

Ecology & Culturing of Edible Bivalves in Goa*

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Environmental characteristics, growth rate, total production and technically feasible methods for the mass cultivation of *Meretrix casta*, *Paphia malabarica*, *Villorita cyprinoides*, *Donax incarnatus*, *Perna viridis*, *Modiolus metcalfei* and *Crassostrea gryphoides* have been investigated. Results show substantial decrease in time for commercial production and considerable increase in the yield suggesting the technical feasibility for the commercial production of these bivalves.

Edible bivalves, especially clams, mussels and oysters, are important source of nutrition in a coastal state like Goa (lat. 15°-16° N; long. 73°-74° E). As elsewhere, at present, most of the shellfisheries of Goa are based on the harvesting of wild stocks from estuaries.

In the past, inadequate information on the environmental and biotic characteristics of shellfish resources acted as a major constraint, for the generation of shellfish resources, through seafarming. Keeping this in view, detailed studies on ecology, biology and development of appropriate culturing methods for some species of edible bivalves were undertaken and the results are presented here.

Two species of clam — *Meretrix casta* (Chemnitz) and *Paphia malabarica*, Chemnitz — and 1 species each of black clam *Villorita cyprinoides* (Grey); bean clam *Donax incarnatus*, Gmelin; green mussel *Perna viridis*, Linnaeus; weaving mussel *Modiolus metcalfei* (Hanley) and edible oyster *Crassostrea gryphoides* (Schothheim) were selected for detailed study. Fortnightly observations on environmental (temperature, salinity, dissolved oxygen, particulate organic matter and sediment type) and biotic (size range, growth and age composition) features of the natural populations (Fig.1) of the above species, were carried out¹. Culture experiments were carried out, either *in situ*² or under simulated conditions in a seawater circulating system³. The data presented pertain to minimum 1 annual cycle. Except for bean clam (*D. incarnatus*) data on time taken for the marketable size and the rate of production, for all the species, are derived from repeated trials, lasting for 3-4 y (1977-1981) continuously.

Most of the species studied have maximum abundance in the estuarine and nearshore regions of Goa (Fig.1). While *V. cyprinoides* generally occurs in

coarse sandy to gravely substratum in the limnetic zone. *D. incarnatus* is widely distributed in medium to fine sandy deposits from mid littoral to subtidal

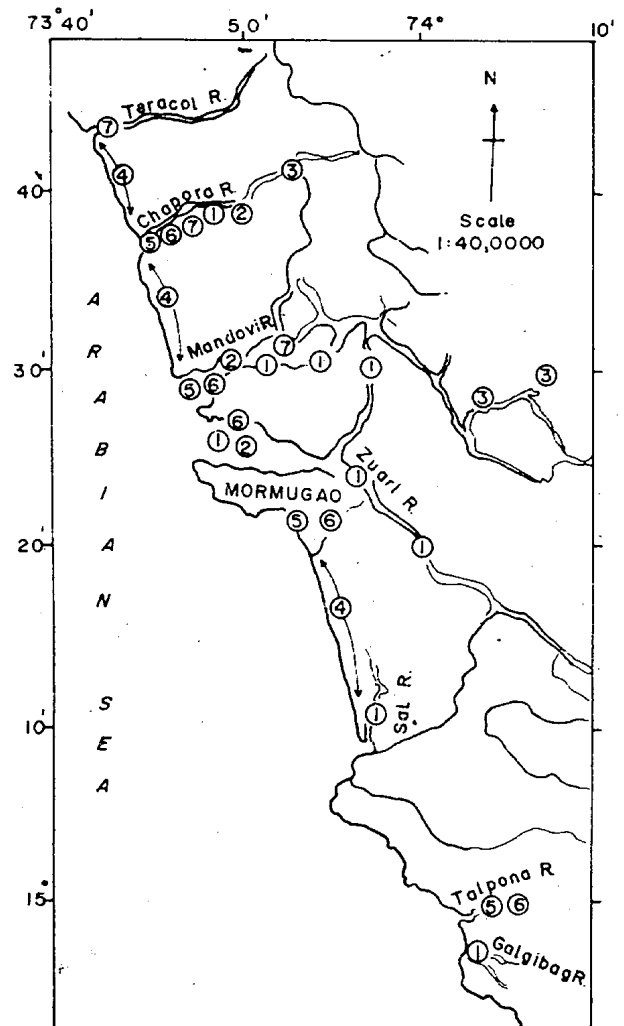


Fig. 1—Distribution of edible bivalves in the estuarine and coastal environs of Goa [(1) *M. casta*, (2) *P. malabarica*, (3) *V. cyprinoides*, (4) *D. incarnatus*, (5) *P. viridis* (6) *M. metcalfei* and (7) *C. gryphoides*]

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regions of open sea beaches. *M. casta* and *P. malabarica* abound in lower littoral and subtidal estuarine sandy mud (Table 1). Wide differences exist in spatial distribution and relative abundance, within the same estuarine biotope. While *P. malabarica* is abundant in the lower reaches of an estuary high population densities of *M. casta* are encountered in the upper reaches of Goa estuaries (Fig.1).

Both the species of mussel are distributed in estuarine and marine environment of Goa, but are more abundant in the former biotope than in the latter. *Perna viridis* is distributed from midlittoral to subtidal with high population density in the lower littoral region. *Modiolus metcalfei* is mostly subtidal in habitat. Though, both the species, abound in hard substratum, *P. viridis* prefers rocks and boulders as against cobble and boulders by *Modiolus metcalfei*.

Edible oyster (*C. gryphoides*) has an extensive natural bed, extending from midlittoral to subtidal in the Chapora estuary (Fig.1). This species, which prefer boulders rather than the rocky substratum also occurs, in less abundance in Teracol and Mandovi estuary (Fig.1).

Physico-chemical factors—Most of the species studied are subjected to different annual range of environmental parameters, within their natural habitat. Though, certain degree of overlapping is observed (Table 1), as far as the distribution of a particular species is concerned, the range of environmental parameters indicate the favourable ecological set-up for the abundance and well being of any of the species, studied.

The most varying environmental factor is salinity, which decreases rapidly in monsoon (June-Sept.) season. Postmonsoon (Oct.-Jan.) season marks the recovery in salinity values, whereas during pre-monsoon (Feb.-May) season, euhaline (sal. > 30 × 10⁻³) condition is attained. Coastal zone and estuaries of Goa, have low water temperature and low dissolved oxygen content, especially in Aug.-Sept. and the lowering of values is attributed⁴ to the intrusion of

upwelled waters in the estuarine and coastal waters of Goa. Particulate organic matter in the water column is the main source of nourishment for the filter feeding organisms, like bivalves⁵. As shown in Table 1, the distribution of organic matter is high in the environs of the natural bed of the species studied. Other important factor is the nature of bottom deposits. Accordingly, each of the species (Table 1) display substrate specificity in its distribution and abundance.

Age and growth—In natural populations⁶, the age composition is mainly comprised 1 or 2 classes (Table 1) with the possible exception of *C. gryphoides*, where 3y classes are observed. Similar observations, for the same species, have been reported earlier⁷, from Kelwa-Mahim backwaters along the west coast of India.

Most of the species of the bivalves studied presently attain sexual maturity when they are 3-4 months old and they have protracted breeding period, extending from Oct. to May^{1,2,8-10}.

The maximum size attained by the species studied (Table 1) is similar to that reported from other parts of the Indian coasts¹¹⁻¹³. Similarly, the growth rates are comparable^{6,10,12,13} to those from other localities. Important growth limiting factors, for the species studied, are salinity and particulate organic matter in the water column¹⁴.

Culturing methods—The ground clutch culture or bottom rearing method (Table 2) involving proper stocking densities of 750-1000 m⁻² in intertidal and subtidal sandy deposits accelerated the growth rate by 30% in *V. cyprinoides* and 50% in *M. casta*. Increase in production (Table 2) for these was 6 to 4 times, more, respectively, than reported¹⁵ for the same species from the natural beds in Goa estuaries. Similarly, *P. malabarica*, grown by bottom rearing method, yields 5 times more than under natural conditions⁸. Results on the seeding (3500-4000 m⁻²) of surf beaten open sea sandy beaches with young *D. incarnatus*, indicated an overall enhancement of 25% in the monthly growth progression accompanied by a 5 fold increase in the production⁹.

Table 1—Variations in Physico-Chemical Factors of the Habitat and Biological Factors of Natural Populations of Edible Bivalves of Goa

Species	Water temp. (°C)	Sal. (× 10 ⁻³)	Dissolved oxygen (ml.l ⁻¹)	Particulate organic matter (mg.l ⁻¹)	Sediment type (mm)	Size range (mm)	Av. monthly growth (mm)	Age group (No.)
<i>M. casta</i>	24.9-32.0	0.1-35.5	3.7-5.9	24-55	Sandy (0.25-0.125)	2-64.5	2.7	2
<i>P. malabarica</i>	23.5-30.4	1.4-35.6	1.3-5.9	28-272	Sandy (0.25-0.125)	1.5-48.0	5.0	1
<i>V. cyprinoides</i>	25.3-31.7	0.1-12.3	3.2-6.0	11-332	Sandy (1.0-0.4)	4-57.5	3.4	2
<i>D. incarnatus</i>	26.1-31.5	12.4-34.9	3.8-5.4	55-370	Sandy (0.5-0.25)	3-24.5	2.2	1
<i>P. viridis</i>	25.4-30.6	7.8-36.3	1.5-4.5	107-503	Rocky/Boulders	5-107	5.0	2
<i>M. metcalfei</i>	25.4-30.3	5.6-35.6	1.7-5.8	70-509	Rocky/Boulders	6-28	3.3	1
<i>C. gryphoides</i>	24.0-29.0	0.7-35.7	2.5-6.0	79-378	Boulders	9-196	7.0	3

Table 2—Details of Culture of Edible bivalves

Species	Technique employed	Culture site	Time taken for marketable size (week)	Rate of production (kg.m ⁻²)
<i>M. casta</i>	Ground clutch	Intertidal -estuarine	10-12	4.7
<i>P. malabarica</i>	-do-	-do-	12-14	5.3
<i>V. cyprinoides</i>	-do-	Subtidal - limnetic	12-16	2.5
<i>D. incarnatus</i>	-do-	Intertidal - marine	8-9	4.0
<i>P. viridis</i>	Floating raft -suspended rope	Water column -estuarine/ marine	18-20	184.0
<i>M. metcalfei</i>	Floating raft -suspended rope	Water column -estuarine	8-10	8.0
<i>C. gryphoides</i>	Floating raft/ Running seawater Facility-plastic trays/nylon bags/ sandwich net	-do-	36-40	13.0

Rope culture of transplanted seeds from natural bed on floating rafts (Table 2) was found to be the most appropriate technology for green mussels and the weaving mussels¹⁰. However, *C. gryphoides* when transplanted in nylon bags or sandwich nets or plastic trays and then grown on floating rafts or in a circulating seawater facility, showed a considerable increase in mean monthly growth (dorso-ventral distance) which got enhanced from 4.5 mm in natural bed to 12 mm under off bottom culture. This besides saving the time for commercial production by more than 40% yielded a high production of 13 kg m⁻² (Table 2) as against 1-5 kg m⁻² in the natural beds⁶. The economic feasibility of some of the experimental culture techniques^{2,6,16} has been high and many times more than reported^{17,18}. The cost for each component in different culture systems do differ, but in all the cases, the cost, direct and indirect, are relatively small and the rate of returns on the investment, fairly high.

Of all the cultivable species of estuarine and marine plants and animals, the bivalves because of their sessile and gregarious habits¹⁹ high physiological adaptability, short food chain, prolonged breeding behaviour and fast growth rate form the most ideal organisms for commercial cultivation, on a large scale. These natural advantages coupled with promising results on techno-economic feasibility, indicate bright prospects for large scale cultivation of edible bivalves in the estuarine and nearshore areas of tropical seas.

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References

- 1 Parulekar A H, Dwivedi S N & Dhargalkar V K, *Indian J Mar Sci*, 2 (1973) 113.
- 2 Qasim S Z, Parulekar A H, Harkantra S N, Ansari Z A & Nair A, *Indian J Mar Sci*, 6 (1977) 15.
- 3 Chatterji A, Ingole B S & Parulekar A H, *Mahasagar - Bull Natl Inst Oceanogr*, 16 (1983) 81.
- 4 Sankaranarayanan V N & Jayaraman R, *Curr Sci*, 41 (1972) 204.
- 5 Chatterji A, Ansari Z A, Ingole B S & Parulekar A H, *Aquaculture*, 40 (1984) 47.
- 6 Parulekar A H & Qasim S Z, *Status report on coastal aquaculture in India*: Tech Rep. Nat Inst Oceanography, Goa, 1981, pp 136.
- 7 Durve V S & Bal D V, *J Mar Biol Assoc India*, 4 (1962) 206.
- 8 Dwivedi S N, Parulekar A H & Hakkim V M A, *Proc 3rd All India Symp Estua Biol*, Cochin (1975) (Abstract).
- 9 Nair S A, Dalal S G & Ansari Z A, *Indian J Mar Sci*, 7 (1978) 197.
- 10 Parulekar A H, Ansari Z A, Harkantra S N & Nair A, *Indian J Mar Sci*, 7 (1978) 51.
- 11 Nair R V & Rao K S, *Bull Cent Mar Fish Res Inst*, 23 (1974) pp 170.
- 12 Abraham K C, *J Zool Soc India*, 5 (1953) 163.
- 13 Algarswami K & Narsimhan K A, in *Proc Symp Living Resour Seas Around India*, edited by S Z Qasim, published by (Mar Biol Assoc India, Cochin) 1973, 648.
- 14 Parulekar A H, Dalal S G, Harkantra S N & Ansari Z A, *Aquaculture*, 29 (1982) 3.
- 15 Ansari Z A, Parulekar A H & Matondkar S G P, *Indian J Mar Sci*, 10 (1981) 128.
- 16 Parulekar A H & Verlencar X N, *J Indian Fish Assoc*, 6 (1976) 53.
- 17 Little I M D & Mirrless J A, *Project appraisals and planning for developing countries* (Heinemann Educational Books, London) 1974, pp 168.
- 18 Pillay T V R & A Dill Wm, *Advances in aquaculture* (FAO & Fishing News Books Ltd, London) 1979, pp 653.
- 19 Korringa P, *Development in aquaculture and fisheries science* (Elsevier Sci Publ Co, Amsterdam) 1976, pp 264.