

In all, 14 species, 13 of them belonging to the family Halocyprididae and one to Cypridinidae, were observed in the collections.

The pattern of distribution showed that two species of ostracods, *Euconchoecia aculeata* and *Cypridina dentata*, were the numerically more abundant and common species of ostracods found along the coast.

Euconchoecia aculeata was represented in February by a large patch with a steep population gradient decreasing southward and a steeper gradient decreasing towards the edge of the shelf. In the southernmost transect, off Quilon, the gradient was reversed and had a maximum density at the edge of the shelf. Maximum density of the patch was off the mouth of Cochin backwater system (211.5 spec./m³). Fair numbers were present at the edge of the shelf. By April the patch in the area sampled had become much thinner with a maximum of 7.4 spec./m³ at the edge of the shelf in the southern transect; the patch had also moved offshore and was found at the edge or beyond the shelf; probably the sampling was done only from the easternmost boarder of the patch.

Distribution of *Cypridina dentata* is interesting in that it was taken only off the estuaries off Cochin (maximum density 38.5 spec./m³), off Quilon and over the edge of the shelf in February. In April the species was present only at the two southernmost transects with a maximum density of 3.1 spec./m³ and an average of less than 2 spec./m³. This species was conspicuously absent beyond the edge of the continental shelf.

Spinoecia porrecta was the third most abundant species, but rather rare and uncommon. Its highest density was observed as 22.4 spec./m³, at the edge of the shelf in the middle transect in February. The patch was still there in April with 5.1 spec./m³.

All the other species were rare with density ranging from 0.02 spec./m³ to a single 4.2 spec./m³ occurrence and less than 1 spec./m³ as an average. They were all distributed along the edge of the continental shelf or in oceanic waters.

The effect of thermocline on the vertical movements of these species was assessed based on their occurrence and aggregation in the samples above the thermocline. Three species, *Microconchoecia curta*, *Orthoconchoecia atlantica*, and *Spinoecia porrecta*, were found to move freely across the discontinuity layer. *Euconchoecia aculeata* and *Cypridina dentata* showed accumulation above the thermocline as may be inferred from B samples, taken from thermocline to the surface, having always larger or roughly similar number of specimens to A samples, taken from bottom to the surface. Probably the specimens that occurred in A samples were fished by the net on the portion of the haul above the thermocline. Two species, *Conchoecetta giesbrechti* and *Metaconchoecia rotundata*, were confined to waters below the thermocline. Angel⁴ included *Paraconchoecia procera* among species with vertical movements restricted to below the thermocline. The present data showed that even though their occurrences were largely so, their presence was also noticed above the discon-

tinuity layer. Thermocline seems to be acting only as a partial barrier in its vertical movements. Other species like *Paraconchoecia elegans*, *Paraconchoecia decipiens*, *Pseudoconchoecia concentrica*, *Alacia alata*, *Halocypris brevirostris* and *Archiconchoecia striata* occurred at a single station each in April. Although their occurrences were below thermocline, more sampling is required to draw any conclusion on their vertical movements.

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References

1. JACOB GEORGE., *Bull. natn. Inst. Sci. India*, **38** (1967), 641.
2. TRANTER, D. J. & JACOB GEORGE, *Proc. symp. corals and coral reefs* (Marine Biological Association of India, Cochin), 1972, 239.
3. PURUSHAN, K. S. & RAO, T. S. S., *Indian J. mar. Sci.*, **3** (1974), 81.
4. ANGEL, M. V., *SARSIA*, **34** (1968), 299.

Benthic Studies in Goa Estuaries*: Biomass & Faunal Composition in the Zuari Estuary

ARUN H. PARULEKAR, G. VICTOR RAJAMANICKAM & S. N. DWIVEDI†

National Institute of Oceanography, Dona Paula 403004

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Benthic biomass and faunal composition in relation to salinity and substratum were reported for a 22.1 km stretch of the Zuari estuary. The fall in salinity in 22.1 km was 13.90%. Medium sand with a mixture of silt and clay dominated the bottom deposits. The average biomass (dry weight) was 40.2 gm⁻². Polyhaline conditions and sandy substratum accounted for higher biomass, but population density was high in euhaline zone. Polychaetes and bivalves were dominant in silty and sandy bottoms respectively. The observations add to baseline information on the bottom fauna of Goa estuaries.

DURING the course of a short term investigation, 22 km stretch of Zuari estuary was studied for the quantitative distribution of benthic fauna in relation to bottom salinity and substratum characteristics. The general features of this estuary, have been described earlier^{1,2}.

Observations were carried out from 29-12-1972 to 8-1-1973. Eighteen sections in north-south direction were fixed for sampling 22 km stretch of the estuary (Fig. 1). The number of stations along

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†Present address: Central Institute of Fisheries Education, Versova, Bombay 400061.

a section varied from 3 to 6 and in all 62 sampling points were worked. At each station, bottom salinity and the type of substratum were recorded. Duplicate samples of benthos were collected by a modified Van Veen Grab, which covered 0.04 m² up to 10 cm. For the sieving and analysis of benthic samples, the procedure reported earlier² was followed. Substratum characteristics were determined by pipette analysis and by mechanical sieve-shaking using standard sieves.

Bottom salinity distribution — Salinity from the mouth to head, decreased with distance along the transect. In the first 10 km from the mouth, the fall in salinity was about 4‰ and the average values were all above 30‰. In the Mandovi estuary, similar situation was observed in the first 4 km (ref. 2). After the first 10 km, the salinity went on decreasing rapidly, till the values became 23.9‰ at 14 km upstream from the mouth. Thus between 10 and 14 km, the fall in salinity at the bottom was 6.1‰. In the next 2 km, i.e. at a distance of 16 km from the river mouth, there was a small rise of 2.6‰. Thereafter the values go on decreasing rapidly, till the lowest value of 19.95‰ was recorded at about 22 km. Thus the total fall in salinity was 13.95‰. For a similar distance in the Mandovi estuary², the reported decline was 16‰. Das *et al.*¹ have observed higher average salinity in the Zuari estuary as compared to the Mandovi.

The salinity values fall into 2 broad zones: (i) above 30‰, longitudinal expanse 10 km; (ii) below 30‰ and above 18‰, longitudinal expanse 12 km.

These 2 zones, mostly agree with the 'euhaline' and the 'polyhaline' zones under 'venus' system^{3,4}. Both these zones are more elaborate in expanse in the Zuari than in the Mandovi estuary².

Substratum — Grain size analysis showed that the bottom deposits are in 3 size-ranges, viz. <0.062 0.062-0.125 and >0.125 mm. The analysis excluded the hard bottom (rocks and boulders) in regions of river opening. Thus 4 distinct sediment zones can easily be identified (Fig. 2). These are sand and sandy clay, sand and silty clay, silty clay and clayey silt (Fig. 2, A, B, C and D respectively).

In the upstream region, the sandy bottom is flanked by clay on either banks whereas in the region of the confluence (Table 1), the clay lies in between the sandy zone. A zone of silty clay is found in the middle reaches, beyond the opening of the Cumbarjua Canal, and it probably indicates the culmination of riverine influence. Downstream from the opening of Cumbarjua canal, the lower reaches of Zuari are characterized by coarser sediments which are well sorted due to high wave action. These sediments possibly originate in the Mandovi estuary² and due to tidal currents¹ are transported to the lower reaches of the Zuari through the Cumbarjua Canal.

Biomass distribution — Biomass values showed wide fluctuations from 0.1 to 453 gm⁻² with a high mean value of 40 gm⁻² (Table 1). Large fluctuations in biomass are seen, not only in between two sections but even within two adjacent stations.

In the euhaline zone (Table 1), the average biomass was 36.2 gm⁻² whereas in the polyhaline zone,

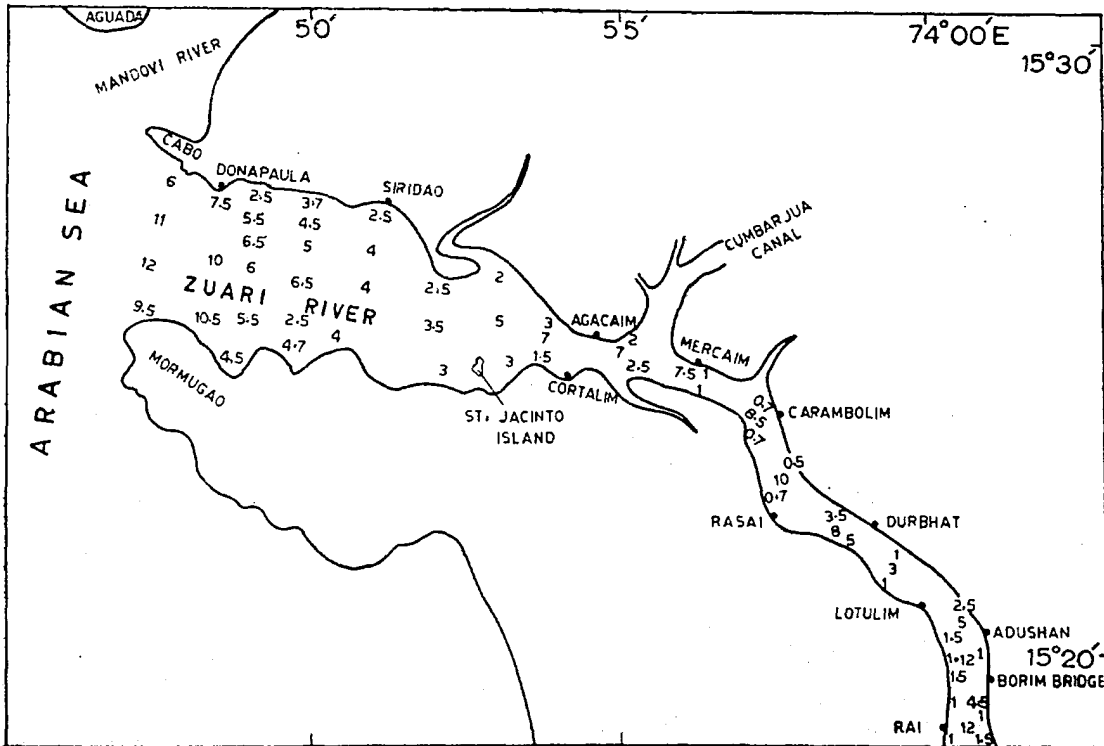


Fig. 1 — Topographical features and depth distribution in Zuari estuary

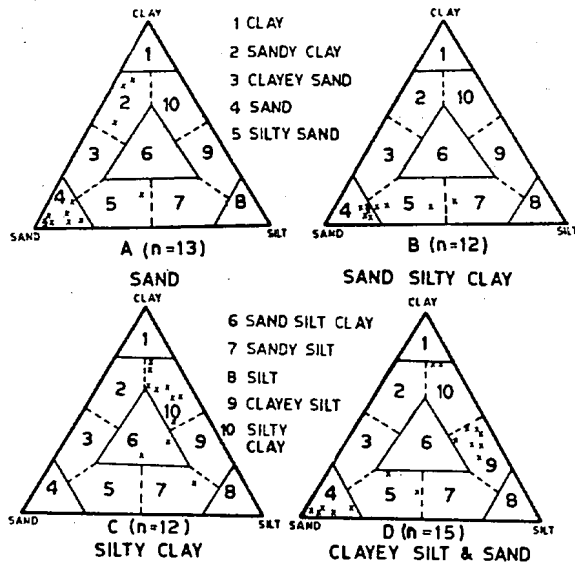


Fig. 2 — Triangle diagrams representing sediment zones in Zuari estuary

the value was 44.2 gm⁻². In the Mandovi estuary, under similar salinity conditions, the mean benthic biomass was 18.5 and 19.8 gm⁻² respectively. In both the estuaries, it is the polyhaline zone, where the benthic biomass is maximum, and even during the south-west monsoon, the benthic fauna in Goa estuaries was found to be rich in the zone of lower salinities⁵.

Benthic biomass variations were also related to the nature of bottom deposits. At the mouth of the estuary (Table 1), the presence of mussel beds, showed a high value of biomass but the highest biomass values in the 22 km stretch were found, where the substratum had a mixture of medium to coarse sand with silt or clay. This type of substratum had exclusive beds of *Tellina* sp. in the lower reaches and *Meretrix casta* in the upper reaches. The average biomass was high in the upper and the lower reaches of the estuary (Table 1), where the substratum was mainly sandy. In the middle reaches, with predominantly silty or clayey deposits, the biomass was low.

Benthic fauna — The macrobenthic fauna (Table 1) was rich in euhaline zone with a mean population count of 609 m⁻² in contrast to 209 m⁻² in the polyhaline zone. The population density was high (159-1437 m⁻²) in the sandy areas and low (50-625 m⁻²) in silty-clay or clayey silt areas.

In both the salinity zones (Table 1) polychaetes followed by molluscs, especially bivalves, were the important faunal groups. Molluscs which were dominant in sandy deposits, were totally absent in silty-clay bottom. The polychaetes contributed more than 90% of the total population in areas having a mixture of sand, silt and clay.

The estuarine fauna is largely contributed by marine, brackish, limnetic and migratory elements⁶, and its abundance is determined by several environmental factors⁷. As such in an estuarine environ-

TABLE 1 — SUMMARY OF OBSERVATIONS, RESULTS AND INFERENCE FOR THE BOTTOM ENVIRONMENT AND BENTHIC FAUNA IN THE ESTUARY OF ZUARI RIVER, GOA

| Section | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII |
|-------------------------------------------|-------|-------|-------|-------|-------|----------|------------|-------|-------|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Distance (km) from river mouth | 0 | 0.9 | 2 | 2.8 | 3.9 | 6.1 | 7 | 8 | 8.9 | 10.2 | 11.1 | 12 | 14 | 14 | 16 | 18 | 20.1 | 22.1 |
| No. of stations | 4 | 3 | 6 | 0 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Mean sectional salinity (‰) | 33-82 | 33-50 | 33-03 | 32-75 | 32-14 | 23-01 | 31-39 | 30-98 | 31-45 | 30-54 | 28-47 | 26-20 | 23-90 | 23-90 | 20-56 | 24-20 | 22-55 | 19-95 |
| Mean grain size (mm) | 0-046 | 0-143 | 0-193 | 0-090 | 0-088 | 0-056 | 0-010 | 0-038 | 0-03 | 0-026 | 0-028 | 0-062 | 0-083 | 0-083 | 0-043 | 0-051 | 0-100 | 0-077 |
| Mean biomass (gm ⁻²) | 7 | 48 | 48 | 44 | 89-9 | 85-8 | 24-8 | 16-3 | 7-4 | 19 | 22-7 | 3-5 | 73-4 | 3-5 | 50 | 1-1 | 184-6 | 19-9 |
| Mean population count (mm ⁻²) | 169 | 253 | 671 | 720 | 1437 | 633 | 983 | 467 | 363 | 201 | 183 | 83 | 101 | 83 | 87 | 87 | 817 | 125 |
| * Faunal composition (%) | | | | | | | | | | | | | | | | | | |
| PW | 35 | 7 | 62 | 28 | 19 | 60 | 80 | 82 | 97 | 91 | 37 | 94 | 41 | 41 | 66 | 20 | 83 | 35 |
| MO | 63 | 93 | 34 | 56 | 47 | 35 | 6 | 10 | 3 | 0 | 0 | 0 | 52 | 17 | 37 | 37 | 17 | 52 |
| Cr | 2 | — | — | 1 | 6 | 1 | 5 | 8 | — | — | — | — | — | — | — | — | — | — |
| Mi | — | — | 4 | 15 | 28 | 4 | — | — | — | 3 | 63 | — | 7 | — | — | — | — | — |
| Sediment zone | — | — | — | — | Sand | Sand | Silty clay | — | — | Silty clay, silt and sand | — | — | — | — | — | — | — | — |
| Salinity zone | — | — | — | — | — | Euhaline | — | — | — | — | — | — | — | — | — | — | — | — |

*PW, polychaetes; MO, molluscs; Cr, crustacea; and Mi, miscellaneous.

ment, no single environmental parameter can be marked out as a ecological master factor⁸. The estuarine fauna, which undergoes many physiological and structural adaptations, in course of time, give rise to a specialized estuarine fauna, mostly euryhaline and partly eurycoelous in nature. Besides this, the migratory component formed of truly marine or limnetic organisms, also find the estuarine environment most suitable for early developmental stages in their life histories. Thus comes into existence the estuarine fauna which utilizes the estuaries for transgression from marine to freshwater or vice versa.

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References

1. DAS, P. K., MURTHY, C. S. & VARADACHARI, V. V. R., *Indian J. mar. Sci.*, **1** (1972), 45.
2. PARULEKAR, A. H. & DWIVEDI, S. N., *Indian J. mar. Sci.*, **3** (1974), 41.
3. SEGASTRALE, S. C., *Arch. Océanogr. Limnol.*, **11** (suppl.) (1967), 7.
4. CASPERS, H., *Int. Rev. Ges. Hydrobiol.*, **44** (1969), 313.
5. PARULEKAR, A. H. & DWIVEDI, S. N., in *Recent researches in estuarine biology*, edited by R. Natarajan (Hindustan Publ. Cor., Delhi), 1973, 21.
6. DAY, J. H., *Trans. Roy. Soc., S. Africa*, **33** (1951), 53.
7. MUSS, B. J., *Medd. fra Danmarks Fisheri-og Havunder.*, N.S., **5** (1967), 1.
8. KINNE, O., in *Marine ecology*, Vol. 1, edited by O. Kinne (Wiley Interscience, New York), 1972, 821.

New Record of the Spider Crab, *Dehaanius limbatus* (A. Milne Edwards) from India*

V. S. KAKATI & K. N. SANKOLLI

Karnatak University Marine Zoological Research Station
Kodibag, Karwar 581303

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Description of *Dehaanius limbatus* (A. Milne Edwards), collected from Karwar and recorded for the first time from India is given. Taxonomic status of *Dehaanius* as a genus has also been discussed, supported by larval evidence of *D. limbatus* described elsewhere.

WHILE working on the larval development of Brachyuran crabs, the authors came across an interesting species of spider crab (Subfamily Acanthonychinae) which, based on adult characters and following the key of Tirmizi and Serene¹ could be initially identified as *Acanthonyx (Dehaanius) limbatus* A. Milne Edwards. Subsequently, on studying the laboratory hatched larvae of the present material, the larvae in possessing such features of generic importance like lateral processes on 3-5 abdominal

segments, spine on telson cornua, etc. were so distinctively different from the known larvae (*petiverii*, Lebour, 1944; *lumulatus*, Heegaard, 1963) of *Acanthonyx* in which the above are totally absent, that they could not possibly belong to *Acanthonyx* but some other genus closely allied to it. This prompted the authors to look into further taxonomic details of *Acanthonyx*. At present *Acanthonyx* is a heterogenous assemblage of two subgenera *Acanthonyx* and *Dehaanius*. But the taxonomic evidence derived from the larvae described² clearly suggests, as explained above, that *Dehaanius* should not be treated as a subgenus of *Acanthonyx* as done in the past^{1,3}, but should be treated as an independent genus. In the present paper, therefore, *Dehaanius* is considered as a valid genus, closely allied to *Acanthonyx* and the present material is ascribed to *Dehaanius limbatus* (A. Milne Edwards), as also confirmed by Dr R. Serene of Paris.

Dehaanius limbatus (A. Milne Edwards)

Synonymy — *Acanthonyx (Dehaanius) limbatus* A. Milne Edwards, 1862; Serene, 1968 and Tirmizi & Serene 1971.

Previous records — This species is recorded from the western part of the Indian Ocean extending to the Red Sea and South Africa¹.

Diagnosis — Carapace subquadrangular, without a distinct postocular tooth, but with 3 large triangular pointed teeth (3 large + 1 small teeth in female) on lateral border and with 9 well marked dorsal tubercles. Rostrum deeply bifid with fairly long horns. Cheliped with a submedian tooth on cutting edge of dactylus; ambulatory legs subchelate. Abdomen of male with all 7 segments free while in female 3rd to 6th fused.

Description — Male (Figs. 1-4): Carapace longer than broad, with regions well marked, without any setae, dorsal surface elevated, not markedly constricted behind the antero-lateral angles; no postocular tooth but a large orbital tooth present; 3 well developed lateral teeth of which hepatic larger than the two posterior ones; dorsal surface with 9 tubercles—1 setiferous at the base of each rostral horns, 2 protogastric, 1 mesogastric, 1 cardiac, 1 intestinal and 1 branchial on either side. Cheliped with dactylus slightly shorter than height and distinctly shorter than anterior border of the palm, 3 indistinct teeth on proximal half of cutting edge of dactylus. Walking legs without any setae except on subchelate portion of propodus; so also no teeth or tubercle on any of the segments except for two rows of almost blunt teeth on the posterior border of dactylus. First pair of walking legs longest. Abdomen of 7 well-defined segments, the first two fused but with distinct suture between them and remaining segments free.

Female (Figs. 5 and 6): Differs from male in the following: Carapace in addition to the 3 lateral teeth observed in male has a small triangular tubercle between the first two lateral teeth; such a tubercle is also present in front of the first lateral tooth. Tubercles on dorsal surface though 9 in number as in male are less prominent. A group of small, curved setae are present anterior to protogastric tubercles, which are absent in males. Colour greenish brown as in males but with a whitish brown patch on gastric

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