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Ecology of Clam Beds in Mandovi, Cumbarjua Canal & Zuari Estuarine System of Goa*

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Observations on environmental parameters clearly indicate two independent ecosystems at Ribandar and Banastrim clam beds in Mandovi-Cumbarjua canal-Zuari estuarine system of Goa. Maximum size attained by *Meretrix casta* in this estuarine system is 55 mm. Recruitment to the clam population at Banastrim is earlier and more prolonged than at Ribandar. Length-frequency studies indicate that *M. casta* at Banastrim breeds throughout the year, whereas at Ribandar, breeding is suspended during peak summer. Low salinity adversely affects the growth. Year-class composition at Ribandar is dominated by 1-yr class and at Banastrim by 0-yr class. Possibility of migration of adult clams at Banastrim is postulated. Dimensional relationship marks out the existence of different stocks of *M. casta* in this estuarine system of Goa. An overall appraisal of the results reveal the possibilities of culture of clams in the estuaries of Goa.

MERETRIX CASTA (Chemnitz) is a commercially important clam, occurring in estuaries and backwaters along the Indian coast. As compared to east coast[1-6] little information is available about the biology of this species from west coast of India[7,8].

The present paper, forming a part of the research project on " Ecology of Mandovi-Cumbarjua Canal-Zuari Estuarine System, in Relation to Changes in Living Populations", gives an account of the ecology, growth, dimensional relationship, standing crop and fishery of *M. casta* from exploited clam beds at Ribandar and Banastrim in Mandovi and Cumbarjua Canal respectively. These clam beds are situated 10 and 19 km respectively from the mouth of Mandovi river. Parulekar and Dwivedi[9] have dealt, in detail, with the topographical features, ecology and benthic standing crop (during south-west monsoon) of this estuarine system.

Materials and Methods

Clams for this study were collected at fortnightly intervals from clam beds of Ribandar and Banastrim (Fig. 1). Both the stations were sampled, on the same day, using a Van Veen's grab, giving a substrate coverage of 0·2 m² up to a penetration depth of 10 cm, in the substratum. To supplement the findings, specimens obtained from the catches of local clam pickers were also examined. In all 1740 clams, 708 from Ribandar and 1032 from Banastrim, have been examined. Observations on meat weight and standing crop pertain to dry weight measurements. Methodology followed in dimensional relationship studies is as per Abraham[4]. Environmental data were recorded along with grab samples.

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Results and Discussion

Environmental Features

Depth — In spite of varying tidal influence, major part of clam beds at both the stations always remain submerged. The water columns vary from 3·5 to 9·0 m (Ribandar) and 3·5 to 7·0 m (Banastrim). The variations in depth are due to freshwater drainage, coupled with tidal influence.

Substratum — The physical nature of substratum at both the stations is uniformly sandy, round the year, except during south-west monsoon, when it becomes mixed with silt and clay. In the post-monsoon (October-January) and premonsoon (February-May) seasons, the sandy substratum is formed of 30% fine sand, 50% medium sand and 20% coarse component. The mixed type of substrate is formed of 65% medium to fine sand and 35% by silt-clay component.

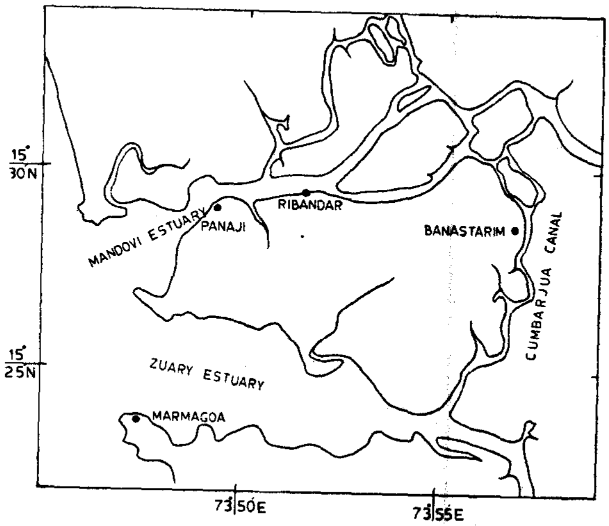

Fig. 1 — Map showing Mandovi-Cumbarjua canal-Zuari estuariane system of Goa with station position

Organic matter — Abundance of organic matter in the substratum is reported to be instrumental in determining the stability of a clam bed[10]. In the present study, organic matter in the sediments has been estimated, primarily, as organic carbon by the method of El Wakeel and Riley[11]. The organic carbon values have been converted into percentage organic matter by multiplying with the factor 1·724 as recommended by Wisemann and Bennette[12]. Organic matter at both the stations (Fig. 2) exhibit a wide range of fluctuations (0·19 to 4·39). At Ribandar, high concentration is encountered in the months of April and June whereas at Banastrim 3 distinct peaks in June, August and January are observed. A comparison of organic matter values at Ribandar and Banastrim reveals that at latter station, the availability of organic matter, throughout the year, is more regular than at the former. On an average, the organic matter constitutes about 1·54% by dry weight, which is well below the world average of 2·5% for nearshore sediments[13].

Temperature — The monthly variations, in bottom temperature at Ribandar and Banastrim, range between 24·9° and 30·5°C and 25·0° and 32·0°C respectively (Fig. 2). The minimum and maximum values at Ribandar are recorded in second fortnight of August and first fortnight of April respectively. At Banastrim, the lowest and the highest temperature values have been obtained in the second fortnight of January and April respectively. The range of variations is more or less similar at both the stations.

Salinity — Of all the observed environmental factors, the salinity values exhibit a wide range of fluctuations (Fig. 2). At both the stations, the values vary between 0·12 and 37·78‰ with maximum fluctuations during the south-west monsoon (June-September). In contrast to Banastrim, the fortnightly values at Ribandar, especially during monsoon, show marked variations which can be attributed to pronounced effect of dilution by rainwater drainage in the mainstream of Mandovi river. The minimum and maximum values, at both the stations, coincide with peak monsoon and peak summer respectively.

Dissolved oxygen — Dissolved oxygen content, at both the stations, exhibits a diversified picture (Fig. 2). At Ribandar, the trend of fluctuations is more striking than at Banastrim, and accordingly the values are observed to be spread over a wide range (2·41 to 5·39 ml/litre). The range (3·71 to 5·28 ml/litre) at Banastrim is moderately small but of a higher magnitude. The variability at Ribandar is due to the dominance of freshwater, during monsoon, and its localized impact on the ecosystem[9].

Growth in Size

Length measurements have been grouped into size classes or length groups of 2 mm each. Clam populations at both the stations (Fig. 3) exhibit a striking difference in size range. At Ribandar, the size ranges from 2·0 to 54·9 mm with majority of the clams spread between 8·0 and 38·0 mm. As compared to Ribandar, the *M. casta* population at Banastrim exhibits a small size range of 2·0 to 30·0 mm, with majority of the specimens between 4·00 and 26 mm. Abraham[4] has reported 56·3 mm as maximum size for *M. casta* in Adyar river and adjoining backwaters. Maximum size for the same

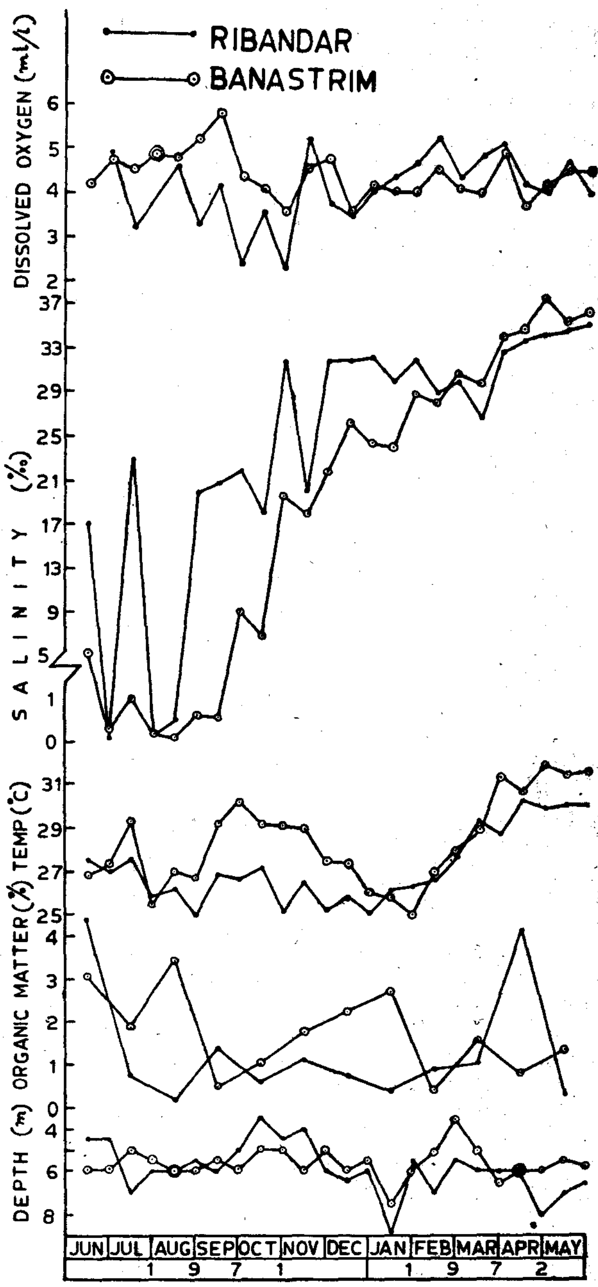

Fig. 2 — Annual cycle of environmental features at Ribandar and Banastrim

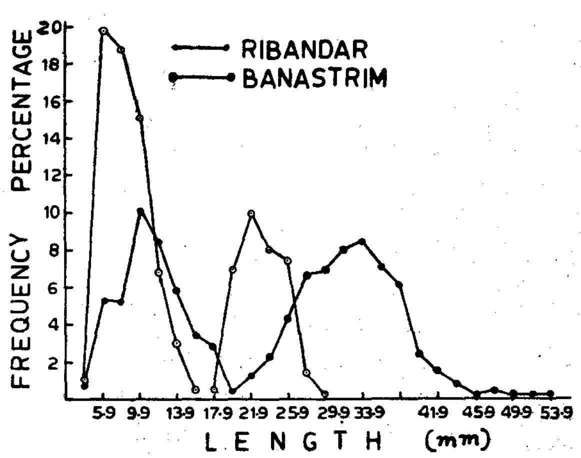

Fig. 3 — Pooled size-frequency of *M. casta* at Ribandar and Banastrim

species in Beypore and Korapuzha estuaries of Calicut is 31 mm[7].

A review of pooled frequency percentage (Fig. 3) indicates that at Ribandar, the clam population is represented by individuals of 9·9 and 33·9 mm respectively. At Banastrim, the size-frequency distribution is represented by 2 prominent graphic modes at 5·9 and 21·9 mm respectively. Pearson[14] has inferred "the individuals of a large collection are grouped, according to their length and each prominent mode or hump, in the plotted distribution is assumed to represent an age-class". Accordingly, *M. casta* populations at Ribandar and Banastrim are represented by two age-classes or groups, viz. 0-yr and 1-yr. The 0-year class at Ribandar and Banastrim is located at 9·9 and 5·9 mm respectively. The size at the end of 1-yr is 33·9 mm at Ribandar and 21·9 mm at Banastrim. In addition to these 2 age groups, one more year class as represented by a mode at 45·9 mm (Fig. 3) is also noticed at Ribandar from May to August.

An analysis of size-frequency distribution (Figs. 3 and 4) indicates the presence of juvenile forms, below 9·9 mm, practically throughout the year, except April to June at Ribandar. Such predominance of juvenile specimens, for a major part of the year, reflects on the protracted breeding habit of the species. Hornell[2] observed that spawning in *M. casta* appeared to take place twice a year during April-May and again in September. Rai[15] reported that the principal breeding season of *M. meretrix* on Bombay coast lasts from March to June, but if weather conditions are favourable and the temperature above 82°F (27·7°C), they breed all the year round except during the monsoon season. Abraham[4] has shown that *M. casta* in Adyar river and backwaters spawns at least twice a year. Durve[5] infers "that this clam (*M. casta*) is a continuous breeder with a break of few months in late summer. This break appears to be due indirectly to unfavourable conditions". The present observations indicate that at Banastrim, *M. casta* breeds round the year whereas at Ribandar (Fig. 4), the breeding is suspended during April-June period.

Fig. 4 shows the progressive increase in size of *M. casta* through different months at Ribandar and Banastrim. At Ribandar, the recruitment as shown by a graphic mode at 5·9 mm commences in the month of July and continues up to October. In November, a definite increase in size is noticed, by the presence of a prominent mode at 9·9 mm. The same mode exists in December. By January, this mode shifts to 11·9 mm, thus indicating an increment of 2 mm. The presence of a mode at 15·9 mm in February gives an indication to the enhancement in monthly growth rate to 4 mm. By April the same mode is located at 21·9 mm, thus showing a progression in size of 6 mm, within 2 months (March and April). In May, the rate of increment is 4 mm, followed by 2 mm, only up to September. The accelerated growth rate, especially during February to May (premonsoon season), is due to high temperature values which are reported to be conducive for the growth of clams[16]. Low salinity values (Fig. 2) during June-September (monsoon season) considerably brings down the rate of growth. It has been observed that under natural conditions, growth in *M. casta* in Adyar

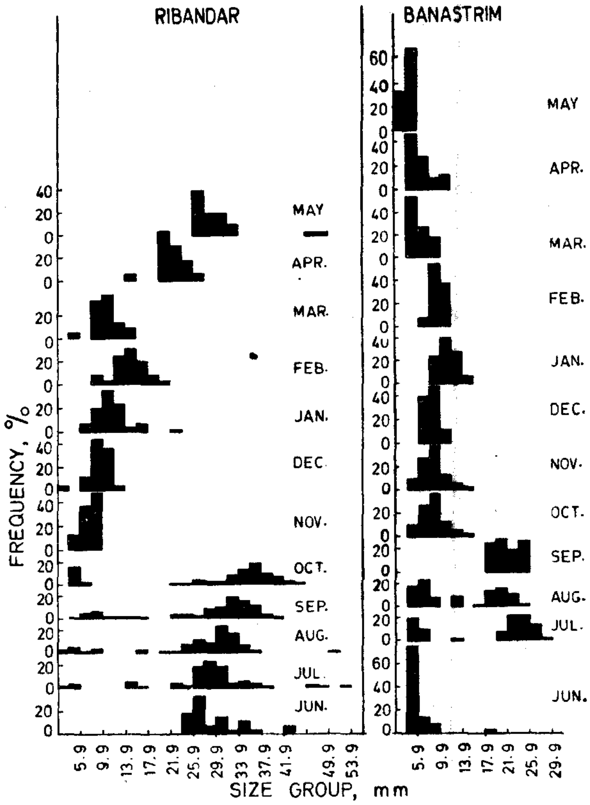

Fig. 4 — Monthly size-frequency distribution of *M. casta* at Ribandar and Banastrim

river and backwaters is suspended during at least 2 periods in a year[4].

It is seen from Fig. 3 that an individual of 5·9 mm recruited in October of 1971 attains a size of 37·9 mm at the beginning of 1972. Thus an increase in length through a 12-month period is 32 mm (monthly av. 2·7 mm) including the period of December and June-September when growth is suspended. This confirms the earlier observations of Abraham[4].

The main feature of the growth studies on *M. casta* at Banastrim clam beds (Fig. 4) is the dominance of young forms, below 9·9 mm, for a major part of the year. This reflects on the prolonged breeding activity of the species and consequently there is almost continuous recruitment to the stock.

A prominent graphic mode is observed (Fig. 4) to be persisting at 5·9 mm from March to July. The same mode shifts to 7·9 mm in August followed by its disappearance in September. From October to December, the mode is almost stationary at 9·9 mm, whereas by January it moves to 11·9 mm. The modes at 5·9, 7·9, 9·9 and 11·9 mm refer to 0-yr class. The 1-yr class is seen to be represented by modes at 21·9 and 23·9 mm respectively during July to September. Poor representation of 1-yr class in the population is possibly due to the migration of adult forms to other localities. Desai[8] in his work on the molluscan benthic populations of backwaters and nearshore environment of Cochin has also reported about the migration of this species. Thus, the clam bed at Banastrim serves as breeding and nursery grounds for young *M. casta*.

Growth in Weight

Clam samples collected from Ribandar and Banastrim were treated for shell and meat weight measurements for studying the rate of growth at different size classes. The observations on meat weight pertain to dry weight. All such measurements relating to shell and meat weight were grouped against appropriate size classes and by employing the method of least squares, the equations for linear regression have been derived (Fig. 5). In order to trace the rate of growth in weight at different size intervals, an index for increase in shell and meat weight in relation to total weight was calculated (Fig. 6).

Indices for shell and meat weight at Ribandar and Banastrim are quite dissimilar (Figs. 5 and 6). Index values vary between 2 and 7·2 (Ribandar) and 5 and 11·6 (Banastrim), thus showing that the growth in shell weight, at Banastrim, is many times more than at Ribandar. At no identical size classes, the relative growth of shell and meat, at either of the stations, is uniform. The rate of increase in meat weight on length (Fig. 4) is considerably higher at Banastrim than at Ribandar. The difference in the rate of growth in meat weight is due to the dominance of juvenile clams (vide Fig. 3) at Banastrim, having higher growth rate[17], than adult forms which form the mainstay of the population at Ribandar.

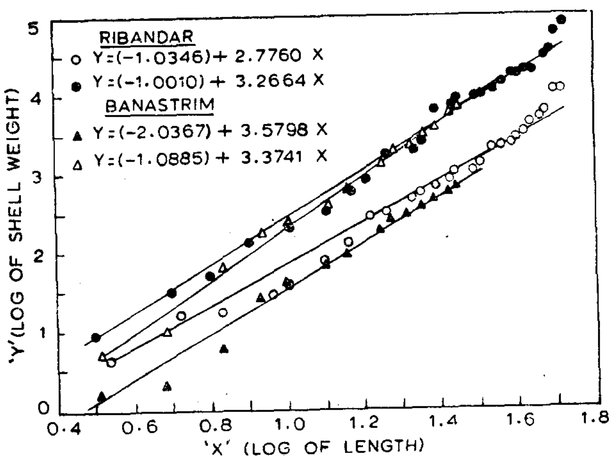

Fig. 5 — Length to shell and meat weight relationship of *M. casta* at Ribandar and Banastrim

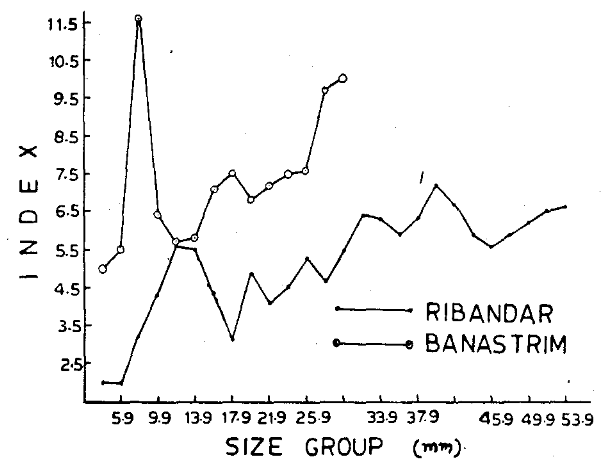

Fig. 6 — Index of growth in shell to meat weight of *M. casta* at Ribandar and Banastrim

An appraisal of Figs. 5 and 6 indicates that the environment at Banastrim is more conducive, for the growth in weight, than at Ribandar.

Dimensional Relationship

Dimensional relationship studies were undertaken primarily to understand the variations, if any, between clams representing 2 different habitat and also to know about the length-weight relationship for determining the degree of association of different body measurements.

The relation of depth, breadth and total weight on length has been expressed by the simple allometric equation[6]. The log/log plot of the date is represented by the equation for the regression line, $Y = a+bx$, where x denotes the length, Y the variable, such as depth, breadth or total weight, whereas a and b are constants to be determined empirically. The equations (Table 1) indicate that for both the stations, an increase in total weight in relation to length is almost of the same magnitude. Similarly, the equations for linear dimensions also exhibit almost same relationship for both the stations.

To testify the degree of association between different dimensions, of clam populations, from different ecosystems, a series of equations have been used by different workers[6,18,19]. These relations are generally expressed by the following equations:

$$D = a_1L^{b_1} \quad \ldots(1)$$
$$H = a_2L^{b_2} \quad \ldots(2)$$
$$W = a_3L^{b_3} \quad \ldots(3)$$

Newcombe[20] further developed other equations, which are as follows:

$$\alpha = \beta = \Upsilon \quad \ldots(4)$$
$$\alpha = (b_3-b_2-1)/b_1 \quad \ldots(5)$$
$$\beta = (b_3-b_1-1)/b_2 \quad \ldots(6)$$
$$\Upsilon = (b_3-b_2-b_1) \quad \ldots(7)$$

Data on dimensions of *M. casta* from Ribandar and Banastrim were fitted into above equations, from 1 to 7 and derivations, as shown in Tables 1 and 2 respectively, were arrived at.

Table 2 shows that relation (4) does not hold good in the case of both the stations, thus reflecting on the differences in dimensional relation-

TABLE 1 — LOG REGRESSION EQUATIONS FOR *M. casta* FROM RIBANDAR AND BANASTRIM

Relationship	Ribandar	Banastrim
Length and total weight	$Y = (-0{\cdot}6075) +3{\cdot}2237x$	$Y = (-0{\cdot}6973) +3{\cdot}3923x$
Length and meat weight	$Y = (-1{\cdot}0346) +2{\cdot}7760x$	$Y = (-2{\cdot}0367) +3{\cdot}5798x$
Length and breadth	$Y = (-0{\cdot}1084) +0{\cdot}8433x$	$Y = (-0{\cdot}0301) +0{\cdot}7854x$
Length and depth	$Y = (-0{\cdot}2009) +0{\cdot}6022x$	$Y = (-0{\cdot}4501) +0{\cdot}5420x$

TABLE 2 — CALCULATED VALUES OF α, β AND ϒ FOR *M. casta* FROM CLAM BEDS OF RIBANDAR AND BANASTRIM

Locality	α	β	ϒ	Average
Ribandar	2·2922	1·9200	2·9826	2·3982
Banastrim	2·9647	2·3559	3·1489	2·8231

$\alpha = \beta = \Upsilon$; $\alpha = (b_3-b_2-1)/b_1$; $\beta = (b_3-b_1-1)/b_2$; and $\Upsilon = (b_3-b_2-b_1)$

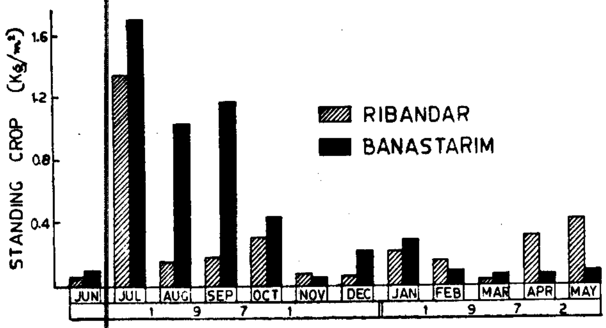

Fig. 7 — Monthly variations in standing crop of *M. casta* at Ribandar and Banastrim

ship amongst the two clam stocks. These differences are directly correlated to the different ecoogical conditions prevailing at these two stations and further they also indicate the existence of two different stocks of *M. casta* in this estuarine system of Goa. The observations on dimensional relationship also support the inference drawn from length-frequency distribution studies, wherein the existence of more than one stock of clam has been indicated. Durve and Dharma Raja[6] have also observed different stocks of *M. casta* in Mandapam fish farm and Athankarai estuary.

Standing Crop

Information on standing crop of any benthic community, of commercial importance, serves as a prerequisite for proper assessment, exploitation and management of living resources. Observations on variation in standing crop in relation to environmental factors will also enable in launching any clam-culture programme.

In the present study, the observations on standing crop of *M. casta* are based on biomass measurements (dry weight) of clams, existing in unit space and time at Ribandar and Banastrim respectively. Biomass values at both the stations (Fig. 7) are at its maximum in the month of July. This is followed by a decline prevailing from August to December. At Ribandar, the decrease in standing crop is more striking than at Banastrim, where it is gradual till September. This decline coincides with intensive clam fishing during the monsoon season (June-September). By the month of January, the standing crop values, at both the stations, go up to be followed by sharp decline in March. At Ribandar, another peak is noticed in April-May, whereas at Banastrim, period of March-June marks a lean period. This lean period also coincides with the unfavourable natural conditions of high temperature and high salinity values (vide Fig. 2).

Fishery

Clams in the estuaries of Goa at present are exploited to a fairly large extent. Based on the preliminary catch data, for 9 months during 1971-72 (Directorate of Fisheries, Goa), the estimated total catch of the exploited estuarine molluscs from Mandovi estuary and Cumbarjua Canal is 887 tonnes/year; out of which *M. casta* alone contributes 315 tonnes. It is thus seen that this species of clam forms an important estuarine fishery in Goa.

Intensive clam fishing is undertaken during southwest monsoon period (June-September) when open sea fishing is completely suspended. Two methods are employed in this fishery and these are hand picking and scoop netting.

Hand picking — These operations are carried out at those clam beds which get fully exposed during low tide. The fishing is generally carried out at early morning or late evening hours. The fishing operations depending on tidal amplitude lasts for 3 to 4 hr/day.

Scoop net — This indigenously fabricated fishing gear is made up of following components: (i) bag — made up of closely knitted coir thread with a mesh size of 2 cm; (ii) a steel or wooden ring of 60 cm diameter for holding the coir bag; and (iii) a bamboo pole, 2 to 2·5 m long. To the tapering end of the pole is tied the ring with bag. The scoop net operations use a dug-out canoe fitted with out-rigger. This method is employed at such clam beds where water column does not exceed 3 m. These fishing operations are normally undertaken during early morning hours. This net, having a mesh size of 2 cm, ensures the conservation of juvenile forms.

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