J. mar. biol. Ass. India, 1991, 33 (1 & 2) : 76-88

PRESENT STATUS OF CLAM FISHERIES OF INDIA *

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ABSTRACT

Among the exploited bivalve resources of India, clams are by far the most abundant. Several species belonging to a number of families constitute the clam resources and they are exploited all along the Indian Coast. In recent times a steady export market for the frozen clam meat is being developed. The distribution of clams, their biology, ecology, physiology, exploitation, resource potential, utilisation and marketing are reviewed in this paper. Based on this review, the lacunae in the present state of our knowledge for the development of clam fisheries and the constraints thereof are identified. In view of their sedentary habits and easy accessability for exploitation, the clams are particularly vulnerable for overexploitation. The thrust areas where research input is required for the rational exploitation of clam resources are highlighted in this paper.

INTRODUCTION

AMONG the exploited bivalve resources of India, clams are by far the most widely distributed and abundant. Several species belonging to a number of families constitute the clam resources and they are exploited all along the Indian Coast. A number of clam species, belonging to the families Arcidae, Veneridae Tellinidae, Donacidae, Solenidae, Mesodesmatidae, Corbiculidae and Tridacnidae are exploited along the Indian Coast and considerable work was done on species of majority of these families. While some general accounts on the clams of India are available (Jones, 1970 ; Alagarswami and Narasimham, 1973 ; Nayar and Mahadevan, 1974 ; Silas *et al.*, 1982; Alagarswami and Meiyappan, 1989) a comprehensive review of the work done on this group is wanting. Further, due to the realisation about the high nutritive of clams and their importance in the economy of the coastal fishing villages coupled with the development of an export market for the frozen clam meat, stimulated research which resulted in a wealth of information on this important group during the last decade. In this article an attempt was made to review the work done on aspects of biology, ecology, physiology and fisheries of commercially important clams of India ; based on this review the lacunae in the present state of knowledge and the constraints for the development of clam fisheries were identified. The thrust areas where research input is required for rational exploitation of clam resources are highlighted.

The author is thankful to Dr. P. S. B. R. James, Director for encouragement and to Shri S. Mahadevan, Central Marine Fisheries Research Institute for suggesting improvements in the text.

* Presented at the 'Symposium on Tropical Marine Living Resources' held by the Marine Biological Association of India at Cochin from January 12-16, 1988.

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Biology and Ecology

Family : Arcidae

Anadara spp. are popularly called as ribbed clams, ark shells, cockles, blood cockles and blood clams. Of the various species, considerable work was done only in *A. granosa*. In this species Patel and Patel (1964, 1974) worked on haemoglobin, dimensional relationships and pea-crab infestations, Patel *et al.* (1966) on the uptake of Manganese-54, Radhakrishna and Ganapathi (1968) on zonation, Narasimham (1969, 1983, 1985, 1988a, 1988b) on maturity, spawning, sex ratio, condition index, dimensional relationships, pea-crab infestation, age and growth and population dynamics, Krishnamurthy and Ramamurthy (1969) on the rate of feeding and Narasimham *et al.* (1984) on ecology.

In *A. rhombea*, Patel and Patel (1964, 1974) studied haemoglobin, dimensional relationships and pea-crab infestation, John (1977) on bioaccumulation of iron, Natarajan and John (1983) on maturity, spawning and sex ratio, Narasimham (1988c) on maturity, spawning, sex ratio, condition index, dimensional relationships, age and growth and Hameed and Paulpandian (1987) on feeding and digestive rhythms.

Family : Veneridae

Venerid clams are the most soughtafter in the clam fisheries of India and three genera namely *Meretrix*, *Katelysia* and *Paphia* are important.

Meretrix meretrix, known as the giant clam was the object of study for spawning (Hornell, 1922 ; Rai, 1932), behaviour in waters of low salinity (Ranade and Kulkarni, 1973), effects of temperature and salinity on the oxygen consumption (Ranade, 1973), body component indices and chemical composition (Nagabhushanam and Deshmukh, 1976), growth on transplantation (Rao and Rao, 1983) and age and growth (Jayabal and Kalyani, 1986).

Meretrix casta is one of the most extensively studied species. Hornell (1922) and Panikkar and Aiyyar (1937) gave information on spawning, Venkataraman and Chari (1951) on biochemical composition, Abraham (1953) on the biology, Durve (1963, 1964, 1973, 1975) on the rate of filtration, spawning, growth on transplantation and change of form, Durve and Dharmaraja (1965, 1969, 1972) on the dimensional relationships, change of form and fatness, Silas and Alagarswami (1967) on pea-crab infestation, Seshappa (1971) on growth and spawning, Parulekar *et al.* (1973, 1984) on ecology and aspects of biology, Durve and George (1973) on condition index, Salih (1974, 1978 a, 1978 b) on growth, oxygen consumption and salinity tolerance, Wafer (1975) on biochemical composition, Harkantra (1975 a, 1975 b) on ecology and aspects of biology, Vijayaraghavan *et al.* (1975) on caloric value, Krishnakumari *et al.* (1977) on aspects of biology and biochemistry, Gopalakrishnan *et al.* (1977) on biochemical composition, Lakshmanan and Nambisan (1980, 1983) on biochemical composition and seasonal variations in trace metal content, Rao *et al.* (1980) on ecology, Mathew and Menon (1982) on oxygen consumption, Sreenivasan (1983 a, 1983 b, 1985) on ecology, spawning and growth on transplantation, Mohan *et al.* (1984) on allometric relationships, Balasubramanyam and Natarajan (1988 a, 1988 b) on biochemical composition and growth, Rao (1988) on spawning, growth and condition index and Joseph and Joseph (1988) on spawning and growth.

Desai (1971) and Kurian (1972) commented on the habitat preference of '*M. ovum*'.

On *Katelysia opima*, Rao (1952) reported on maturity, spawning and growth, Mane (1973, 1974, 1975, 1976, 1981) on early larval development, adaptations to low salinity, oxygen consumption, growth, spawning and biochemical composition. Ranade and Kulkarni (1973) on effects of temperature and salinity on oxygen consumption, Ranade (1973) on behaviour and adaptations to low salinity, Nagabhushanam and Mane (1975, 1983) on reproduction and neurosecretion, Krishnamoorthy and Soman (1975) on uptake of Tritium, Mane *et al.* (1979) on effect of pesticides and narcotics, Kalyanasunderam and Kasinathan (1983) on age and growth, Sreenivasan (1985) and Joseph and Joseph (1988) on maturity, spawning and growth.

Joshi and Bal (1965) studied the chemical composition in *K. marmorata.*

In *Paphia malabarica*, Krishnakumari and Rao (1974) gave an account on pea-crab infestation and condition index, Vijayaraghavan *et al.* (1975) on caloric value, Parulekar *et al.* (1984) on ecology and Rao (1988) on maturity, spawning, age, growth and dimensional relationships.

In *P. laterisulca*, Nagabhushanam and Dhamne (1977 a, 1977 b) studied the spawning and neuroendocrinology, Mane and Nagabhushanam (1979) on maturity, spawning, dimensional relationships, age and growth and Mane and Dhamne (1980) on salinity tolerance.

Winckworth (1931) made observations on the growth of *P. undulata.*

Family : Donacidae

Among the members of this family, popularly called as wedge or bean clams, considerable information is available on *Donax cuneatus*. Maturity, spawning, age, growth and dimensional relationships were studied by Nayar (1955), reproduction by Rao (1967), respiration by Rao and Kutty (1968) and Mane and Talikhedkar (1976), neurosecretary cells, reproduction and biochemical composition by Nagabhushanam and Talikhedkar (1975, 1977 a, 1977 b), growth by Talikhedkar (1978), effect of pesticides and narcotics by Mane *et al.* (1979) and reproductive biology and population density by Victor and Subramoniam (1988 a, 1988 b).

Alagarswami (1966) gave an account of maturity, spawning, age, growth and dimensional relationship in *D. faba* while Rao and Kutty (1968) studied respiration.

In *D. incarnatus*, Ansell *et al.* (1972, 1973) made observation on the population density, growth, length-weight relationship, condition index and biochemical composition Vijayaraghavan *et al.* (1975) on the caloric value, Nair *et al.* (1978) on growth, Balasubramanyan *et al.* (1979) on energy content, Parulekar *et al.* (1984) on aspects of biology and Mohan *et al.* (1986) on allometric relationships.

Family : Solenidae

Clams belonging to this family are known as razor clams. Rao *et al.* (1964) gave an account of maturity, spawning, age, growth and dimensional relationships in *Solen kempi* and Vijayaraghavan *et al.* (1975) worked on the caloric value.

Family : Corbiculidae

Villorita cyprinoides, popularly known as the black clam, was studied by Nair and Shynamma (1975 a, 1975 b) for biochemical composition and salinity tolerance, by Nair (1975) for growth, Vijayaraghavan *et al.* (1975) for caloric value, by Lakshmanan and Nambisan (1980, 1983) for biochemical composition and trace metal content, Ansari *et al.* (1981) for biochemical composition, Chatterji *et al.* (1984) for growth, Parulekar *et al.* (1984) for ecology, Achari (1988 a) for larval development and Joseph and Joseph (1988) for population density, spawning, age and growth.

CLAM FISHERIES

In India, while the effort expended and catch of finfish and crustacean species are regularly monitored, such a system is not in vogue for clams mainly because the fishing is generally seasonal and is carried on, on a subsistence level at several small centres, Nevertheless, surveys conducted by different authors at important production centres have yielded valuable information on clam fisheries. There are no regulations for the exploitation of live clams. The land is given on lease by Government for the exploitation of subsoil shell deposits.

Species-wise clam production

In Table 1 are given the species-wise estimated annual production of live clams at different centres along the Indian Coast. It may be noted that the production figures for various centres pertain to different years. Where more than one study was conducted from the same area, the latest information alone was given.

Of the estimated annual production of 45,412 t of clams, the black clam *Villorita cyprinoides* with a catch of 29,077 t forming 64%, is the mainstay of the clam fisheries. This species forms a fishery along the west coast in Goa, Karnataka and Kerala States in the saline and also in near freshwater habitat. Major production centres are the Vembanad and Ashtamudi Lakes (Table 1).

Next in importance are the venerid clams with an estimated annual production of 14,052 t forming 30.9%. These clams are widely distributed and form fishery in all the maritime States where clams are currently exploited. In this group, *Katelysia opima* is most important with 5552 t followed by *Meretrix casta* (4642 t), *Paphia malabarica* (1793 t) and *M. meretrix* (965 t).

The blood clam *Anadara granosa* accounts for 2,000 t / year and forms 4.4% of the clam landings (Table 1).

Other commercially important clam species, collected usually in small quantities at various places and for which catch statistics are not available are *P. laterisulca*, *K. marmorata*, *Gafrarium tumidum*, *Mesodesma glabratum*, *Tellina* sp., *A. rhombea*, *Donax cuneatus*, *D. faba* and *D. incarnatus*. In the Nicobar group of islands, Ramadoss (1983) mentioned about the exploitation of the giant clams *Tridacna maxima*, *T. grocea* and *T. squamosa*.

Statewise production of clams

There is no information from Gujarat, Orissa and West Bengal. It may be due to the absence of exploitation rather than the non-availability of the resources. For the erstwhile Bombay Presidency (including parts of Karnataka), Rai (1932) estimated the production of clams at about 1,800 t / year. The only other study which gave an estimate of the clam production in Maharastra State (1,100 t/year, Table 1) was by Ranade (1964). The production from Goa was 887/year (Table 1).

Of all the maritime States, clam production of Karnataka State was intensively studied. In the Kalinadi Estuary, earlier, Alagarswami and Narasimham (1973) estimated the annual production at 1 000 t, Nayar *et al.* (1984) at 2 000 t, Neelakantan *et al.* (1985) at 69 to 662 t and Rao *et al.* (1989) at 545 t. For the Mulky Estuary, Rao (1984) estimated the annual clam landings to vary between 271 to 951 t, Rao and Rao (1985) at 500 t and Rao *et al.* (1989) at 2,392 t (Table 1) indicating considerable fluctuations in the catches. In 7 estuaries in (Karnataka Table 1), Rao and Rao (1985) estimated the annual production of clams at 1,550 t. However, in a recent study Rao *et al.* (1989) indicated the annual catch of the Karnataka State, wherein 10 estuaries are productive at 6,592 t.

Kerala State stands far ahead of all maritime States in clam production with a catch of 32,927 t which accounts for 72.5% of the total clam landings. The Vembanad and Ashtamudi Lakes account for the above production (Table 1). Rasalam and Sebastian (1980) estimated the production of *V. cyprinoides* in 1968 at 27,000 t while in recent times the catch has come down to 21,490 t (Table 1).

TABLE 1. *Clam production at different centres*

Place	Production (t/year) *Species-wise	Total	Source
Thane to Ratnagiri	Mm & Ko 70%		
	Pl, Km & Dc rest	1,100	Ranade (1964)
Gav-khadi	Sk	3	Rao *et al.* (1964)
Goa	Vc 500, Mc 315	887	Parulekar *et al.* (1973);
			Ansari *et al.* (1981)
Kalinadi	Vc 525, Mm 20	545	Rao *et al.* (1989)
Aghnashini	Mc 500, Mm 250, Vc 5	755	,,
Uppunda	Mc 10, Ko 65, Pm 80	155	,,
Coondapur	Mc 50, Mm 40, Ko 5,		
	Pm 500, Vc 8	603	,,
Sita	Mc 230, Mm 5, Ko 5, Vc 5	245	,,
Swarna	Vc 15	15	,,
Udyavara	Mc 215, Pm 5, Vc 5	225	,,
Mulky	Mc 1814, Pm 578	2392	,,
Gurpur	Mc 300, Pm 600, Vc 375	1275	,,
Nethravathi	Mc 233, Vc 149	382	,,
Vembanad Lake	Vc 21490	21490**	Achari (1988 b)
Ashthamudi	Ko 5552, Vc 6000	11437	Appukuttan *et al.*, (1988)
Vellar Estuary	Mc over 87%	985	Sreenivasan (1985)
Pulicat Lake	Mc 102	102	Thangavelu and Sanjeevaraj (1988)
Kakinada Bay	Ag 2000, Mm 400,	2,500	Narasimham (1973)
	Ko 40, Pm 30, Dc 30		Silas *et al.* (1982)
Godavari Estuary	Mm 250	250	Narasimham (unpublished)
Bhimunipatnam Backwater	Mc 66	66	Rao *et al.* (1980)
	Total	45,412	

* Mm = *Meretrix meretrix*, Mc = *M. casta*, Ko = *Katelysia opima*, Pm = *Paphia malabarica*, Pl = *P. laterisulca*, Dc = *Donax cuneatus*, Sk = *Solen kempi*, Vc = *Villorita cyprinoides*, Ag = *Anadara granosa*

** Average for 1974-85.

Along the east coast of India the clam resources are smaller. In Tamil Nadu, the Vellar Estuary and the Pulicat Lake together contribute to 1,087 t while in Andhra Pradesh the clam production, coming from the Kakinada Bay, the Godavari Estuary and Bheemunipatnam Backwater was estimated at 2,816 t.

Stock assessment of clams

In India few studies were conducted to assess the stock position of the clam populations. In Karnataka, based on the surveys conducted during 1979-80, Rao and Rao (1985) estimated the standing stock of clams in 11 estuaries at 5345 t with *M. casta*, *V. cyprinoides* and *P. malabarica* accounting for about 88%, 7% and 4% respectively. In a recent study by Rao *et al.* (1989), also conducted in Karnataka during February-May, 1984 in 8 estuaries (Table 1), the standing stock of clams was estimated at 8,027 t comprising *M. casta* 70.3%, *V. cyprinoides* 12.8%, *P. malabarica* 11.3% and *M. meretrix* 5.5%. These studies showed wide variation in the abundance of clams in some estuaries over a period of 4-5 years. For example the standing stock of clams in Coondapur during April, 1979 was 1,167 t against 19 t in May, 1984, in Udyavara during December, 1980 it was 1,457 t against 34 t in May, 1984 and in Mulky the standing stock was 1,603 t in March, 1979 against 4,369 t in May, 1984. Also, considerable changes in the species composition are discernible such as the appearance of *P. malabarica* in the Gurpur Estuary (Rao *et al.*, 1989). Recently Joseph and Joseph (1988) estimated the Y max of *M. casta* in Netravathi - Gurpur at 661 t, in Mulky at 2,581 t, in Udyavara at 1592 t and in Coondapur at 8,110 t. The same authors gave the Y max of *K. opima* in Mulky as 1,035 t.

In the Kakinada Bay, during March-April, 1983, the standing stock of the blood clam, *A. granosa* was estimated at 6,895 t and that of *M. meretrix* at 1,082 t (Narasimham *et al.* 1984). In a detailed investigation on the population dynamics of *A. granosa* in the Kakinada Bay Narasimham (1988 a) estimated the instantaneous rates of total (Z), natural (M) and fishing mortality (F) at 3.9, 1.3 and 2.6 respectively. The age at recruitment (t_r) = 0.29 yr. and age at first capture (t_c) = 1.0 yr. This study suggested that at the present level of F, maximum YW/R value of 10.42 g is possible if t_c is reduced to 0.6 yr.

Exploitation of shell deposits

As in the case of five clams, the production of shells from subsoil deposits pertain to different years (Table 2). An estimated 1,76,610 t of subsoil shell deposits, also called lime shell, are exploited annually. The shells of the black clam dominate in the Vembanad Lake; *Meretrix, Cardium, Tellina, Arca, Pitar,* etc. in the Pulicat Lake and Venerid clams in other places. The production of lime shell in 1968 from the Vembanad Lake was estimated at 2,00,000 t (Rasalam and Sebastian, 1980), but it has come down to 41,000 t to 70,000 t during 1979-84 (Achari, 1988 b); however, the production of lime shell was higher by 17,000 t in the Pulicat Lake compared to 40,000t in 1914-15 estimated by Hornell (1916).

The estimated reserve of the lime shell in Karnataka estuaries is 21,35,700 t (Gopal *et al.*, 1976; Venkataraman and Bahat, 1978) suggesting vast scope to step up production.

Fishing methods

The live clams are collected by men, women and children at low tides in shallow waters as well as in the intertidal region. They are taken either by hand-picking or by using hand-operated scoop or rake nets (Alagarswami and Narasimham, 1973). In the shallow waters, collection of clams is made without using any diving aids. A spade or a knife is used in sandy substratum to remove the clams. The shells from the subsoil deposits are exploited

TABLE 2. *Exploitation of subsoil shell deposits (mostly clams)*

Place	Annual production (t)	Source	Remarks
Kalinadi	24,500	Rao *et al.* (1989)	
Aghnashini	7,600	,,	
Sharavathi	100	,,	
Venkatapur	100	,,	
Coondapur	20,436	Rao (1983)	Average for 1975-76 to 1981-82
Swarna	9,000	Rao *et al.* (1989)	
Vembanad Lake	52,764	Achari (1988 b)	Average for 1979-84
Athankarai	3,995	James (1978)	
Pulicat Lake	57,215	Thangavelu and Selvaraj (1988)	Production in 1980
Bahundi	500	Alagarswami & Narasimham (1973)	
Chilka Lake channel	400	,,	
Total	1,76,610		

by hand-operated shell dudge (Rao, 1983) or by suction type mechanical dredge (Rasalam and Sebastian, 1980). Non-powered wooden country craft are used for transport. In mud flats, wooden planks may be used for propulsion.

Utilisation

Along the west coast, the clams are consumed mostly by the poorer sections of the coastal population, particularly during the monsoon when there is a general cessation of fishing activity in the sea. Along the east coast they are eaten to a limited extent only. Of late, the clam meat is used as a feed in aquaculture of prawns. The shell is used in the manufacture of cement, calcium carbide, sand-lime bricks and lime. The lime-shell is used for manuring coffee plantations, as a mortar in building construction, in the treatment of effluents, as a pesticide by mixing with copper sulphate and in the glass, rayon, polyfibre, paper and sugar industries (Hornell, 1916, Alagarswami and Narasimham, 1973; Rasalam and Sebastian, 1980; Rao, 1984). In recent times frozen clam meat is exported to Japan. In 1984, 1,072 t of frozen clam meat (mostly *K. opima*) valued at Rs. 1.51 crore was exported.

Marketing

The clams are marketed near the production centres either bynumbers or byvolume. At the production centres in Karnataka, *P. malabaricus* fetches the maximum price of shell-on weight while *M. casta* and Rs. 1,000 pertonne *V. cyprinoides* are priced at Rs. 200-400/t ; the lime-shell is sold at Rs. 50-100/t (Rao *et al.*, 1989). The price realised by *A. granosa* is Rs. 500/t at Kakinada.

GENERAL CONSIDERATIONS

The above review of work shows that the available data on clam resources are mostly based on sporadic surveys or collected by enquiry except for a few production centres such as some estuaries of Karnataka, the

Vembanad Lake and the Kakinada Bay from where we have a sound data base. From Gujarat, Orissa and West Bengal there is no information. Even in those States where some information was available, it is outdated such as for Maharastra or incomplete in the sense that a good number of estuaries and backwaters were not surveyed as is the case in Kerala, Tamil Nadu and Andhra Pradesh. For undertaking any developmental programmes it is imperative to have information on the availability of resources. Regular monitoring of the catch and effort data of clams should be undertaken and to start with at least some of the major production centres should be covered. It is high time that priority is given to undertake comprehensive surveys to estimate the resource potential. The clam atlas of Karnataka prepared by Rao *et al.* (1989) is a beginning in this direction and similar studies are needed for other states.

While some work was done on ecology and aspects of biology such as size at first maturity, spawning, sex ratio, condition index, growth and biochemical composition of the commercially important clam species, information pertaining to life history, age composition of the commercial catches, recruitment pattern to the fishery, age at first capture and the mortality rates of the exploited stocks is meagre. Such information is vital to study the population dynamics of the clams which in turn will help to evolve suitable management measures for rational exploitation.

It may be mentioned that small sized clams are collected in considerable quantities both in the Vembanad and Ashtamudi Lakes (Achari, 1988 b ; Appukuttan *et al.*, 1988). Such a practice would have adverse effect on the stock and a minimum size limit should be fixed for exploitation, by taking into account the length at first maturity.

Rao and Rao (1985) observed that *M. casta* occurs in high density of 110 t/ha in the Mulky Estuary and Sreenivasan (1983 a) mentioned that seed clams ($<$ 13 mm) occur at a density of 1,08,355 numbers per sq.m in the Vellar Estuary. By adopting a simple technique of transplantation to suitable areas production can be augmented as revealed by the studies of Rao and Rao (1983) and Narasimham (1983, 1986, 1988 b).

It is known that dredging for subsoil deposits in the Kalinadi and Vembanad Lake has damaged the habitat (Nayar *et al.*, 1984 ; Narasimham *et al.*, 1986 ; Achari, 1988 b). Similar habitat destruction occurs when civil engineering works are taken up. It is desirable to demarcate the area for dredging the subsoil shells and for fishing the live clams. To replenish the clam stocks 'clam sanctuaries' can be created.

There is limited demand for clams as food as they continue to remain as non-conventional item of food. There is need to develop acceptable products out of clam meat and a vigorous extension drive should be launched to expand the consumer market and explore the foreign markets. Such a step would result in increased production and also better market price.

Clams are known to accumulate heavy metals, marine toxins, sewage and pesticide pollutants. From India two instances of the outbreak of PSP due to consumption of *M. casta* were reported (Silas *et al.*, 1982 ; Karunasagar, 1984). A consignment of frozen clam meat sent to Japan was rejected as it was polluted by Keroseine (Appukutten *et al.*, 1988). In view of the hazards of consuming clam meat contaminated by enteric pathogens and toxins, Ray and Rao (1984) stated that '.. we recommended that monitoring for sanitary quality of shellfish growing waters and shellfish meats be undertaken immediately in areas of shellfish production and utilisation.' Apart from monitoring there is need to set up depuration facilities at major production centres.

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