres in juxtaposition to the cutis of the dorsal body wall. This collagen wall forms an excellent bulwark against wave action in the turbulent intertidal environment. Such a layer is completely absent from the protected ventral side.

RECORD OF *ATHANAS INDICUS* (COUTIERE) (DECAPODA : ALPHEIDAE) ASSOCIATED WITH *STOMOPNEUSTES VARIOLARIS* (LAMARCK) (ECHINODERMATA : ECHINOIDEA) FROM VISAKHAPATNAM COAST

by P. N. GANAPATI and D. R. KANAKAYYA SASTRY

The alpheid shrimp *Athanas indicus* associated with the sea-urchin *Stomopneustes variolaris* is reported from the Visakhapatnam coast and it is the first record of this species from the Indian peninsula. The barnacle *Balanus amphitrite*, a parasitic gastropod of the family Stiliferidae, and the goby *Koumansiasis macrocephalus* are reported as other symbionts of the sea-urchin. The association of the shrimp and the goby is related with their feeding habits. Experiments have shown that they find their host by photoreception. The association of the snails may be related with their breeding habits as they were never collected without their egg masses. In spite of the ubiquitous settlement of barnacles, the occurrence of *B. amphitrite* is reported because of its successful attachment on the test of the sea-urchin.

THE IMPORTANCE OF SEA LEVEL IN COASTAL PROCESSES

by R. RAMANADHAM and R. VARADARAJULU

In a series of studies by the authors upon the various coastal processes along Visakhapatnam coast, the influence of sea level has been felt as one of the important factors contributing to the coastal processes, viz., littoral currents and sediment transportation. The rising sea level, accelerates the action of waves in producing strong littoral currents. Even though the change in sea level itself produces a current which transports material from the beach, its effect in amplifying wave action upon the shore seems to be more important through making upper reaches of the beach accessible to the waves. The abnormal rise in sea level produced by the wind action during the storms associated with high swell, causes severe erosion of the beach.

DISTRIBUTION OF *UCA ANNULIPES* (LATREILLE) IN THE INTERTIDAL MUD-FLATS OF THE VELLAR ESTUARY

by A. RAJENDRAN

A quantitative study was made of the pattern of distribution of *Uca annulipes* in the intertidal mud-flats on the northern bank of the Vellar estuary. Using a quadrat 0.5 m², 132 samples were taken over an area of 33 square metres. The samples were analysed for poison distribution. Before the onset of the monsoon, the male fiddler crabs were contagiously distributed with variance/mean ratio of 0.533, and the females tended to be randomly distributed with variance/mean ratio of 1.095. During the monsoon when the estuary was in flood, fiddler crabs migrated for a distance of about 20 m away from the pre-monsoon water mark. During the post-monsoon period the female crabs showed a contagious distribution with variance/mean ratio of 0.893, whereas the males approached a random distribution with variance/mean ratio of 1.095.

FAUNAL ASSOCIATIONS OF ALGAE IN THE INTERTIDAL REGION OF VISAKHAPATNAM

by A. L. N. SARMA and P. N. GANAPATI

The foreshore algal vegetation was found to harbour an enormous faunal wealth consisting of both macro-and micro-fauna, representing very diverse groups. *Musculus strigatus* (Bivalvia, Mytilidae) and the Sacoglossans (Gastropoda, Mollusca), *Volvatella pyriformis*, *Cylindrobulla pusilla*, *Oxynoe viridis* are recorded for the first time from the peninsular India. *Lobiger neville* is the first report from the Coromandel coast. The composition and density of the phytal fauna is influenced by the structure, texture, colour, contour and the physical and developmental state of the alga. The sediment-retention capacity of the alga was found as an important factor in the density of particular groups of organisms like foraminiferans, polychaetes, and nematodes. A comparison of the faunal density is made with similar studies carried out in other parts of the world. It is found that, numerically, the

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seaweed faunal associations are comparable with the level bottom communities. The specific assemblages of Sacoglossa (Gastropoda, Molluscas) and Bryozoa with specific algal types are brought to light.

THE GROWTH RATES OF FOUR SPECIES OF INTERTIDAL BRYOZOANS IN COCHIN BACKWATERS

by N. RAVINDRANATHA MENON and N. BALAKRIBHINAN NAIR

Growth rates of four species of bryozoans viz., *Electra crustulenta* (Pallas), *Electra bengalensis* (Stoliczka), *Alderina arabianensis* Menon and Nair, and *Schizoporella cochinchinensis* Menon and Nair, are presented in this paper. The growth in the case of all these species was found to be continuous. The growth was slow in the young colonies but a marked acceleration in the rate of growth was evident after 15 days of age in the case of all species except *E. crustulenta*. Comparing the regression co-efficients of the four species, *A. arabianensis* shows the highest co-efficient followed by *E. bengalensis*, *S. cochinchinensis* and *E. crustulenta*. This indicates that the growth was more pronounced in the case of *A. arabianensis*. Even though recorded from diverse habitats, the results of growth rates suggest that *E. crustulenta* is more at home in oligohaline and mesohaline waters as may be seen from the greater growth rates in these situations.

INDIAN SPECIES OF THE GENUS *BUGULA* OKEN

by N. RAVINDRANATHA MENON and N. BALAKRISHNAN NAIR

Six species of *Bugula* Oken viz., *B. neritina* (L), *B. robusta* Mac Gill, *B. crossandii* Hastings, *B. cucullata* Busk, *B. flabellata* (Thompson) and *B. plumosa* (Pallas) collected from the intertidal zone of the S.W. coast of India are figured and described in this paper. A key to the Indian species is furnished. A study of the range of intra-specific variations shows that except in the case of the cosmopolitan species *B. neritina*, characters, such as the size and shape of zoecia, nature of cryptocyst, size and angle of articulation of avicularia, show differences. These characters are probably of geographical and ecotypical nature. General observations on the pattern of distribution of these forms suggest that this is the result of cumulative effects of transport through the agency of ships, floating objects and marine organisms. Occurrence of *B. flabellata* and *B. plumosa* in this region extends the distribution of these species to tropical waters.

ON THE NATURE OF TOLERANCE TO SALINITY IN TWO EURYHALINE INTERTIDAL BRYOZOANS *VICTORELLA PAVIDA* KENT AND *ELECTRA* *CRUSTULENTA* PALLAS

by N. RAVINDRANATHA MENON and N. BALAKRISHNAN NAIR

Victorella pavida Kent occurring during the monsoon and post-monsoon periods in the Cochin backwaters exhibits differences in the range of salinity tolerance. Thus, colonies of *V. pavida* collected during the monsoon period

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can apparently tolerate a range from fresh water to 10 ‰, whereas those occurring during post-monsoon show an altogether different range of tolerance from 16‰ to 22.4‰. The greater tolerance to salinity shown by two populations of *V. pavidus* is indicative of the fact that two races of this species are probably involved in the Cochin backwaters, adapted to the changing conditions of the salinity. *E. crustulenta* Pallas also behaves in a manner similar to that of *V. pavidus* Kent. Thus the colonies collected during the monsoon period showed a tolerance from fresh water to 21‰ and those collected during the post-monsoon period showed a range from 16‰ to 32‰. The differences in tolerance noted in these tests may be functioning as an isolating factor brought in by the changes in the environmental conditions, which in due course may assist one of the races to get adapted to the less saline conditions prevailing in the upper reaches of the estuary. A scrutiny of the structure of the two populations shows that the colonies collected during the low saline period of the monsoon contain zoeecia with little calcification, cryptocyst without spinules and opercula which are chitinised in contrast with the zoeecial characters of the typical *E. crustulenta*.

RESPIRATION IN RELATION TO SALINITY VARIATION IN INTERTIDAL BARNACLES

by D. G. V. PRASADA RAO and P. N. GANAPATI

Respiration in relation to salinity variation was studied in two species of intertidal barnacles *Balanus amphitrite amphitrite* (Darwin) and *B. tintinnabulum tintinnabulum* (L) from two widely different habitat conditions. Habitat relationships were observed in their respiratory regulation, *B. amphitrite amphitrite* which inhabits low salinity areas was able to regulate to much lower salinities than *B. tintinnabulum tintinnabulum* which inhabits the open intertidal region where the salinity variations are very narrow. A metabolic breakdown was observed at 10‰ in *B. amphitrite amphitrite* and at 15‰ in *B. tintinnabulum tintinnabulum*. In both the species a lowering of the metabolic rate was observed at lower salinities. A critical salinity of 5‰ was observed in both the species below which there was no oxygen consumption. It is probable that at extremely low salinities they may be shifting into anaerobic metabolism to tide over the abnormal conditions in the environment.

EGG INCUBATION AND YOLK UTILIZATION IN THE ISOPOD *LIGIA OCEANICA*

by T. J. PANDIAN

The egg number, which averages to 53 (± 9.5 eggs) per female *Ligia oceanica* of Helgoland, shows no definite correlation to body size of the mother animals. In between the incubated eggs, the occurrence of nematodes *Gammarinema ligiae*, *Rhabditis* sp. and *Diplogaster* sp. is observed. The course of embryonic development of *L. oceanica* exhibits progressive increases in content of ash (4.4 to 31.6 per cent) and non protein nitrogen (from 1.5 to 2.7 per cent) and steady decreases in content of protein (from 41.8 to 36.8 per cent), fat (from 48.8 to 27.4 per cent), carbohydrate (from 3.5 to 1.5 per cent) and energy (from 5956 to 4175 cal/g dry weight). Water content of fresh egg is 76.1 per cent and after an initial increase to 77.2 per cent in the eggs prior

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to hatching, it decreases to 72.1 per cent in the freshly hatched juveniles. A single egg contains 301 (± 34.4) μg dry substance equivalent to 1.79 calories. Cumulative yolk utilization efficiency during the total development is 72.1 per cent for energy, 90.5 for protein, 57.8 per cent for fat and 43.8 per cent for carbohydrate. Of the total energy expended on embryonic metabolic processes, oxidation of protein contributes only 10.1 per cent, while the rest is supplied by non-proteinous substances (fat 86.9 per cent and carbohydrate 3.0 per cent).

POLYCHAETES OF THE FAMILY SABELLARIDAE WITH SPECIAL REFERENCE TO THEIR INTERTIDAL HABITAT

by G. P. KUMARASWAMY ACHARI

The family Sabellariidae comprises of a group of tubicolous polychaetes represented by species distributed from the intertidal zone to a depth of 4000 m and from the tropics to the subpolar regions. Six genera containing 53 species and ten varieties are so far known and some from massive reefs of sand tubes in the intertidal regions, protecting the shore line from heavy surf.

The paper presents an account of the distribution of Sabellariidae of the Indian region with stress on their comparative ecology. It includes environmental studies and tube building habits of the group based on collections from different localities on the west and east coast of India.

The informations on the reef building habits of Sabellariidae in the intertidal habits in stabilising the shore-line is presented and the bathymetric distribution of the members of the group in different oceans is compared.

TIDAL RHYTHM IN THE FEEDING ACTIVITY OF THE INTERTIDAL AMPHIPOD *HYALE HAWAIENSIS* (DANA)

M. MOHAN JOSEPH

The feeding activity of the intertidal herbivorous amphipod *Hyale hawaiiensis* (Dana) on the green alga *Enteromorpha compressa* (Linnaeus) Greville was studied in the laboratory.

In freshly collected specimens of *Hyale hawaiiensis*, feeding activity is clearly dependant on tidal cycles. The faecal pellet production was assumed to be directly correlated to the feeding activity and is expressed quantitatively. The maximum production occurs at the time of high tides when in the field the *Enteromorpha* belt is covered by or wetted by the rising water. During the exposure periods, faecal production also decreases with the receding tide. This activity rhythm fades away after 6-7 days in the laboratory.

Experiments under different environmental conditions suggest that this rhythm may be due to the inhibitive effect of the depleted oxygen caused by the respiration of algae. This view is supported by the minimum faecal production observed during the night hours when algae respire without producing oxygen by photosynthesis.

ECOLOGY OF INTERTIDAL MOLLUSCS OF GULF OF MANNAR AND PALK BAY

by K. S. RAO and K. S. SUNDARAM

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 subzones—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, *Grassostrea cucullata* and *Chthamalus stellatus stellatus* have been recorded in the supralittoral fringe. In the midlittoral zone *C. stellatus* is usually abundant along with some *Cellana radiata*, *Modiolus striatula*, *Tectarius* spp, *Donax* spp and *Prienespio* sp. In the Infralittoral fringe, tubiculous 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, *Isegnomon* 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.