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ESTUARINE ANIMALS AND THEIR ADAPTATIONS*

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THE ESTUARY provides an unique habitat with diversified ecological niches where many groups of animals and plants are able to tolerate fluctuation in salinity, degrees of submersion and attachment to substrata. The faunal components in this region consist of an assemblage which have either arrived from the freshwater habitat or from the marine zone and have adjusted themselves in the buffer area. Further, some species have adapted themselves thoroughly in the estuarine environment and have become dominant in this region.

Several species of sponges, sea anemones, free-living nematodes, oligochaetes and polychaetes, echiuroids, sipunculids and some species of cirripedes have been able to adapt themselves to estuarine environment. Based on the distribution pattern of the cirripede fauna of the estuarine systems in India, one notes that as we progress from the marine to polyhaline waters of estuary, the number of species diminishes rapidly and, when the conditions become predominantly mesohaline, no species of cirripedes are found, since there are no truely freshwater forms.

In the case of cirripedes, pedunculate barnacles *Octolasmis cor*, aperculte barnacles, *Balanus amphitrite amphitrite*, *B. patellaris*, *Chthamatus malayensis* and *Semibalanus sinnurensis* have adapted themselves in the estuarine environment. The adaptations are (1) retentin and release of larvae at different tidal rhythms and prevailing currents, (2) by having long and stright cirri to cope with the silt, and (3) mechanism of osmotic regulation and consequent salinity tolerence.

The Adyar Estuary located along the Madras Coast, India was once abundant in various species representing lamellibranchs, gastropods, polychaetes and crabs (Graveley, 1941 ; Panikkar and Aiyar, 1939). Today after four decades of human settlement, the same backwater region has become by far the most polluted among the nine stations established by the scientists of the Pollution Project of the Marine Biological Station, Zoological Survey of India, on a twenty kilometres stretch of the Madras Coast of Bay of Bengal. One of the biggest solid-waste dumps of the city of Madras adjoins the mud flats of the Adyar Estuary. After reclamation and filling of the lowline area with the city refuse and due to heavy metals and other types of pollution, many of the fauna disappeared leaving only certain hardy species. *Uca lacteus*, *U. marionis*, *Ocypoda macrocera*, *O. quadrata* and *Marphysa gravelyi* are able to tolerate and adapt themselves to heavy metal pollution and has become dominant occupying territories of their own in this region. Of these, *Uca lacteus* de Haan dominates all other species of crabs and animals of other phyla. Data on the concentration profile of heavy metals in this crab as well as in water, sediments and algae *Enteromorpha* and other

* Invited Lecture.

species, reveals that in Adyar Estuary, the temperature, pH, DO and salinity of the water ranged from 25°-32°C, 6.99-9.07, 2.5-4.2 ml/L and 19-30‰. The metal oncentration in water were Cu 0.033-0.304 ; Cd 0.001-0.009; Ni 0.015-0.047; Pb 0.032-0.101 and Zn 0.011-0.339 mg/L. In the sediments the Cu, Cd, Ni, Pb and Zn concentrations were 2.6, 0.08, 1.5, 1.38 and 1.46 μg/g respectively.

Water from this region on analysis showed that the zinc concentrations was high (0.339 mg/l) followed by nickel (0.11 mg/l) copper (0.099 mg/l). In the sediments, all metals were found to be highest, concentration factor being Cu = 26, Cd = 80, Ni = 12 and Zn = 143. The alga *Enteromorpha* appeared to be concentrated Cu (34.05 μg/g) and Ni (21.43 μg/g) preferentially with cadmium and Zinc at below detectable levels. This pattern is in striking contrast to that of animals in this regions showed a Cu + Zn combination. *Marphysa gravelyi* lives burried in the sand and its metals accumulation was poor. Ni and Pb concentrations were 10 μg/g correlating to the low concentration of these metals in the sediment of this region.

In *U. lacteus*, Cu was consistently higher than Zn in the hepatopancreas while Zn was the dominant metal in the ovaries. In rare cases, Cu was high in the appendages (691.72 μg/g) and in the gills (466.94 μg/g) probably due to adsorption. Cd concentration was usually below 5.0 μg/g (or BDL) in most of the tissues except in the gills of a few *U. lacteus* in some cases (28.13 μg/g).

As a detritus/algae feeder, *U. lacteus* appeared to accumulate Ni, in the hepatopancreas (15.31 μg/g), muscle (15.77 μg/g), abdomen (with intestine — 14.78 μg/g), gills 21.24 μg/g and ripe ovaries (17.56 μg/g) correlating well with its food.

However, lead is a major pollutant in the tissues of animals of the Adyar Estuary. The lead concentration in *Uca lacteus* during December (monsoon period) was 52.84 μg/g and 41.01 μg/g in hepatopancreas and ovary respectively. Pb concentration above 15.0 μg/g was observed in the muscle, ovaries, appendages, carapace and whole animals. The lead concentration of the algae of this region was 23.64 μg/g and since *U. lacteus* lives entirely on detritus and algae the concentrations of Pb was very high (2 times) in all its tissues. Relatively high Pb values were found by Stemp *et al.*, (1979) in animals living in areas of major pollution centres and near harbour.

It may be stated that all the metals were found to be highest in *Uca lacteus* than *O. quadrata*. Males and females of three species of crabs *U. marionis*, *U. lacteus* and *O. quadrata* were analysed as a whole for these metal concentration. In the case of *U. marionis* and *O. quadrata* the concentration of Cd, Cu, Ni and Pb in males and females were more or less equal, whereas, in *U. lacteus* the males and females differed in their lead concentration (Pb in female was 18.84 μg/g, in male it was BDL). Males always have proportionally larger quantities of Cu than females.

In *Ocypoda quadrata* the concentratin of Zn was higher in female whole animal (124.11 μg/g) than the copper value 184.57 μg/g whereas in the male whole animal, copper was higher (99.02 μg/g) than the zinc concentration (73.78 μg/g).

In another species, *Ocypoda marcrocera*, Zn was the predominant metal in the muscle 201.95 μg/g while Cu concentration was 144.27 μg/g. The concentration of Cd was very low in all the tissues of males and females of *O. macrocera*. There is a differential accumulation of metals in males and females of crabs studied from this region as seen in *U. lacteus*, *U. marionis* and *O. quadrata* (*eg.* females different from males in this Cu, Ni and Pb concentrations).

Though the concentration factor of Cd is the highest between sea water and sediments, this metal seems to be moving up only to algae and shows no passage into crabs tissues. Even in *U. lacteus* only the appendages appeared to have absorbed Cu and Cd from the sediments and water.

Translocation of metals from the gills to the hepatopancreas has been noted by various workers (Vernberg and Vernberg, 1974; Phillips, 1980) when optimum salinity and temperature occurred in the environment. Cu and Zn are regulated to some extent by the crustaceans, but since Cu is deeply involved in the physiological status and is needed for the blood pigment, haemocyanin; accumulate this metal in greater amounts than other metals. Further, great variability between individuals is found for Cu, and may be correlated to the moult - intermoult cycle (Zucherkandl, 1960; Bryan, 1964, 1968; Martin, 1974; Phillips, 1980).

The low concentrations of heavy metals (except Cu and Zn) which are essential metals observed in thes ecrabs (*U. lacteus, U. marionis, O. macrocera, O. quadrata*) and *M. gravelyi* are due to (1) these metals are not biologically available *i.e.* in complexed forms which are simply eliminated via the fecal matter without being adsorbed through the intestine, (2) have efficient excretory system/regulatory mechanism through which these metals are excreted, (3) are complexed or bound to various proteins, lipids, muco-proteins, muco-polysaccharides and certain carbohydrates, and therefore harmless (to some extent) to the animals, (4) eliminated through ecdysis (as in cadmium), (5) due to thick impermeable cuticle and (6) at the cellular level.

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