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BLOOD CLAMS—MATERIAL FOR PHYSIOLOGICAL AND BIOCHEMICAL STUDIES

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ABSTRACT

The paper discusses the distribution and the diagnostic features of blood-clams *Anadara granosa* L. and *Anadara rhombea* Born collected during radioecological surveys of east and west coasts of India. The occurrence, distribution and diagnostic features of a new subspecies *Scapharca deyrollei crispi* subsp. nov. are also discussed.

INTRODUCTION

APART from taxonomy of the shell remains of the Ark-shells, belonging to the most ancient superfamily *Arcacae* of the order *Taxadonta* lamellibranchs, found in Indian waters, by Melvill and Abercrombie (1893), Gravely (1941), Hornell (1951), Satyamurti (1956), Subrahmanyam *et al.* (1949) and Kundu (1965), little is known of these oldest bivalves, which have survived through the middle and later palaeozoic era. Their breeding habits, larval development, growth and distribution along the Indian coastline are some of the aspects on which practically very little information exists. Along with other bivalves arcid clams contribute a substantial part of the shell-fish fishery around Bombay, Konkan, Goa, Andhra and Madras coasts (Hornell, 1951, Narasimham, 1968 and Radhakrishna and Ganapati, 1969). In these areas these clams are much valued by poorer coastal people. Perhaps due to its red tough muscles the fisherfolk believe that it is highly nutritive, and these are given to women-folk during pre-natal periods (Hornell, 1951). So also a good quality lime is obtained by burning the heavy shells of these bivalves. It is also pulverised with the husks and used as poultry feed. These nicely ornamented shells are much sought after by shell crafts industry and amateur shell collectors. In view of ark-shells economic importance, physio-ecological studies of these bivalves are much desired. To initiate studies towards the understanding of these bivalves, in this communication, complete description of three species of arcid clams fished around east and west coast of India is given. Studies on the haemoglobin of these species, and radio-ecology have been discussed elsewhere (Patel, 1970, Patel and Patel, 1964, 1968, 1971, Patel *et al.* 1966 a, b Patel and Ganguly, 1968).

ARK-SHELLS OF INDIAN WATERS

Melvill and Abercrombie (1893), Gravely (1941), Hornell (1951), Satyamurti (1956), Subrahmanyam *et al.* (1949) and Kundu (1965) have collected a number of species of ark-shells from both the east and west coasts of India including the Gulfs of Mannar and Kutch. The shells of commoner edible blood clams *Anadara* (=*Arca*) *granosa* Linnaeus and *A. rhombea* Born, along with a few other species were recorded by Gravely (1941) from Madras beach, but the later studies by Satyamurti (1956) include neither of these species from the Gulf of Mannar, and are rare in Gulf of Kutch (Kundu, 1965). Around Bombay, *A. granosa* has been recorded in abundance, whereas stray occurrence of *A. rhombea* was reported by Melvill and Abercrombie (1893), Hornell (1951) and Subrahmanyam *et al.* (1949). During our search for live ark-shells we found both the species in abundance, burrowing in the mud flats near a region at the mouth of Vellar estuary off Porto-Novo (East coast), hitherto not reported. *A. rhombea* was, however, predominant. On the other hand, in Bombay waters (West coast) large beds of *A. granosa* were found off Sewri to Trombay, Mora, Belapurpada and Vashi in Thana creek, whereas *A. rhombea* was scarce. However, extensive beds of *A. rhombea* were found in Ratnagiri waters (West coast). In Bombay, one more species of ark was found in abundance, which has so far not been recorded by earlier authors. The shell, in general, bears resemblance to *Scapharca deyrollei* Jousseaume described by Lamy (1907) from Penang coast, which had 36-37 granular ribs, whereas the local species has 29 ± 1 smooth ribs. A new subspecies is therefore, created for this ark. Besides Bombay waters, we have recorded this subspecies from Alibag waters on the west coast and Pulicat lake (Madras coast). Karande (1969) also recorded moderate to heavy settlement of this subspecies along other fouling organisms on the panels exposed in Bombay harbour.

Nomenclature

We have followed the classification adopted by the majority of today's malacologists in considering *Anadara* and *Scapharca* as full genera, which are biologically separated from the true genus *Arca* of order Taxadonta. As early as 1843 Reeve observed two types of *Arca*, however, he did not separate them into different sub-genera. His first division included ark-shells without byssus and strongly developed radiating ribs. The second division comprised of forms which have byssus, and lighter weakly ribbed shell with non-crenulated margin. The two species of *Anadara* presently described thus agree with those included in Reeve's first division, and *Scapharca* to those of the second group. Recently Lim (1968) combined *Scapharca* and *Cunearca* and split up *Anadara* into *Anadara* and *Tegillarca*. Following this system *A. rhombea* and *A. granosa* would fall under *Tegillarca*, whereas *S. deyrollei* subsp. *crispi* nov. with inequivalve shell will remain under *Scapharca*.

Anadara granosa Linneaus and *Anadara rhombea* Born

Both these species appear to have been confounded by many students of molluscs including Lamark and Reeve. The former author considered both the species as varieties of *A. granosa* designating three varieties of *A. granosa* on the number of radiating ribs (Reeve, 1843). Later on Reeve removed the doubt by separating two of the three varieties as *A. granosa* s. str. During our studies, we were also quite confused by the resemblance the two species bear. On closer examination, however, a good many inter-specific characteristics were found, these are given in detail along with length-weight-breadth-and-height relationships (Table 2). In most of the localities both the species are found together, they burrow freely and have no byssus. *A. rhombea* differs from *A. granosa* in having dirty black shell with, at times, hairy periostracum, which is quite persistent on posterior end and having narrow umbones. Linular space is broad and diamond-shaped giving a wider angle for opening. The hinge margin is slightly arched. The radial ribs not deeply set and devoid of prominent transverse ridges, but are coarse. Ribs on anterior end are considerably smooth. Shell equivalve with 25 ± 1 ribs (Table 1). Relatively greater height in relation to length gives the rhomboid ark-shell a gibbose shape, hence named *Anadara rhombea*. The most characteristic feature of this species is the presence of keel from umbones to hind region, and the presence of one complete marginal chevron along with numerous verticle chevrons (Fig. 1).

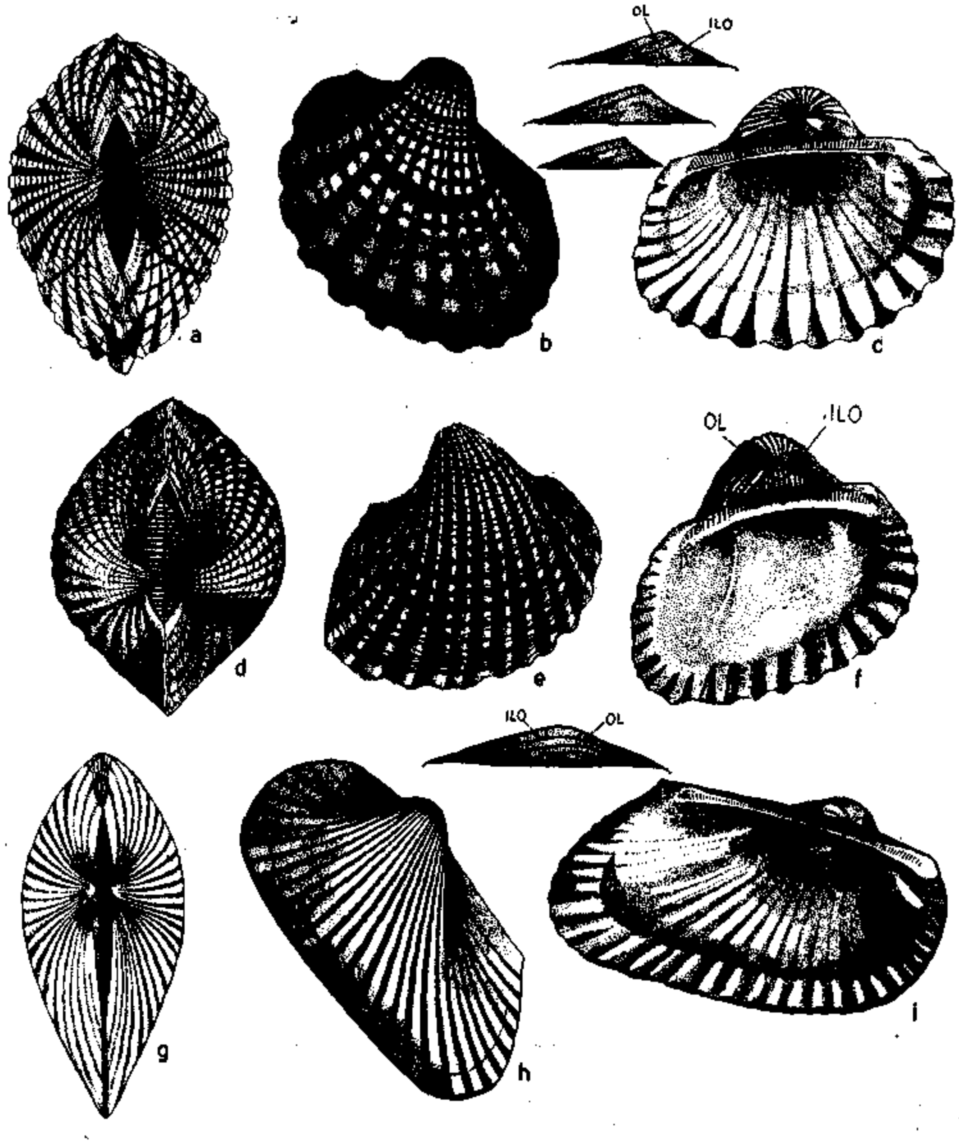

Fig. 1. Inner, outer and dorsal view of the shells of (a-c) *Anadara granosa* with variations in chevrons (d-f) *A. rhombea* and (g-i) *Scapharca deyrellei* subsp. *crispi* nov.

Anadara granosa has reddish brown shell with more or less persistent periostracum which is non-hairy. In the population off Trombay mussel beds, the periostracum was reddish, whereas in Sewri population it was dirty grey. This decolouration (bleaching) may well be due to relatively heavy pollution especially oil pollution off Sewri than Trombay. Umbo broadens rapidly from apex, and is twisted towards anterior end. The area of ligament is rather narrow, kite-shaped and more drawn out towards posterior end than anterior margin, the oblique ligament thickening—chevrons—two complete and two incomplete showing variation in pattern of development (Fig. 1). The hinge margin is more or less straight. The equivalve has 21 ± 1 deeply set strongly tuberculated ribs, showing prominent impressions on the inner side of the shell (Table 1).

Scapharca deyrollei crispi subsp. nov.

The description by Lamy (1907) of the shell of *Scapharca deyrollei* from Penang coast is rather sketchy and runs as follows:

'This ark has an elongated shell with depressed centre unequivalve and inequilateral and its posterior extremity flattened. It has 36-37 ribs.'

The description of the new subspecies is given below:

This subspecies is relatively smaller, lighter, and longer than high, light inequilateral, and margin not crenulated. Hinge margin straight with smaller teeth. Ligament relatively weak with four complete and two incomplete chevrons (Fig. 1). Umbones placed more towards anterior than posterior end. Ribs shallow, distinct, smooth and not split into two at periphery as in *A. bistrigata* Dunker. The most characteristic features of the subspecies being shell elongated, inequivalve, the presence of byssus and bearing 29 ± 1 smooth ribs irrespective of the size (Table 1).

Comparative diagnostic features of the two subspecies of *Scapharca deyrollei* Jousseaume (1893)

Scapharca deyrollei subsp *deyrollei* Jousseaume (1893)	*Scapharca deyrollei* Jousseaume (1893) *crispi* subsp. nov.
1. 36-37 radial ribs	28-30 radial ribs
2. shell with a depressed centre	shell without a depressed centre
3. Ridges granular	Ridges smooth

TABLE 1. *Variation in number of radial ribs in* A. granosa, A. rhombea *and* Scapharca *of various lengths (in each group about 500 animals were examined)*

Length cm	*A. granosa*	Number of radial ribs in *A. rhombea*	*S. deyrollei* sub. sp. *crispi*
1-2	20-21	25-26	28-30
2-3	20-21	24-26	29-30
3-4	19-21	25-27	29-30
4-5	20-21	25-26	—
5-7	20-21	25-26	—

Diagnosis : Although, in the absence of a detailed description by Lamy (1907) the predominant diagnostic character is the difference in number of ribs, the authors feel that this difference is sufficiently significant to separate the two subspecies.

Distribution : Mahim creek*, Bombay harbour and Alibag waters on the west coast, and Pulicat lake on the east coast of India.

Etymology : The authors gratefully name the subspecies after Professor D. J. Crisp, F.R.S., Director, Marine Science Laboratories, Menai Bridge, U.K., who introduced us to Marine Biology.

Registration No : The type specimen has been deposited in the collections of the Zoological Survey of India, Calcutta.

Date of Collection : September 12, 1963.

Place of Collection : Mahim creek, oyster farms.

Name of Collectors : B. Patel } Bhabha Atomic Research Centre,
S. Patel } Bombay-85.
B.F. Chhapgar, Curator, Taraporevala Aquarium, Bombay-2.

Table 1 shows the number of radial ribs in the three species of ark shells discussed, of various size. It will be seen that the number of ribs in the species remains constant irrespective of the size of the animal. However, the radial ribs and transverse ridges become increasingly prominent with the size/age of the animals.

Length-Weight, Length-Breadth, Length-Height Relationship

During the breeding season (January-March) when arks of various size groups were available, about 500 specimens each of *A. granosa*, *A. rhombea* and *Scapharca* were collected. Animals were washed, kept dry for an hour and then weighed. Length, breadth and height were measured.

Table 2. *Relation between length, breadth and height in three species of ark-shells*

Species	Length	
A. rhombea	1.17 H+0.22	1.29 B+0.10
A. granosa	1.27 H+0.13	1.34 B+0.28
S. deyrollei subsp. *crispi*	1.70 H+0.15	1.40 B+0.91

As in other molluscs, the relationship between length and gross weight was allometric and can be expressed by a general equation $W\text{-}AL^a$, where W and L denote weight and length respectively. Thus the value of A was 0.49, 0.35 and 2.57 for *A. granosa*, *A. rhombea* and *Scapharca* respectively. The value of a was 3.0 and 2.74 for *Anadara* species and *Scapharca* respectively. These agree well with those calculated for other species of molluscs, which are reported to lie between 2.5 and 4.5

* Species was collected in abundance from Mahim oyster farms during 1963-65. Unfortunately these farms have been reclaimed since then, leading to total loss of the species from local ecosystem.

with the exception of worm-like *Teredo* where it is 1.7 (Isham *et al.* 1951 ; Wilber and Owen, 1964). The relationship between length, breadth and height was found to be isometric and can be expressed by the general equation L=mH+c or mB+c, where L, B and H stand for length, breadth and height respectively. Table 2 records the length, breadth and height relationships in the three species. Further the straight line drawn to calculated dimensions gave an excellent fit with the actual observed breadth and length, which vary proportionately to the length during the period of growth and thereby maintaining more or less same geometry of form throughout the life in these species.

TABLE 3. *Number of growth rings in population of* A. granosa *of various size groups*

Length cms	No. ring	No. of specimens having 1 ring	2 rings	more than 2 rings
2.0-2.5	34	66	—	—
2.5-3.0	35	47	18	—
3.0-3.5	64	14	22	—
3.5-4.0	43	21	28	8
4.0-5.0	64	12	12	12
5.0-7.0	—	20	40	40

Table 3 gives the number of growth rings in a sample population of *A. granosa* of various size groups. It will be seen from the table that 40% of population examined had no so-called ' growth rings ' irrespective of size. In rest of the sample it varied greatly. In a few cases several rings were observed near the shell periphery. Certainly these cannot be considered winter or summer annuli. Perhaps it may have been due to increased mantle secretion during initial growth. Earlier Kusakabe (1958) observed formation of several rings within a few days during the larval development of *Anadara subcrenate*. Similarly both in *A. rhombea* and *Scapharca deyrollei* sub sp. *crispi* also no growth rings were observed which could be used for age determination.

THE CRAB—*ANADARA* RELATIONSHIP

Like many other species of bivalves *A. granosa* and *A. rhombea* harbour pinnotherid crabs. It was interesting to note that in Porto-Novo waters about 5-10% of *A. granosa* were infested, but not a single specimen of *A. rhombea* was found with the crab. *A. granosa* from Bombay waters were also free from infection, whereas window-pane oyster *Placenta placenta* population from the same locality was heavily infected. About 40-45% of *A. rhombea* population from Ratnagiri waters was also found harbouring the crab. Earlier, Hornell (1909) observed heavy incidence of pea crab (*Pinnotheres placunae*) infection in *Placuna placenta* population from the Gulf of Kutch, whereas Tuticorin population was free of infection, though the environment in general was identical. It would be, therefore, interesting to investigate the factors controlling the pea-crab infection.

The gills of infested *A. rhombea* were rather damaged and looked anaemic, a few even lacked usual red appearance of the pallial bulgings. Employing the visual index, it was observed that the average haemoglobin score in the infested animals was 1.24, whereas it was double in normal healthy animals (Table 4), suggesting that the feeding activities of crab had not only caused the gill erosions, but also affected the blood content. However, no significant differences were observed between the gross weight and length, and between the gross weight and soft parts of

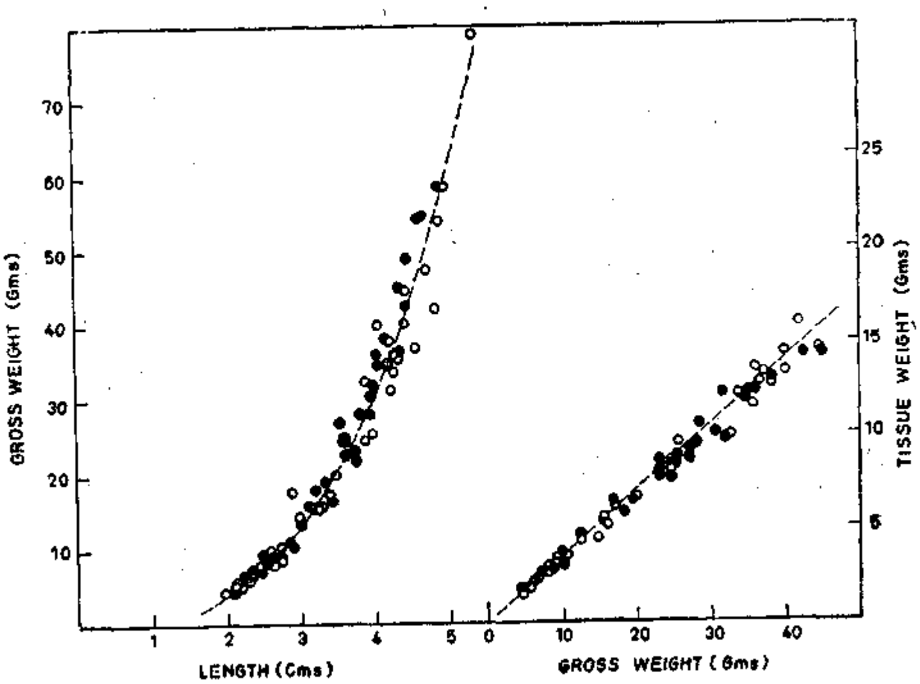

Fig. 2. Relation between gross weight and tissue weight and length in non-infested (●) and infested (o) *Anadara rhombea* population.

infested and non-infested population. Stauber (1945), and Christensen and McDermott (1958) reported that feeding activities of *Pinnotheres ostreum* had heavily

TABLE 4. *Average haemoglobin index in infested and non-infested* Anadara rhombea *assessed visually*

Hb index score		% Infested	% Non-infested
No colour	0	13	Nil
Pink	1	53	6
Light red	2	26	47
Dark red	3	8	54
Average Hb score		1.24	2.48

damaged the gills of the host *Crassostrea virginica*. Similar damages to the gills, gonads, digestive glands and mantle of *Meretrix casta* were caused by *Pinnotheres* sp. (Silas and Algarswami, 1965). Overcash (1946) determined the dry weight of the soft parts in relation to the volume of the shell cavity of the oysters, and reported that infested hosts were in poorer conditions. Egami (1953) demonstrated this experimentally by removing the gills of *Crassostrea gigas*, which ultimately caused a decrease in the growth rate. However, Christensen and McDermott (1958) and Silas and Algarswami (1965) found no significant differences in mean lengths of *C. virginica*, and in mean weight of *Meretrix casta* of both the categories respectively.

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