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38. BIOTIC POTENTIAL AND ENVIRONMENTAL RESISTANCE OF BIVALVES OF MANGALORE COAST

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ABSTRACT

Blotic potential and environmental resistance of seven sgecles of bivalves inhabiting Mangalore coast have been quantified from data gathered during the pa^t 15 years. Ths species examined are the oysters *Crassostrea madrasensis* (Preston), *Saccostrea cucullata* (Von Born), the clams *Meretrix casta* (Hanley), *Katelysia opima* (Gmelin) *Villorita cyprinoides* (Gray), Donax *incarnatus* (Gmelin) and the mussel *Perna viridis* (Linnaeus) Components of blotic potential are described in terms of distribution and density, growth survival, longevity, age, size at first maturity and production. Environmental resistance was delineated by examining spawning', settlement, survival crowding, overgrowth, fouling and mortality. Data on these aspects have been presented and discussed.

Blotic potential of estuarine species of bivalves was higher than that of marine species. In the estuaries, the main limiting factors were silting, heavy flooding, extremely low salinity levels during the south-west monsoon, lack of substrata for settlement and other causes of mortality. In the marine habitat, exposure, desiccation, overcrowding, laclc of settlement space, competition for food and space, overgrowth, predation, surf action and mortality limited realisation of full biotic potential. A multidjsclplinaty approach to problems in bivalve population ecology has been lacking till now and this paper stresses the need for work on these lines.

INTRODUCTION

Knowledge of its biotic potential and environmental resistance is an important prerequisite for the development of a strategy for management of a living species resource. Factors that limit abundance, distribution in space and time, life and activity have been studied in many living marine bivalves. But a comprehensive approach to examine a species resource from its biotic capability and to delineate how the environment resists the full componentof biotic potential from being realized in a natural habitat, has been lacking in the case of marine bivalves except in the oyster *Crassostrea virginica* (See Mackenzie 1981). In the present paper an attempt has been made to examine these two aspects as completely as possible In the sedentary phase of seven species of bivalves inhabiting the coast of Mangalore.

MATERIAL AND METHODS

Seven species of bivalve molluscs inhabiting the Mangalore coast formed the material for the study. These were the oyster *Crassostrea madrasensis* (preston), the clams *IVIeretrix casta* (Hanley) and *Katelysia opima* (Gmelin) inhabiting the Mulki estuary (lat. 13°5' N; long, 74°46' E), the oyster *Saccostrea cucullata* (Von Born) and the mussel *Perna viridis* (Linn) inhabiting the Someshwar coast (lat. 12°47'N;

long. 74°5rE), the clam *Villorita cyprinoides* (Gray) inhabiting the Netravathi-Gurupur estuary (iat. 12°50'N; long. 74°50'E) and the wedge clam *Donax incarnatus* (Gmelin) inhabiting the Panambur shore (lat. 12°57'N; long. 74°48'E). The data have been collected during various periods between 1971 and 1936.

Environmental parameters have been studied by analysing water samples for physical and chemical characteristics usingstandardmethods. Data on distribution, density and biomass production have been gathered by quantitative sampling using appropriate quadrants of 25, 50 or lOOcm^ size. Growth was studied by length frequency or Pauly's integrated method (paully 1983) using data on shell length. Data on longevity, survival, age, size at maturity and mortality were calculated from the basic shell length data recorded. La, K and t^ were calculated by Von Bertalanffy's growth equation (Von Bertalanffy 1938). -Reproductive activity was examined by the methods described by Joseph and Madhyastha (1982,1984). Data on settlement, survival, crowding, overgrowth, fouling and interrelationship with other organisms were quantified from field and laboratory observations carried out during the study period.

RESULTS AND DISCUSSION

Crassostrea madrasensis

Although C. *madrasensis* is distributed in all the five major estuaries of Dakshina Kannada coast, dense populations appear only in the Mulki and Hangarakatta estuaries. Within the Mulki estuary, the oyster beds extend from the bar mouth to 4 km upstream. Distribution is patchy, individual oysters are found lying at the silty bottom. Population density ranged from 0 to 8 oysters/m2, the average being 2/m» [mean biomass, (wet weight) 18 g/m»]. The average growth rate was 9.15 cm and 5.05 cm during the first and second years. The age at marketable size (7 cm) was 9 months. The Von Bertalanffy growth parameters were: Loo = 32.8 cm, K=0.0524, and 1^= —1.3 quarter year. Lmax in Mulki estuary was 28.4 cm. The population age structure showed dominance of zero and 1 year olds in the population. The minimum size at first maturity was 12-14mm in male and 24-26 mm in female. Above 30-32 mm shell lengh, there was no relation between size and stage of maturity. The sex ratio of the oyster was near 1:1. During the somatic growth phase (June-September) the indeterminate oysters dominated, at times constituting as much as 100%. No hermaphrodite or transition stage was noticed.

Environmental parameters seem to have a great influence on the activity of *C. madrasensis.* During the course of a year, two distinct phases of activity could be observed. A period of active somatic growth coincided with the southwest monsoon (June-September) which was characterised by low levels of ambient salinity (S%X15°/oJ. During October-May a period of sexual activity, gonadal growth, maturation and spawning coinciding with the buildup of ambient salinity to levels >157oc,- Spawning was observed between S°/„„ 25 and 36°/oo. Salinity shifts appear to play a regulatory role in synchronizing gonadal activity and spawning of this species. Spat settlement pattern showed two periods of peak settlement in Nov. ember January and March-May. There was no settlement during August-September. The mean rate of growth of spat was 2.1 cm, 1.4 cm, 1.0cm, 1.0 cm, 0.7 cm and 1.0 cm during the first six months respectively. The young oyster reached a size of 7.2 cm after 7 months of growth on suspended cultch. Crowding and overgrowth resulted in poor spat growth and survival. Fouling by barnacles, polychaetes, and spat of *Saccostrea* sp, boring by *Polydora ciliata* and parasitization by the trematode *Bucepfialus* accounted for the bulk of the biological components of environmental resistance. The major fouling organisms were 3 species of algae, 1 species of sponge, 2 hydrozoans, 7 bryozoans, 14 species of crustaceans and 6 species of molluscs. 3 spp of crabs and 2 spp of oyster drills formed the chief predators. The important parasites were *Polydora, Bucepfialus, Tylocephalum* and *Ostrincola.* Mortality was related to predatlon, parasitization, overgrowth by competition, suffocation due to heavy silting, shell fracture during spat growth, biological factors and other causes.

Saccostrea cucullata

The rock oyster *S. cucullata* forms an important component of the fauna of the surf beaten rocky shores at Someshwar. Heavy spat fall and competition for space result in overcrowding of oysters as a result of which large flattened blocks of oysters with stunted growth form dense patches along the intertidal belt. The density ranged from 15 to 320 oysters/m^ [mean biomass (wet weight) 30 g to73g/m2]. The mean wet weight ranged from 1.67 g (August; to 3.64 g (May) in males and from 1.68 g (September) to 3.14 g (May) in females. Oysters ranged in size from 3.0cm to 7.1 cm shell length, the majority being in size ranges between 4.0 and 5.5 cm. Growth was fast immediately after settlement, but later reduced or negligible because of overcrowding and over growth on adjacent oysters. Heavy surf action on the shore altered the shell shape resulting in flattened individuals. The majority of oysters in the population belonged to the zero year group. The size at first maturity was 3.2 cm in female and 3.5 cm in male oysters.

Environmental effects were observed on the settlement, shell shape, growth, spawning, survival, fouling and mortality of the oysters. Sexual maturity was attained during April-May. Spawning commenced in June and extended till December with two peaks during June-September and November-December. The spawning season coincided with reduction of ambient salinity to 33.3°/„„ — 29.78°/„„. The male: female ratio was 1 :1.34 with a few hermaphrodites (167oo)- Among the environmental factors, settlement level, desiccation, overcrowding and overgrowth were the dominant ones which prevented the oysters from realising their full biotic potential. Fouling by other organisms was limited; the common foulers were barnacles and three spp of algae.

Meretfix casta

The clam *M.casta* forms the most important component in the bivalve population in all the estuaries of Dakshina Kannada. Large quantities are landed throughout the year. These clams are distributed throughout the estuarine stretch in th» Natravathi-Gurupur, Mulki, Udyavara and Coondapur estuaries. The average standing crop values (wet weight/m^) in the various estuaries are: Netravathi-Gurupur 174 g/m*, Mulki 956 g/m^, Udyavara 863 g/m', and Coondapur 1024 g/m2. The estimated values of Ymax are: Netravathi-Gurupur 661 t, Mulki 2581 t, Udyavara 1592 t and Coondapur 8110t. In all the estuaries higher densities were recorded during the pre-monsoon (Jan- May) period The population mainly consists of zero year class The average size of *M. casta* in the four estuaries are: Netravathi-Gurupur 29.6mm, Mulki 30.7 mm, Udyavara 26.7 mm and Coondapur 29.6 mm, Mulki 30.7 mm, Udyavara 26.7 mm and Coondapur 29 8 mm.

All the estuaries showed considerable variations in ambient salinity during the course of a year. The salinity ranged from almost fresh (0.2°/<,3) during monsoon to typically marine (36.00%(,) conditions during summer. Some mortality occurred during the monsoon period due to low salinity and heavy silting. The spawning season was prolonged, extending from October to May with several peaks fn between. Settlement of spat was characterised by patchiness. Heavy spatfall was noticed during November-December. Survival rata of spat was very high as they were not affected by crowding, overgrowth and fouling. Estuarine crabs and catfishes were the common predators of newly settled spat. Three parasistes/ commensals were observed; these were the creb *Pinnotherus,* the copepod *Conchylirus* and the trematode *Bucephalus.*

Katelysia opima

Biotic potential of *K. opima* was studied in Mulki estuary where this species is distributed in good quantities. The distribution was limited to silty areas near the bar mouth. The mean density ranged from 30 g to 533 g/m^. The estimated value of Ymax was 10351. Mean size of *K. opima* was 34.1 mm (range 10.5 mm to 48.7 mm) in the feral population. La was 52.8 mm, K=0.1049 and to= - 2.40. Differential rates of growth were observed between the two broods within a year class. The September brood had a faster growth rate than the April brood. Bulk of individuals in the population belonged to zero year group. The average life span of the clam was *Ca* 2y. The minimum size at first maturity was 20mm.

Resistance by the environment to the biotjc potential of *K. opima* was apparent in the survival of clams during the low saline south west monsoon. Large scale mortality of clams inhabiting all areas in the estuary except regions close to the bar mouth was a regular feature. About 90% of standing crop was prolonged, from December to May. Settlement was sparse and patchy. Survival of young clams appear to be related to the nature of the bottom and ambient salinity. This species was least affected by problems in fouling and crowding. The parasites recorded were *Pinnotheres* and *Bucephalus.*

Villorita cyprinoldas

The upper reaches of the Netravathi-Gurupur estuary supports a moderate population of *V. cyprinoides.* The bottom was sandy with very coarse sand dominating (40.7%) the sediment. Population density ranged from 8 to 82 individuals/m^. Moment estimates of K (Reddy 1983) ranged from 0.0812 to 3.3214. Biomass ranged from 4.11 g to 44.14 g (wet weight)/m2 and 1.06 g to 9.94 g (dry weight)/ m2. The highest biomass values were during December-March. A fast rate of growth was noticed; the clams reaching 17.0 to 19.0 mm in 3 months, 24.0 mm in 6 months, 28.5 mm in 9 months, 31.5 to 32.0 mm in 12 moths and 35.0 mm in 16 months. The Von Bertalanffy growth parameters were L a = 38.96mm, K= 0.1289, and to =-1.74.

The ambient salinity showed a variation from 0.447„„ to 13.257„„ between October and March. Gametogenic pattern and spawning ware closely related to salinity cycles. Gametogenesis commenced during October-November and resulted in first spawning in December. Spawning season extended till late March with peak activity during February-early March. Spat fall was observed from November onwards. The sex ratio was near 1:1 and no hermaphrodite was recorded. No metazoan associates or parasites were noticed in this species. Also, there were no fouling organisms. This population formed a more or less single species community. Heavy flooding and silting during the peak of the south west monsoon caused mortality in both small and large-sized clams.

Donax incaxnatus

Extensive beds of the wedge clam *Donax incarnatus* are found all along the sandy shores north of New Mangalore Port. The biotic potential of this species was studied at a locality on the sandy shore at Panambur. The substratum was formed of fine sand (Krumbein 1939) which formed 75.09% to 94.2% of the sediment. The population density ranged from 89 to 39446 individuals/m'. The peak density was during January and the least during April. Biomass values (whole wet weight) ranged from 124g/m2 (April) to 1892 g/m» (January). Biomass (dry tissue weight) ranged from 6.55 g/m2 (October) to lOOOSgm' (January). The size of clams ranged from 14.7 mm (May) to 20.7 mm (April). > 90% of individuals during periods of peak abundance belonged to newly settled spat. The monthly rates of growth during the first 12 months were 5.19 mm, 4.06 mm, 3.00 mm, 2.48 mm ,2.59 mm, 2.01 mm, 1 71 mm, 1.56 mm, 1.78 mm, 0.52 mm, 1.0 mm, 1.0 mm and 0 30 mm respectively. The whole population belonged to individuals of less than 1 year age. Lm«x was 26.1 mm. The von Bertalanffy growth parameters were. La = 30.94 mm, K = 0.162 and to - 0.04

Breeding in *D. incarnatus* took place mainly from November to February. Heavy settlement along the surf zone resulted in very high population density. Effect of the environment's resistance was clearly manifested by the sudden and very heavy mortality of newly settled spat. Population density ranging from 14342/m* in November to 39446/m' in January resulted in heavy crowding which probably caused high mortality. Also, settlement in the surf zone resulted in exposure to high sand temperature (32.2°C to 35.0°C) and desiccation. This also would have caused high mortality of newly settled spat. Thus, the survival rate of newly settled spat was as low as 0.44% at the end of the breeding season.

Perna viridis

The green mussel *P. viridis* forms mussel islands on the intertidal rocks at Someshwar. Heavy settlement results in large patches having a thickness range of 2.1 cm to 6 0 cm. The population density ranged from 2388 individuals/m2 (May) to 44075 individuals/ m' (October). The range in biomass (whole wet weight) was from 1772.2 g/m^ (October) fo 12794.8 g/ m' (February). The size of mussels ranged from 1.2 mm in October to 80.6 mm in May.

Small sized mussels formed the bulk of the population during October-December. Mussels reached a mean length of 34 25 mm at the end of 12 months' growth. The Von Bertalanffy growth parameters were: Loo = 41 93 mm, K= 0.1518 and to - - 0 038

The spawning of mussels commenced in January. Intermittent spawning was observed in February and May to November. Heavy spatfall occurred during January-March and September The sex ratio was close to 1 :1 with no hermaphrodites in the population- Settlement intensity was very high. Inspite of heavy crowding, spat and juvenile mortality were very limited. Competition for settlement space was very high, resulting in several layers of mussels carpeting the rocky substrata. As growth proceeded, mussels relocated themselves within the mussel islands. 40 species of fouling and associated organisms were recorded in the mussel island community. Mortality was low in the population. However, loss of mussels from the bed due to severe wave action was commen.

From the foregoing account of the biotic potential and environmental resistance of seven species of bivalves, the following conclusions could be drawn. The study has demonstrated that a concerted effort could identify the important aspects of a species' biotic potential and delineate the environment's resistance. Biotic potentials of the estuarine species are fairly high). In the estuary the limiting factors are heavy flooding and extremely low salinity levels during the south-west monsoon, heavy silting, lack of clean shell substratum for settlement of larvae and mortality due to predators, competition tor settlement space and parasites. Fouling, crowding and overgrowth were important factors affecting the survival of freshly settled spat in the estuary. The biological components of environmental resistance were fairly high in the estuary, thus preventing the fuU complement of biotic potential from being realised. In the marine habitat, the main componenfs of environmental resistance were overcrowding, overgrowth, lack of settlement space, severe wave action, predation and mortality due to desiccation. Survival rate of spat in species like *D. incarnatus* was as low as 0 44%. Levels of ambient salinity played an important role in regulating reproductive activities and also affecting growth rates. The study shows that removal of limiting factors in g species population by the careful application of specific methods can enhance production '^»««- '^^'^ '^ ^" important point to be con- ^'^^'^'^ '" management of mariculture practices, Such an approach would open up the possibi- "ty of increasing production through mariculture several folds than that at present,

REFERENCES

JOSEPH, M M. AND M. N MADHYASTHA. 1982. Gametogenesis & Somatic versus gonadal growth in the oyster *Crassos-* "•*« *madrasans/s* (Preston). *Indian Jour. Mar. Sc/.;* 11' :303-310.

JOSEPH, M. M. AND M. N. MADHYASTA. 1984. Annual reproductive cycle and sexuality of the oyster *Crassostrea madrasensis* (Preston). *Aquaculture,* 40:223-231.

KRUMBEIN, W. C. 1939. Tidal lagoon sediments on the Mississippi delta *In* jrask, P. D. (Ed) *Recent Marine Sediments.* Dover Publications, New York, P. 178-205.

MAC KENZIE, C. L. Jr. 1981. Biotic potential a"^ environmental resistance in the American oyster *Crassostrea virginica)* '" Long Island Sound. *Aquaculture.* 22:229-268.

PAULY, D. 1983. Some simple methods for assessment of Tropical fish ^^^^^^ ^^O ^Z^,, ^^^^ *p* 234: . g^

REDDY, D. K. N 1983. Studies on the population ecology and reproductive biology ^f the clam *Villorita cyprinoides* (Gray;, *M. F. Sc. Thesis. University of Agricultural Sciences, Bangalore,* pp. 100,

VON BERTALANFFY, L. 1933. A quantitative theory of growth. *Hum. Biol.,* 10: 181-213.