# CANDIDATE SPECIES, OTHER THAN SHRIMPS FOR COASTAL AQUACULTURE

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## 1. INTRODUCTION

Aquaculture is practised in three types of environments namely in freshwater, brackishwater and in the sea. The term 'Coastal aquaculture' is widely used to denote aquaculture in the coastal areas and comprises both brackishwater farming and mariculture. It is either land-based or sea-based and the latter is popularly known as sea farming.

As per the statistics released by FAO, in 1990 India occupied second position in the world with an estimated aquaculture production of 10.1 lakhs tonnes. A break-up of the figures indicates that freshwater fish culture is the most significant component accounting for 97.1% and the balance of 2.9% mostly composed of shrimps, came from coastal aquaculture. While the cultured shrimp production is slated to increase rapidly in the coming years, there are other cultivable species and their culture offers immense scope. In this article are given brief description of distinctive characters, biology and culture potential of various organisms (excluding shrimps) suitable for coastal aquaculture.

## 2. FINFISHES

Fishes have formed a part of man's dietary component from time immemorial. The coastal areas which serve as nurseries for many finfishes have been effectively utilised for aquaculture of these fishes. Among the fishes, the milkfish, the grey mullets and seabass are widely distributed and are traditionally cultured in coastal ponds in serveral countries. Other fishes which are suitable for coastal aquaculture are the groupers, the seabreams and the sandwhitings.

### 2.1. The Milkfish (Chanos chanos) (Forsskal, 1775)

The milkfish (Fig.1A) is one of the fishes admirably suited for aquaculture in the coastal areas. Qualities like, tolerence to wide variation in salinity and temperature, rapid growth, high resistance to diseases and parasites makes this high quality fish ideal for farming. Milkfish culture is in vogue for centuries in several southeast Asian countries. The young ones of milkfish have wide distribution in India, along the coasts of Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Karnataka. The seed is also avialable in the seas around islands of Andaman and Nicobar and the Laccadives.

**Distinctive characters :**

Milk fish belongs to the family Chanidae. Body elongate, moderately compressed devoid of scutes along the belly. Mouth small without teeth; lower jaw with a small tubercle at the tip, fitting into a notch of upper jaw, bran stegal rays only 4. Dorsal fin situated at about the midpoint of the body; the anal fin is short and far behind the dorsal fin base. Scales small, lateral line present. Back of the fish olive green, flanks silver, dorsal, anal and candal fins have dark margin.

**Biology**

The milkfish spends its early part of life, nearly one year in lagoons or estuaries which serve as a nursery ground. But for attainting sexual maturity and spawning it returns to the sea. It spawns annually or biannually, after completing five or six years. Fecundity is 3 to 7 million eggs. It grows upto 180 cm in length attaining 20 kg weight. Milkfish feeds mostly upon benethic filamentous microalgae as well as plankonic algae or parts of higher plants.

**Culture**

Development of hatchery technology for milkfish has not been perfected. However, recently in Taiwan, 68 million seeds were produced through natural spawning of brooders maintained in ponds. In India milkfish seed is collected from the nature, from the inshore waters. The main season for seed collection is from March to June, with a subsidary season during October to December. The 'Seed' after a brief nursery phase of one month are transferred to the production ponds when they are 5.8 cm long with weigh 1.5 - 5 g. In the first year, milkfish has a higher growth rate in brackishwater attaining 30-45 cm in length (weight 300-800 g) than in the sea where it grows to 25-30 cm during the same period. The survival rate of the fish ranges from 80 to 95%. The production in one batch stocking practice is 250-500 kg/ha while in multiple batches stocking, the production may vary from 300 to 1900 kg/ha. Very high production, 10-12 tonnes/ha in deep water intensive systems have also been reported from Taiwan.

## 2.2 Grey mullets

Mullets are high quality fishes which have a strong aquaculture presence, especially in Egypt and Rome. The desirable characters which make these fishes popular for farming are : high quality flesh, extreme tolerance to variation in salinity (0-38 ppt) and temperature (3 to 35°C) and low position in the food chain. In India, mullets are found in the estuaries and coastal regions of Kerala, Karnataka, Goa, Tamil Nadu and West Bengal.

**Distinctive characters**

Mullets belong to the family Mugilidae. Among the 14 valid species of mullets four are commercially important.

**2.2.1. Mugil cephalus** (Lionaeus, 1758)

Commonly known as 'flathead mullet' (Fig 2 B) has a robust body with the head much flattered dorsally and fatty tissue covering most of the eye. Lips thin, the lown margin having a high symphysial knob; hind tip of maxilla not curved below tip of premaxilla, pectoral axillary scale long, 33 to 36% of pectoral fin length, anal fin with 3 spines and 8 soft rays. Scales in lateral series 38 to 42. Colour blue and green on back and silvery on sides, shading to white below. There are 6 to 7 purple blotches at the base, indistinct brown bands down the flanks and a dark purple blotch at the base of pectoral fin. Grows to a maximum length of 90 cm.

**2.2.2 Liza macrolepis** (Smith, 1849)

Widely known as the 'large scale mullet' (Fig. 2 A) this fish has moderately robust body with wide and flattened head. The fatty tissue is seen only in the rim of the eye. Lips thin, lower lip with a high symphysial knob; hind end of upper jaw reaches vertical from anterior rim of eye, no elongate pectoral axillary scale; anal fin with 3 spines and 9 soft rays. Scales in lateral series 31 to 34. Colour greenish grey above and silvery on sides and belly. The body devoid of any bands or stripes. It grows to a maximum length of 60 cm.

**2.2.3. Liza subviridis** (Valenciennes, 1836)

Popularly known as 'greenback mullet' (fig. 3 B) this fish has a robust body with head wide and dorsally flattened. The fatty tissue covers only the iris of the eye. Lips thin, lower lip with a high symphysial knob, hind end of upper jaw reaches vertical from posterior nostril. Pectoral axillary scale rudimentary or absent. Anal fin with 3 spines and 9 soft rays. Scales in lateral series 27 to 32. The body is dark greenish above but silvery below, caudal fin edged with black.

**2.2.4. Liza tade** (Forsskal, 1775)

Known as the 'Tade mullet' (Fig. 3 A) this fish has a slender elongate body with a much depressed and pointed head. Fatty tissue covers only the iris, lips thin, lower lip with high symphysial knob; hind end of upper jaw reaching vertical between posterior nostril and anterior rim of eye, pectoral axillary scale absent. Anal fin with 3 spines and 9 soft rays. Scales in the lateral series 30 to 35. The body is greenish brown above, silvery below, often with 5 to 7 indistinct longitudinal marks on the upper half of the body in the adults.

**Biology**

Grey mullets occupy a wide range of habitats *viz.*, the shallow seas, creeks, swamps, estuaries and backwaters. The adults feed on algae, diatoms, crustaceans, decaying organic matter, detritus etc. found at the bottom while the young one feed mostly on plankton. Eventhough most mullets spwan in the sea, the larval and early growing phase is spent in the estuaries and lagoons. The life-span of most species varies between 2 and 3 years with maximum growth in the first year of life.

**Culture**

Technology for induced breeding and seed prodcution of mullets has been developed. In India although induced breeding of *Liza troshelli* and *L. macrolep* is has been achieved, hatchery technology is yet to be developed. Seeds (2 to 3 cm long) of grey mullet can be collected from the inshore waters. Experiments in India have shown that a production of about 2.2 t/ha for *Liza tade* and *L. parsia* can be obtained. In Hongkong production varies from 2.5 to 3.5 t/ha.

**2.3 The pearl spot (Etroplus suratensis** (Bloch)

The pearl sport, *Etroplus suratensis* (Fig. 4 B) is an important brackish water fish with restricted distribution in India, Sri Lanka and Pakistan. It is easily adaptable, fast growing rapidly breeding and non-predaceous. These qualities make it an ideal fish for coastal aquaculture. In India it occurs in Kerala, Tamil Nadu, Orissa and Andhra Pradesh.

**Distinctive characters**

*Etroplus suratensis* belongs to the family Cichildae. The body is along, strongly compressed and elevated. Eyes are large, diameter 3 to 4 times in head length. Mouth small, teeth villiform in a single row anteriorly but in one or two rows posteriorly on both jaws. Single dorsal fin with the spinuous portion greater in extenT than the soft portion. Lateral line present in the upper part of body. The colour of the fish is light green, with eight obliQue bands between the occipital region and base of the caudal fin. Most of the scales above lateral line have a central white spot. The dorsal, caudal, ventral and anal fins are of a dark green colour, but the pectoral fin is yellowish with a black base. The fish has strong spines on the dorsal and anal fins.

**Biology**

The pearl spot attains sexual maturity within a year. It breeds in confined waters such as ponds, almost throughout the year. A single female fish can lay upto 6000 eggs at a time. The eggs are attached to submerged objects like twigs, bamboo poles by the females after clearing the area. These fishes show parental care. The male fertilizes the eggs and the female guards over them during development. During the early phase of life the fish feeds on zooplankton and aquatic insect larvae. Later they feed upon filamentous algae and other vegetable matter.

**Culture**

Induced spawning and artifical seed production technology has not been developed in India. However the pearlspot is cultured in the traditional fish culture ponds of Kerala, where it is considered as a great delicacy. The pearlspot grows upto 30 cm in length and 1.5 kg in weight by the end of first year and growth slows down afterwards.

### 2.4 The Seabass (Later calcarifer (Bleeker)

The seabass also know as ' Giant perch' (Fig 1 B) is a widely distributed high quality fish. It can tolerate wide variations in temperature and salinity and has fast growth rate. This prime estuarine fish is popularly called 'Bhekti' and is found along the east and west coasts of India.

#### Distinctive characters

The Seabass belongs to the Family Centropomodae. The body elongate and moderately compressed with a deep caudal peduncle. Head pointed, mouth large, slightly oblique and the lower edge of the preopercle serrated, with a strong spine, the spinous and soft parts of the dorsal fin seperated by a deep notch. The lateral line extends on to the tail. The juveniles are olive brown above with silvery sides and white belly. The adults are greenish or bluish above and silvery below. Scales large, ctenoid. Eyes bright pink, glowing at night.

#### Biology

The seabass is carnivorous and feeds upon fishes and crustaceans. The fry feed on zooplankton and the fingerlings upon crustaceans, worms, molluscs etc. Growth is fast during the first three months. Fishes above 50 cm attain sexual maturity. This fish is a protandrous hermaprodite. Usually younger fish in the age group of 3 to 5 years are males and older fishes in the 4 to 7 years group are females. It migrates to the sea for breeding. It is observed to grow to 28.7, 49.2, 68.7 and 79.7cm respectively during the first four years.

#### Culture

The seabass has been successfully bred and cultured in Thailand, Singapore, Taiwan and Philippines. However, in India hatchery technique for this fish is yet to be perfected. Seabass is cultured in the traditional culture ponds, 'Bheries' of West Bengal. In culture ponds it is known to attain 1.5 to 3 kg in the first year and 5 kg in the second year.

### 2.5 The Groupers

The Groupers are commercially important fishes which are cultured extensively in Taiwan, Thailand, Singapore and Malaysia. In India two species of groupers of the family Serranidae, *Epinephelus tauvina* and *E. malabaricus* are economically important. These fishes are carnivorous.

#### Distinctive characters

#### 2.5.1. Epinephelus tauvina (Forsskal, 1775)

Popularly known as 'Greasy gruper' (Fig. 5 B) it has an elongate and thick set body. Preoperculun has a slightly convex serrated upper edge and serval strong spicules at lower angle. Gill rakers, 27 to 30 on lower part of 1st gill arch. Dorsal fin with 11 spines and 15 to 16 soft rays. Caudal fin rounded. The fish is light brown in colour, with darker vertical or oblique bands; upper parts of head and body and base of pectroal fins covered by red/brown spots, spots on cheek are arranged in regular series from eye to preopercular angle. Spots in large adults obscure or absent.

#### 2.5.2. Epinephelus malabaricus (Schneider, 1801)

Known as the 'malabar grouper' (Fig. 5 A) this species is often misidentified as *E. tauvina.* The preopercle is finely serrate, with a shallow notch, the serrae enlarged at the angle. Lower gill rakers 13 to 16, dorsal fin with 11 spines and 14 to 16 soft rays, mid-lateral body scales distinctly ctenoid with minute auxiliary scales. The head and body generally pale greyish brown covered with small orange, golder brown, or dark brown spots. Five more or less distinct slightly oblique, irregular, broad, dark bars on body. Also three dark blotches present on the interopercle.

#### Culture

Groupers are suitable for culture in net cages and in tide fed ponds. Not much success has been achieved in Taiwan on seed production and culture *E. malabaricus.* The seed, 12 cm in length, stocked at a density of 40,000/- ha grow to 30 cm (600-800 g) in 8 months with 80-90% survival and yielding more than

20kg/ha production. The supplementary feed in fresh trash fish. In India, experimental net cage culture of *E. tauvina* was carried out at Mandapam wherein it was reported that a net income of Rs. 2,193 can be realised within a period of 11 months.

### 2.6 The Seabreams

The seabreams are important culturable group of finfishes which have been neglected by researches and aquaculturists in India. The sea breams belong to the family Sparidae. Of the various species, four are important *viz. Acanthopagrus berda* (picnic seabream); *Argyrops spinifer* (king solider bream), *Acanthopagrus bifasciatus* (two bar seabream), and *A. latus* (yellowfin seabream).

#### Distinctive characters

The seabreams have an ablong and more or less deep and compressed body. Head large with a step or straight upper profile, the snout scaleless but the cheeks scaly and the preopercle is without spines or serrations on the margin. The spines on the dorsal, anal and pelvic fins strong, the dorsal with 10-13 spines. The colours vary from pinkish or raddish to yellowish often with silvery or golden reflections and dark coloured spots, stripes or bars.

In *A. berda* (Fig 6 B) and *A. bifasciatus* (Fig 7 A) the upper profile is straight; in A latus (Fig 7 B) a prominent bulge is present at the eye and in *A. spinifer* (Fig 6 A) the profile is rather straight. In *A. bifasciatus* two vertical black bars present across the head; and in *A. latus* a diffuse dark blotch present at the origin of lateral line and a dark interorbital band along the opercle.

#### Biology and culture

These fishes are bottom living, generally found on rough and muddy sand grounds in coastal waters, estuaries and bays. In Taiwan, A. berda has been induced to spawn in the hatchery. In the net cage culture of A. latus in Taiwan, from an initial length of 5-6 cm the fish attained the marketable size of 600 g in 12 months with 90% survival rate. Culture of seabreams in India is yet to be taken up.

### 2.7 Sand whiting (Sillago sihama) (Forsskal, 1775)

*Sillago sihama* is the sand whiting of commercial importance in the Indian waters. It occurs in the coastal waters along both the coasts.

#### Distinctive characters

Body elongate with a pointed snout. Mouth small, terminal 2 or 3 series of scales on cheeks, a small sharp spine on opercle. Two seperate dorsal fins present, the first with 9-12 slender spines. Lateral line slightly arched. The fish is silvery grey in colour, without dark blotches. Both dorsal and caudal fins dusky, other fins pale (Fig. 4 A)

#### Culture

Experimental culture of *Sillago sihama* at Mangalore and Mandapam gave encouraging results. However commercial culture of sand whitings has not been taken up.

## 3. CRUSTACEANS

The crustaceans comprise shrimps, lobsters and crabs and there is insatiable demand in the world trade for live and processed products. The lobster and crab culture in India are still in the nascent stage of development and there is great scope to augment production by farming them on scientific lines.

### 3.1. Lobsters

Lobsters are highly priced crustaceans which inhabit different ecological niches like coastal waters and the deep sea. The tropical spiny lobsters which belong to Family Palinuridae are suitable for aquaculture. The characteristics like easy adaptation to captive condition, relatively fast growth rate and low cannibalistic tendency make these lobsters suitable for aquaculture. In India, the north western region and the coasts of Trivandrum, Kanyakumari and Tirunelveli Districts of Kerala and Tamil Nadu have been identified as

the productives areas for the lobster fishery. The exorbitent prices for lobsters in the recent years have intensified lobster fishery which in turn has put the natural lobster population under heavy exploitation. This calls for farming of lobsters. Among the spiny lobsters, *Panulirus polyphagus, P. homarus* and *P. ornatus* are important.

### 3.1.1. **Panulirus polyphagus** (Herbst, 1793)

Commonly known as the 'mud spiny lobster' *P. polyphagus* (Fig.8) has a rounded carapace and moderately covered with spines and tubercles. Antennular plate with a pair of anterior spines. Abdomen without grooves. Antennules very long, about 1/2 times the total body length, legs 1 to 4 without pincers. Body of the lobster dull greenish. Each abdominal segment with a distinct transverse white band (not black edged) across posterior margin. Legs irregular, blotched creamy white.

### 3.12. **Panulirus homarus** (Linnaeus, 1758)

Known as the 'scalloped spiny lobster' (Fig. 9 A) this species has a rounded carapace with numerous spines. Antennular plate with two equal pairs of spines and many scattered smaller spines in between. Each abdominal segment with a transerverse groove, sometimes interrupted in the middle, its anterior margins formed into shallow scallops. Colour of the body is dark greenish to blackish. Lateral border of each abdominal segment with a white circular spot. It grows to about 30 cm.

### 3.1.3. **Panulirus ornatus** (Fabricius, 1798)

Popularly known as the 'ornate spiny lobster' (Fig 9 B) this is the largest species under this genus, growing to a length of 50 cm. Carapace rounded and covered with numerous spines and tubercles. Antennular plate bearing two pairs of spines, the anterior pair being much larger than the posterior. Each abdominal segment smooth, without transverse grooves. Body colour greyish brown. Each abdominal segment with a broad dark transerve band and two large white spots on either side. Legs with black and light yellow stripes.

### Biology

Spiny lobsters are heterosexual which attain sexual maturity at the age of 2 to $2^1/_2$ years. They reproduce in the inshore waters. Though breeding is continuous, peak breeding occurs in different periods of the year for different species. The life cycle of the lobster involves various phases like 'Phyllosoma larva' 'Puerlus' and baby lobster before developing into an adult. Growth is relatively fast in the early stages and the animal attains 20 to 25 cm in the first 2 years. After this the growth rate is very low being 2 to 3 cm only per year. The spiny lobsters are omnivorous, feeding on a wide variety of benthic organisms likes bivalve molluscs, polycheates, fishes and decaying animal matter.

### Culture

Lobster is farmed commercially along the Gujarat coast. The farmers purchase lobster seed of 30-35 g at Rs. 20/kg. These juveniles of *P. polyphagus* are grown in pits of size 30x15x1.25 m and covered with monofilament net fixed at the margin. The tide flushes the pit with fresh seawater twice daily. Crushed trash fish and small crabs are used as supplementary feed. The lobsters grow to 100-125 kg in 10 to 13 weeks.

One of the main constraints in lobster culture is the inadequate seed supply. Though it has been possible to breed the lobster under laboratory conditions, a viable technology for seed production has not been developed. In the recent years the export of live, whole cooked or frozen lobsters of small and medium size has encouraged more fisherman on the southwest and southeast coast to venture into lobster farming.

### 3.2 Mud crabs

Mud crabs inhabit the inshore sea (upto 40 m depth) estuaries, backwater and mangrove swamps of all maritime states of India. Two species of mud crabs belonging to the family Portunidae are commercially important viz. *Scylla tranquebarica* and *Scylla serrata* and are suited for coastal farming.

**Distinctive characters**

**3.2.1. Scylla transquebarica** (Fabricius)

The outer margin of wrist (carpus) of chelipeds with 2 sharp spines, colour of upper surface of body (carapace) light to dark green, polygonal markings on all walking and swimming legs.

**3.2.2. Scylla serrata** (Forsskal)

Outer margin of wrist (carpus) of chelipeds with one blunt spine, colour of upper surface of body carapace greenish brown; no polygonal markings on walking and swimming legs; lower surface of fixed finger of chelipeds dark to pinkish red in colour.

**Biology**

Mud crabs are continuous breeders and peak breeding season varies from place to place. The size at first maturity is 120 mm for *S. transquebarica* and 83 mm for *S. serrata.* The interval between successive spawnings is about 2 months. The eggs carried on the pleopods vary from 0.5 to 0.9 million for *S. serrata* and 1.1 to 2.0 million for *S. tranquebarica.* In the life history of crabs there are 5 zoeal and one megalopa stage before matamorphosing to the first crab stage. The maximum sizes attained by male and female of *S. tranquebarica* are 220 cm (2.0 kg) and 198 mm (1.7 kg) and that of *S. serrata* 127 mm (400 g) and 124 mm (350 g) respectively. These crabs are omnivorous, feeding mainly on crustaceans, bivalves and fishes.

**Culture**

Commercial farming of mud crabs is well established in the southeast Asian countries like, Tailand, Taiwan, Indonesia, Philippines and Malaysia. In India, mud crabs are reared in 1.5 m deep ponds for 5 to 6 months. The ponds are provided with a bamboo or knotless net fence. In some areas undersized crabs are held in cages, pens or ponds for a period of 20 to 30 days for 'fattening' the crabs. In the pond culture system a production of 1059 to 1393 kg/ha/3 months has been reported from Thailand while in Indonesia the production is 2250 to 5000 kg/ha/ 1 month. In India more farmers are venturing into crab culture following the recent demand in the export market for live crabs.

## 4. MOLLUSCS

Molluscs such as oysters, clams, mussels, scallops and several species of gastropods are rich in protein and among seafoods are considered a delicacy in many parts of the world. The pearl oysters yield valuable pearls. The shell of the molluscs is used in lime-based industrues and also in making curios. The bivalves and gastropods are either sedentary or have restricted movements, feed low in the food chain and are well suited for farming. The Central Marine Fisheries Research Insititute (CMFRI) has developed technologies for farming edible oyster, mussels, clams and pearl oyster and production of cultured pearls. However commercialisation of these technologies is yet to take off.

### 4.1. Pearl oysters

The Pearl oysters belong to the family Pteridae. In Indian waters six species of pearl oysters have been recorded and out of them the Indian pearl oyster *Pinctada fucata* (Gould) and the black-lip pearl oyster *P. margaritifera* (Linnaeus) produce valuable natural pearls. The last pearl fishery was held in 1961 in the Gulf of Mannar and in 1966 in the Guld of Kutch.

**Distinctive characters**

**4.1.1. Pinctada fucata** (Gould)

In *P. fucata* the hinge is almost as broad as the width of the shell, anterior border of the shell does not extend or just extends in front of a perpendicular line drawn from the tip of the anterior ear, posterior ear well developed with modertely developed sinus, byssus notch slit-like, left valve highly convex, outer shell with 6-8 radial bands of reddish brown colour and of golden, pink or ivory colour and the non-nacreous border on the inner surface of valves has brownish or reddish patches.

**Biology**

The pearl oysters are strictly marine filter feeders, feeding mostly on microalgae and particulate matter. The sexes are separate. *P. fucata* attains sexual maturity at about 15.5 mm at the age of 3 to 4 months. The growth is fast during first year. The estimated length at the end of first year is 45 mm, second year 55 mm, third year 60 mm, fourth year 65 mm and fifth year 70 mm and the corresponding estimated weights are 10g, 30g, 45g, 60g, and 70g.

**Culture**

Complete package of technology including hatchery production of seed pearl oyster farming and production of cultured pearls in P. fucata has been developed by CMFRI. The Institute conducts regular training programmes and gives priority to transfer of technology to end users.

**Distinctive characters**

**4.1.2. Pinctada margaritifera** (Linnaeus)

In *P. margaritifera* the hinge is shorter than the width of the shell, anterior border of shell far in advance of a perpendicular line drawn from the tip of the anterior ear, posterior ear and sinus absent, byssal notch broad, left value moderately convex, outer shell dark brown with greenish tinge and radially distributed white spots, nacreous layer iridescent and of silvery sheen colour. The non-nacreous border is or dark colour and hence the name black-lip pearl oyster for this species.

**Culture**

Success was achieved in the hatchery production of seed in *P. margaritifera* Technology for the production of cultured pearls is yet to be developed in India. In several pacific island countries cultured pearls are produced from this oyster.

**4.2 Edible oysters**

Edible oysters have wide distribution in the estuaries, bays and coastal regions. Oyster culture technology which is simple and less capital intensive has been perfected after years of experimental work. Fast growth rate, tolerance to wide variation in salinity and easy availability of oyster seed make oysters ideal for aquaculture. Among the six species of edible oysters found in the Indian waters, *Crassostrea madrasensis* and *C. gryphoides* are suitable for culture. The estuaries of Kerala, Karnataka, Andhra Pradesh and Tamil Nadu are rich in oyster rresources.

**Distinctive characters**

**4.2.1. Crassostrea gryphoides** (Schlotheim)

Known as the west coast oyster, *C. gryphoides* has elongate and thick shell valves. Left valve cup-like. Hinge area well developed and has a deep median groove with lateral elevations. Adducter muscle scar broad, more or less oblong and striations on the scar absent or obscure. Grows to 17 cm.

**Distinctive characters**

**4.2.2. Crassostrea madrasensis** (Preston)

Commonly brown as the Indian backwater oyster, *C. madrasensis* has elongate shell valves which are highly irregular. Left valve deep and the right one slightly concave, hinge narrow and elongated. Adducter muscle kidney-shapted and dark purple in colour. It grows to a maximum size of 22 cm.

**Biology**

The edible oyster is a sedantary animal which attaches to the substratum by the cupped lower valuve. The oysters are highly euryhaline. The oysters feed on the planktonic organisms and organic detritus. The sexes are seperate, but hermaphrodites have also been reported. A single female oyster measuring 80-90 mm spawns 10 to 15 million eggs at a time. *C. madrasensis* spawns throughout the year with peak activity during March-April and July-September along the Tuticorin coast. Growth of the oysters varies from place to place. In the CMFRI hatchery at Tuticorin spat of *C. madrasensis* attained a length of 38 mm in 3 months and under the field conditions the oyster attained 87 mm length in one year.

### Culture

In *C. madrassensis* complete package of technology including controlled seed production and farming by different methods such as rack and tray, rack and string and stake have been developed by CMFRI. In other countries raft and long line methods of culture are also practised. The rack and string method is estimated to give a production of 80t/ha/y the rack and tray method 120 t/ha/y and the stake methods about 20t/ha/y. Although the oyster culture technology is simple and easily adoptable, lack of awareness among enterpreneurs and limited demand for oyster meat in the local market hinder the commerciatization of oyster culture technology in India.

## 4.3 Mussels

Mussels are bivalve molluscs found attached to rocks and other hard objects by their byssus threads. Two species of mussels *Perna viridis* (green mussel) and *P. indica* (brown mussel) (Fig. 10) belonging to the Family Mytilidae occur along the southeast and southwest coasts of India. The consumption of mussel meat is limited to some areas along the coasts of Kerala, Goa and Maharashtra.

### Distinctive characters

The diagnostic characters of the two species of *Perna* are tabulated below.

| Character | *Perna Viridis* Linnaeus | *Perna indica*Kuriakose & Nair |
|---|---|---|
| External colour | Green | Dark brown |
| Mantle margin colour | Yellowish-green | Brown |
| Ventral shell margin | Highly concave | Almost straight |
| Middle dorsal margin | Arcuate | A distinct dorsal angle or lump present |
| Anterior end of shell | Pointed break down turned | Pointed and straight |
| Number and size of hinge teeth | Two small teeth on the left valve and one on the right valve | One large tooth on the valve and a corresponding depression on the right valve |

### Biology

The mussels attach to hard substratum by byssus threads and are capable of discarding the byssal strands and secreting new ones for enabling them to change position. They feed mainly phytoplankton by filtering the seawater. Sexes are separate. The mussels attain maturity at 15.5 to 28.0 mm. Along the east coast at Kakinada, *P. viridis* was found to spawn during December to July with peak activity between January and May. At Calicut, on the west coast, the peak spawning was observed during August to October. Growth fo mussels has been found to vary from place to place. In the Kakinada Bay, *P. viridis* in the natural bed grows to 63 mm in 6 months, 91.5 mm in one year, 117 mm in 2 years, 129 mm in 3 years and 135 mm in 4 years.

### Culture

Mussel seed has been produced under the laboratory conditions by induced spawning. However, large-scale production of mussel spat in the country has not been tried so far. Mussel seed collected from the wild were cultured in the open sea, at Calicut, Ratnagiri and Kovalam and in the Bay areas of Karwar and Dona Paula. Rafts made of teakwood or bamboo poles measuring from 5m x 5m to 8m x 8m size have been used. Seed of 20 mm to 30 mm length were secured on coir rope (20-25 mm dia) and nylon rope (14 mm dia). The production rates at various centres is given below :

| | | |
|---|---|---|
| Calicut (Open sea) | : | 4.4-12.3 kg/m rope/5 months |
| Off Karwar Bay | : | 7.6-10 kg/m rope/5-6 months |
| Dona P Bay | : | 6 kg/m rope/6 months |
| Ratnagiri (Open sea) | : | 7 kg/3 m rope/6 months |
| Kovalam (Open sea) | : | 6.6 kg/m rope/4 months |

Mussel meat is gaining popularity in the recent years. The lack of awareness among entrepreneurs and financial institution about the benefit of mussel culture is one of the main constraints which stands in the development of mussel culture in India.

### 4.4 Clams

Among the exploited bivalve resources of India clams are by far the most widely distributed and abundant. Clam meat is nutritious and is a cheap source of protein rich seafood. Clam species belonging to the families Arcidae, Veneridae, Corbiculidae and Tridacnidae are suitable for culture. They occur in estuaries and backwaters along both of coasts of India. However, the giant clams of the family Tridacnidae are restricted in distribution and they are found in the seas around Andaman & Nicobar Islands and in the coral islands of Laccadives.

**Distinctive characters**

#### 4.4.1 Anadara granosa (Linnaeus)

Anadara granosa popularly known as the 'blood clam' belongs to family Arcidae. Shell thick, inflated and dark brown. This species differes from other clams in having taxodont dentition (small teeth in a single straight series) and about 20 elevated ribs bearing rectangular nodules (Fig. 11 B). It occurs all along the Indian coast in soft muddy substratum and forms a fishery of some magnitude in the Kakinada Bay.

#### 4.4.2 Paphia malabarica (Chemnitz)

Belongs to the Family Veneridae. It is popularly called the textile clam (Fig 12. B) Shell slightyly inflated, surface concentrically grooved. Pallial sinus 'U' shaped and very deep. Lunule relatively short. Shell length only one and one third times longer than height. Hinge area short with narrowly diverging teeth. Shell yellowish brown in colour, indistinctly rayed with greyish brown bands or mottled with brownish angular markings.

#### 4.4.3 Mertrix casta (Chemnitz)

Known as the yellow clam, *M. casta* (Fig 12 C) belongs to the Family Veneridae. Shell thick, smooth, devoid of sculpture and triangularly ovate. Outer surface pale yellowish brown tinted with dark grey posteriorly and very faintly rayed with greyish raidal lines. Pallial sinus entire, not sinnute, lunule inconspicuous, anterior lateral tooth on the left valve and depression on the right valve characteristically striated.

#### 4.4.4. Meretrix meretrix (Linnaeus)

Differs from *M. casta* in having less elongated lateral tooth and more ovate shell (Fig 12 D). Also it grows to a larger size.

#### 4.4.5 Katelysia opima (Gmelin)

K. opima comes under the family Veneridae. Shell thick, inflated, smooth, triangularly ovate (Fig 11 A) Pallial line deeply sinute. Apex of the pallial sinus is blunty angular. Lunule district, flattened and rather abroad. Area behind the umbones is well defined, flattened and greatly elongated reaching almost upto the hind margin of the shell. Outer surface of shell polished, pale yellowish brown or straw coloured, variously mottled and rayed with purplish grey markings.

#### 4.4.6 Villorita cyprinoides (Gray)

Popularly known as the black clam *V. cyprinoides* come sunder the family Corbiculidae (Fig 12 A). Shell thick, ovately triangular with strong concentric ridges; ridges more strongly developed in the anterior half. Umbones prominent, well elevated, hinge margin very short and thick, always with three oblique cardinal teeth of which the anterior in the right valve and posterior in the left valve are obsolete. Pallial sinus small, lunnule narrow and ligament large. Periostracum dark olive brown to blackish brown.

### 4.4.7. The Giant clams

Giant clams come under the family Tridacnidae. Four species of giant clams have been reported from the Indian waters (Fig. 13). The Tridacnid clams have large massive shells with broad radial ribs, sometimes bearing large fluted scales. Edges of valves usually scalloped.

*Tridacna crocea* Lamarck : Smallest of the giant clams and grows to 15 cm. Large, thick, triangularly ovate shell with large byssal gape, 6-10 broad flattened ribs with concentric ridges. Shell greyish white, flushed with yellow or pinkish orange. Popularly called as Crocus or Boring clam.

*T. maxima* Roding : Shell strongly inequilateral. Resembles *T. crocea* but its 6-12 broad radial ribs have much more strongly developed concentric scales. Large byssal gape with distinct plicae at edges. Ventral margin of the valve often deeply scalloped. Sheel greyish white, sometime tinged with yellow or pinkish orange. Grows to about 35 cm. Popularly known as Great clam or Rugose Giant clam.

*T. squamosa* Lamarck : Large, thick, strongly inflated shell with small or medium sized byssal gap. 4-12 strongly convex ribs with riblets in interspaces. Broad, sometimes long fluted scales on ribs which may project beyond ventral margin considerably. Greyish white, sometimes tinged with yellow. It is known is Fluted or Scaly clam and grows to 40 cm.

*Hippopus hippopus* Linnaeus : Large thick elongate lozenge shaped shell with tightly closed byssal area. 13-14 convex raidal ribs with low riblets. Often covered with foliaceous or almost tube-like spines. Greyish white with yellowish orange tinges. Often dark red patches on ribs arranged in irregular concentric bands.

#### Biology

The clams are basically filter feeders, except the giant clams which are capable of producing their own food with the help of the symbiotic algae lodged in their mantle. All the species of giant clams are listed as endangered. Considerable information is available on the biology of Indian clams and the salient features are given in the Table.

#### Culture

Viable technology has been developed in India for the production of the seed of *A. granosa, M. meretrix, M. casta* and *P. malabarica* at CMFRI. The giant clams have been successfully bred under laboratory conditions in Philippiness and Australia. However in India the giant clam resources have not been studied extensively. There is growing interest in several Pacific islands countries, Austrialia and Philippiness to develop giant clam culture. Culture of clams, in India is still in the experimental stage. *A granosa* cultured in the Kakinada Bay gave a production of 39.0-41.6 t/ha/5-5$^{1}/_{2}$ months. Considering the extensive clam resources availability along the Indian coasts there is vast potential for developing commercial clam culture in the next few years.

### 4.5 **Top shell** (Trochus niloticus Linnaeus)

The gastropod *Trochus niloticus* (fig 14 A) also known as the top shell occurs in the Andaman and Nicobar group of Islands. This is used widely in the shell craft industry for making buttons and art objects. The flesh is also eaten.

#### Distinctive characters

This belongs to the family Trochidae. The shell is conical or pagoda-like. On the surface reddish brown longitudinal bands are present.

#### Biology

*T. niloticus* feeds on the bottom deposits and fresh algal beds. The sexes are seperate and cannot be differentiated by external characters. Sexual maturity in female is reached at 9 cm length in shell diameter and in males at 6-7 cm shell diameter. Spawning takes place throughout the year with peak during or immediately after the warm season. Life-span is over 10 years when it grows upto 14 cm in shell diameter. In the Andamans the top-shell attains 5 cm shell diameter (at the base) in first year, 5-8 cm in second year and 8-10 cm in the third year.

**Culture**

Culture of *T. niloticus* has not been tried in India so far. However this is well suited for sea ranching in the A & N islands where the natural population is under heavy fishing pressure. As a conservation measure export of top shell from the country is banned.

### 4.6 Turbo shell (Turbo marmoratus Linnaeus)

This giant gastropod is also known as 'green snail'. It is distributed in the Gulf of Kutch, Gulf of Mannar, Palk Bay, Waltair, Laccadive and the Andaman Islands. The shell of the animal is widely used for making curios. The flesh which is rich in iron and calcium is also utilised for human consumption.

**Distinctive characters**

The turbo shell belongs to the Family Turbinidae. It has a thick and massive shell with a wide aperture. The outer surface is dark and motted with brown and white. The pearly lustre of the shell is clearly visible when the meat is shucked and the shell is polished.

**Biology and culture**

*T. marmoratus* feeds on benthic algae. It grows upto 18 mm. Information of biology is lacking. Culture of this species has not been tried.

## 5. SEAWEEDS

Seaweeds are marine algae which grow in estuaries, shallow seas and coastal areas where suitable substrate are available for attachment. Seaweeds are rich in trace elements and a variety of phytochemicals namely agar, carrageenan (agaroid) and algin are manufactured from seaweeds. Four groups of seaweeds namely green, brown, red and blue green algae occur along the Indian coast. Among these the most important are red algae and the species suitable for aquaculutre are *Gelidiella acerosa, Gracilaria edulis, Hypnea musciformis* and *Acanthophora spicifera* (Fig. 15).

**Distinctive characters**

### 5.1. Acanthophora spicifera (Vahl.) Beorgs

The plant is coarse with small and spinous branchlets alternately and spirally arranged, growing apex protruded, spermatangial clusters plate like.

### 5.2 Gracilaria edulis (Gmelin) Silva

Plants alternately irregularly branched, branches hardly constricted tetrasporangia surrounded by unmodified cortical cells.

### 5.3 Gelidiella acerosa (Forssk) Fieldman et Hamal

Plants tufted, winy, erect axes sparsely branched, provided with short determinate branchlets, 2-6 mm long, spirally or pinnately arranged, medulla with thick walled cells 18-30 mm diameter, tetrasporangia in swollen branchlets.

### 5.4 Hypnea musiformis (Wulf.) Lamour

Central axis clearly visible in the sectional view of mature thallus, plants irregularly branched in all directions and abundatly covered with short branchlets or ramuli, terminal portions of the branchs twisted as tendrils, tetrasporangia zonate.

**Culture**

In India only experimental culture of seaweeds has been carried out by CMFRI and other research organisations. Culture of *Gracilaria edulis* by inserting fragments of the plants in HDPE rope nets/coir rope net/nylon monofilaments have given goods results. A total production of 120 t (wet weight) was obtained in 4 harvests at a rate of 3 kg/m$^2$ of rope. *Gelidiella acerosa* was grown by tieing small fragments on coir ropes interwoven

on G.I. pipe grames and tied on to poles fixed in the inshore waters. One fold increase in weight was obtained when harvested after 75 days. At 4 m depth area 2 fold increase in biomass was obtained after 60 days. In the experimental culture carried out by CSMCRI a 33 fold increase in weight was noted after one year. *Hypnea musiformis* when cultured by the longline method gave fourfold increase in biomass after 25 days. Culture of *A. spicifera* in the inshore waters, in 1 m depth gave 2.6 fold increase after 25 days, while in ponds the gave 3.6 fold increase in weight after 45 days. The fertile bay and coastal areas of India are ideal locations for seaweed culture. Grazing by fishes was found to be major problem in the experimental cultural of seaweeds at Mandapam and Minicoy. Since seaweed culutre is simple, without any major inputs it can be taken up by small-scale fishermen as an additional source of income.

## 6. SEA CUCUMBERS

The seacucumbers are commercially important as the product, 'Beche-de-mer' processed form them is considered a delicacy. Beche-de-mer is not consumed in the country and the entire product is exported. In the coastal areas about 75 species of seacucumbers have been reported, of which six are used for processing. *Holothuria scabra* and *H. atra* are the two main species and are found in the Gulf of Mannar and Palk Bay. These species have also been reported from the Andaman and Nicobar Islands.

### Distinctive characters

*Holothuria scabra* Jaeger is black on the upper side with white or light yellow bands across the body, and the lower side is white in colour with black dots. *Holothuria atra* Jaeger is completely black all over. The body of the these animals do not disintegrate on exposure to air.

### Biology

*Holothuria scabra* are found in the region from intertidal area upto 20 m depth. The seacucumbers feed on algae, organic detritus, molluscs etc. found in the mud. The sexes are seperate and the size at first maturity for males is 210 mm and for females 213 mm. The fecundity is estimated at ten lakhs eggs. *H. scabra* is found to reach a length of 136 mm, 225 mm, 284 mm, 322 mm and 348 mm at the end of first, second, third, fourth and fifth year respectively. Grows upto 400 mm in length. In the Gulf of Mannar this species breeds twice a year, during March to May and November-December.

*Holothuria atra* inhabits dead coral reed flats or muddy patches where the depth is 1-5 m. Smaller speciments, 200-300 mm length were noted on the reef flat while larger ones, measuring, 600 mm were seen on the outer edge of the reef.

### Culture

A measure of success was achieved in the induced breeding and seed production of *H. scabra* by CMFRI. Seed measuring 20 mm length were cultured experimentally in different grow-out systems, like rectangular cage (2 x 2 ft) covered with nylon net, pens constructed from bamboo screens or in tanks fixed at the bottom of sea at a depth of one and half meters. At present seacucumber culture is not practised in the country. In view of the growing demand for Beche-de-mer in the International market, the prospects for developing seacucumber culture are bright.

### ACKNOWLEDGEMENT

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## TABLE

### Details on the biology of the clams suitable for farming in the Indian waters

| | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| **Resource** | *Anadara granosa* | *Meretrix meretrix* | *Meretrix casta* | *Paphia malabarica* | *Katelysia opima* | *Villorita cyprinoides* |
| **Location** | Kakinada Bay | Tuticorin | Mulky estuary | Mulky estuary | Mulky estuary | Vembanand Lake |
| **GROWTH** (mm) | Ist yr. 41.1<br>2nd yr. 55.3<br>3rd yr. 66.3 | 1st yr. 29.0<br>2nd yr. 48.3<br>3rd yr. 62.3 | 6 months-36.5<br>1 yr. - 42.6 | 6 months-36.3<br>9 months-43.1<br>1st yr. - 49.1 | 1st yr. 22<br>2nd yr. 31<br>3rd yr. 43 | 1st yr. 30<br>2nd yr.41<br>3rd yr. 43 |
| **Maximum length** (mm) | 72 | 91 | 55 | 65 | 43 | 50 |
| **Length at first maturity** | Male : 20 mm<br>Female : 24 mm | 21-26 mm | 11-17 mm | 20 mm | 11-20 mm | 11-15mm |
| **Spawning period** | Throughout the year | January to April<br>June to October | Throughout the year | October-February | October November | May to August<br>January to March |

The fig.1 to 9 (except 1 B and 4 B) are photocopies of the drawings given in : Fisher W. and Bianchi - G. (Eds) FAO species identification sheets for fishing purposes, Fishing Area 51, Western Indian Ocean Volume I to VI.

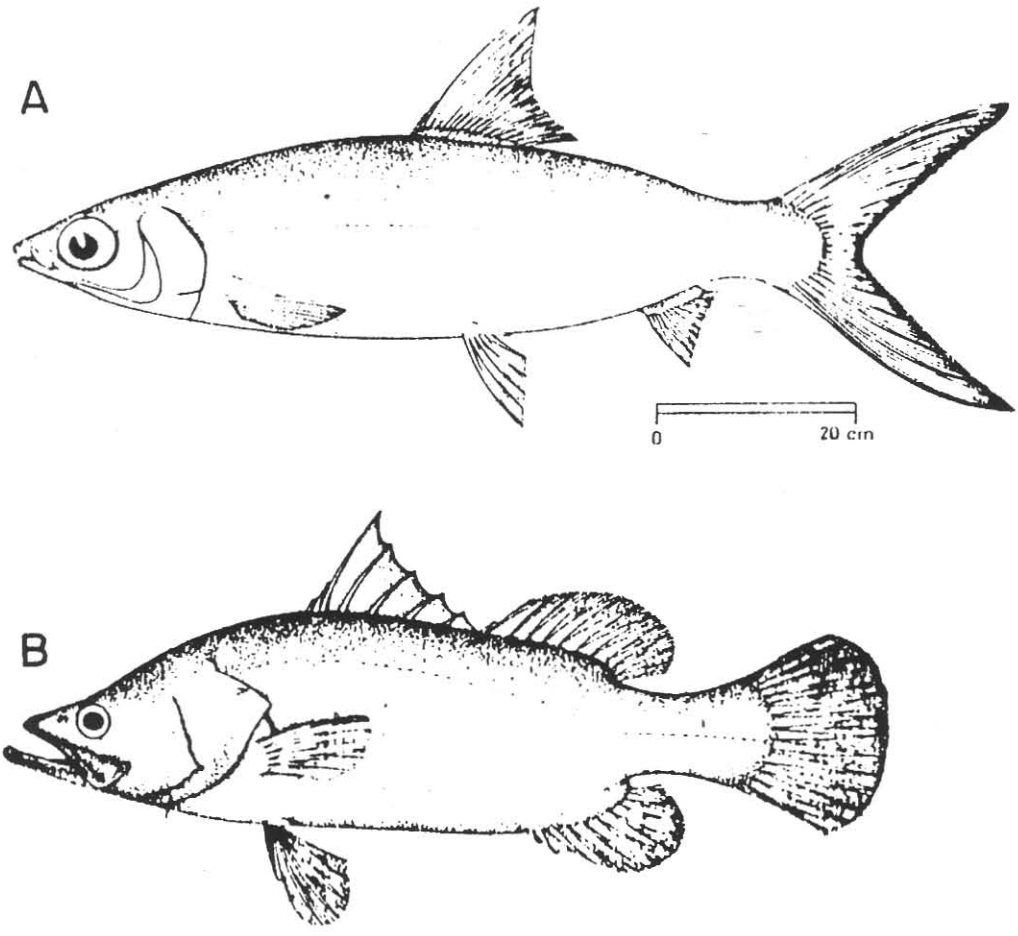


Fig. 1 A. Chanos chanos (Forsskal, 1775)

B. Lates calcarifer (Bleeker)

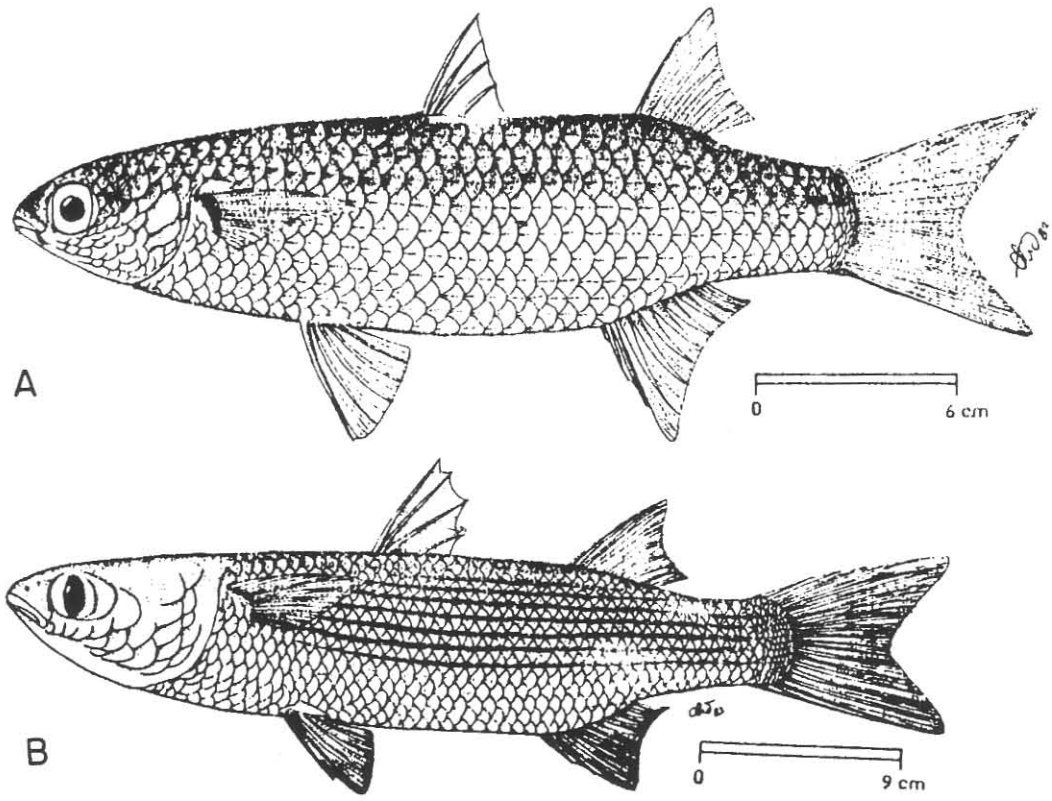


Fig.2 A. Liza macrolepsis (Smith,1849)

B. Mugil cephalus (Linnaeus,1758)

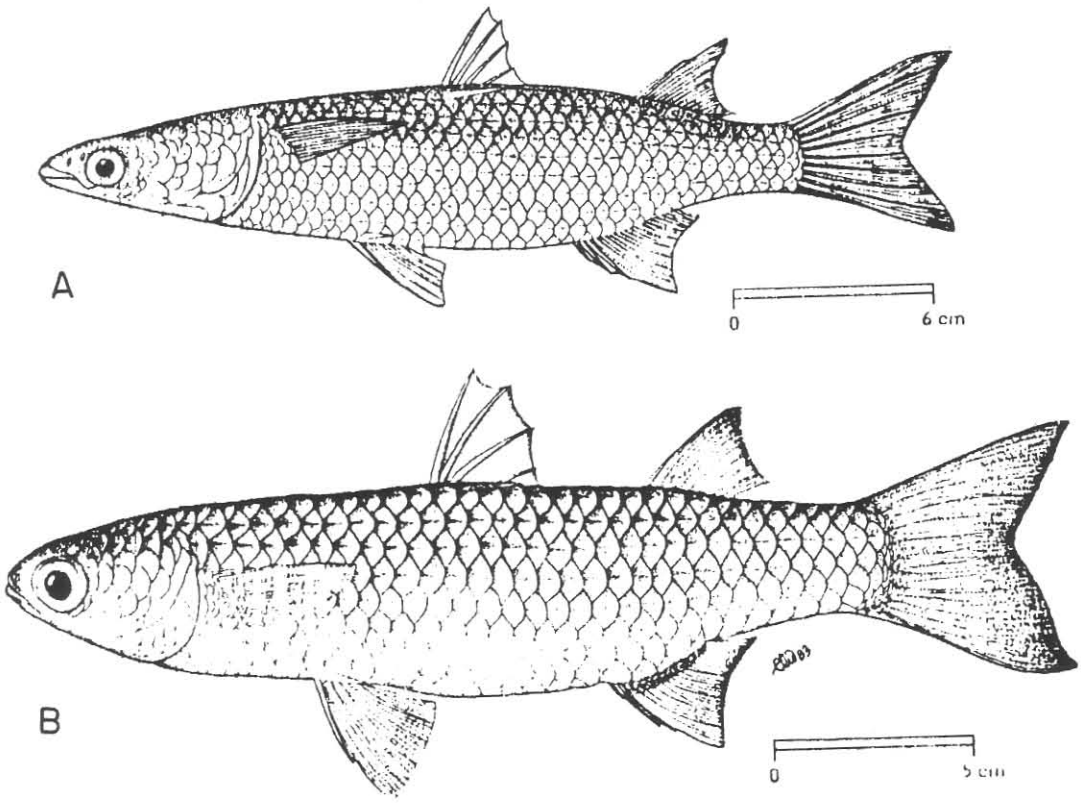


Fig.3 A. Liza tade (Forsskal,1775)

B. Liza subvirides (Valenciennes,1836)

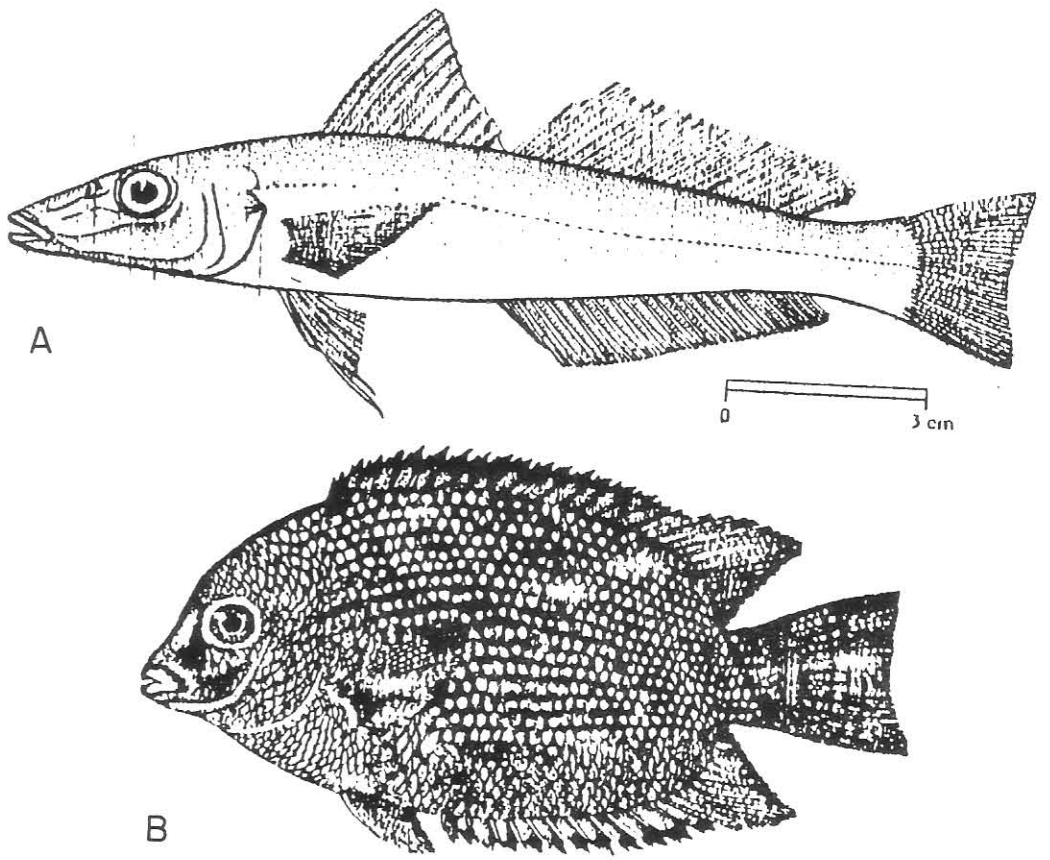


Fig.4

A. Sillago sihama, ( Forsskal,1775 )

B. Etroplus suratensis ( Bloch)

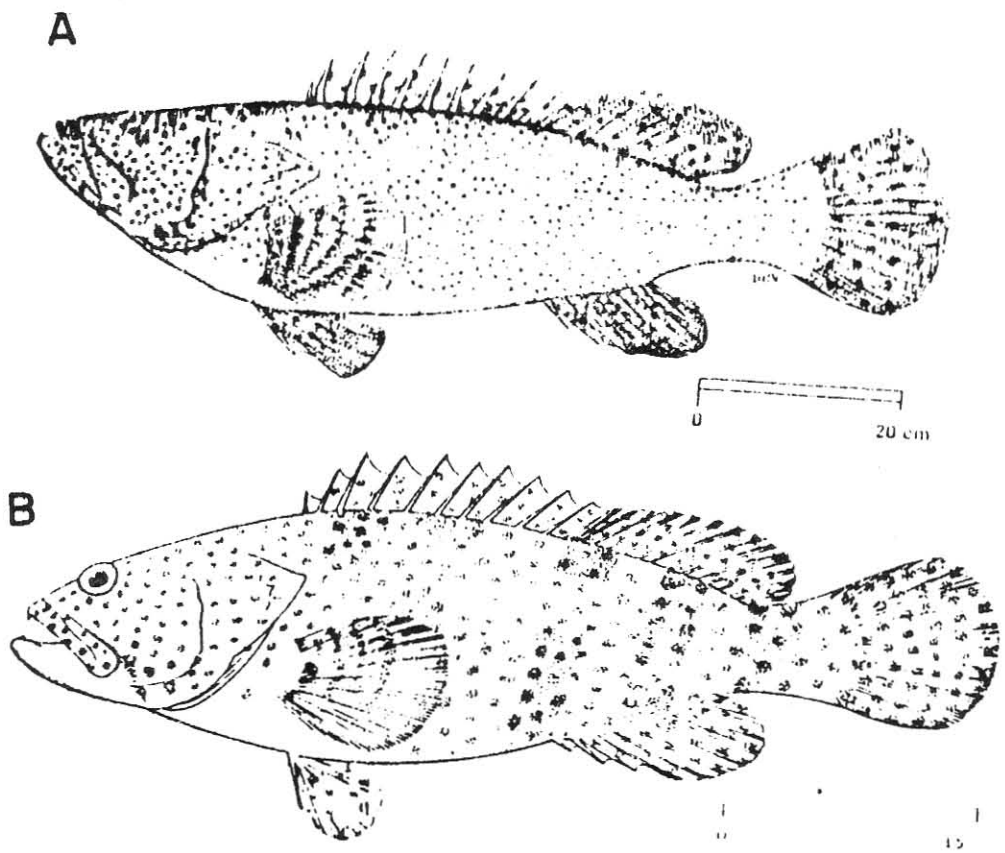


Fig. 5 A. Epinephelus malabaricus (Schneider, 1801)

B. Epinephiles tauvina (Forsskal, 1775)

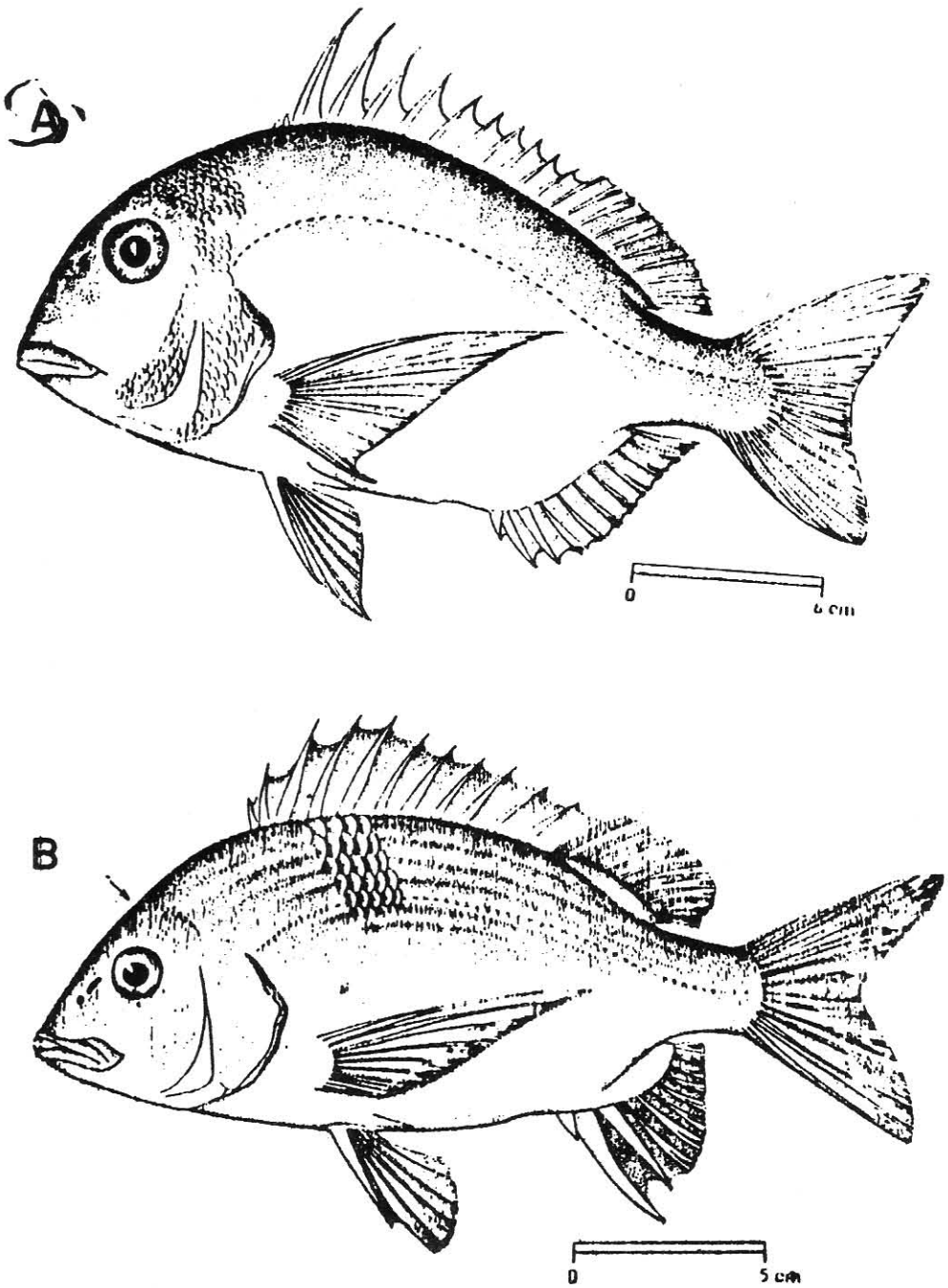


Fig. 6

A. Argyrops spinifer (Forsskal 1775)

B. Acanthopagrus berda (Forsskal 1775)

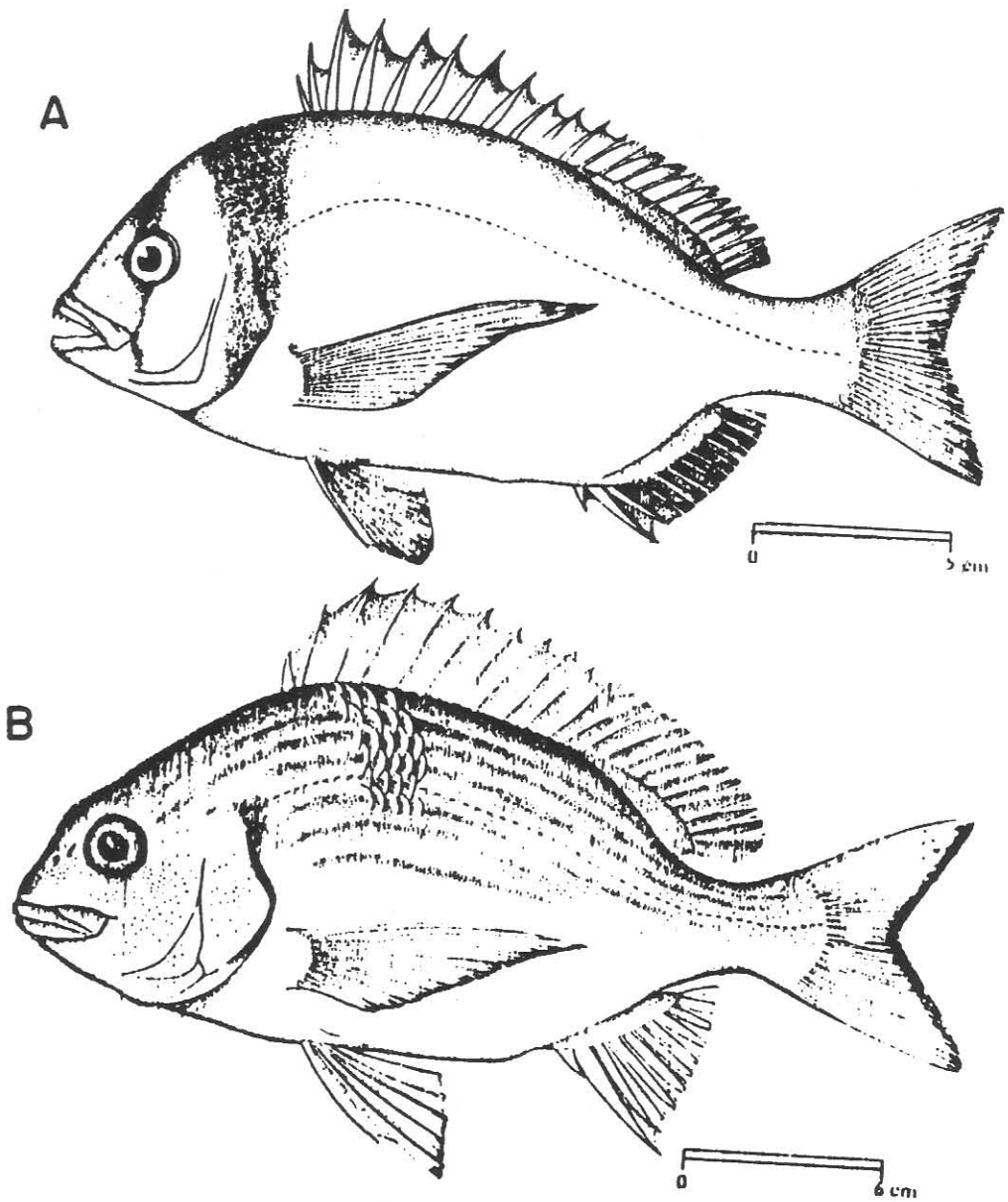


**Fig.7** A. Acanthopagrus bifasciatus (Forsskal, 1776)

B. Acanthophagus latus (Houttuyn, 1782)

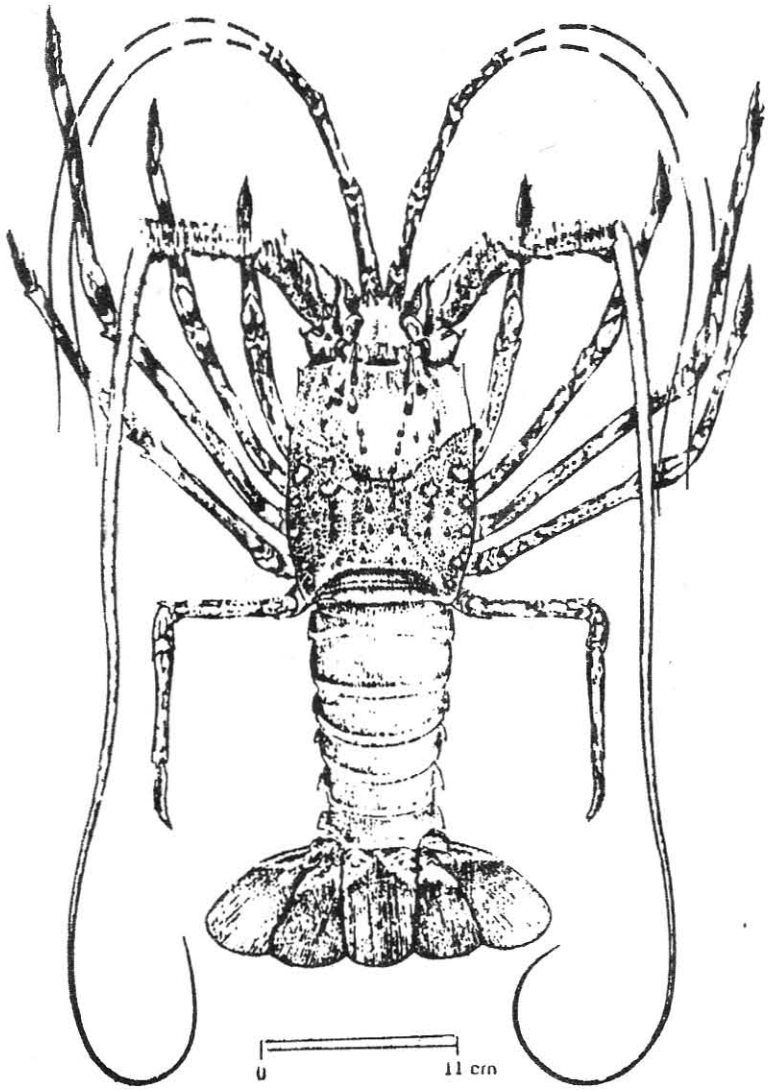


Fig.8 Panulirus polyphagus

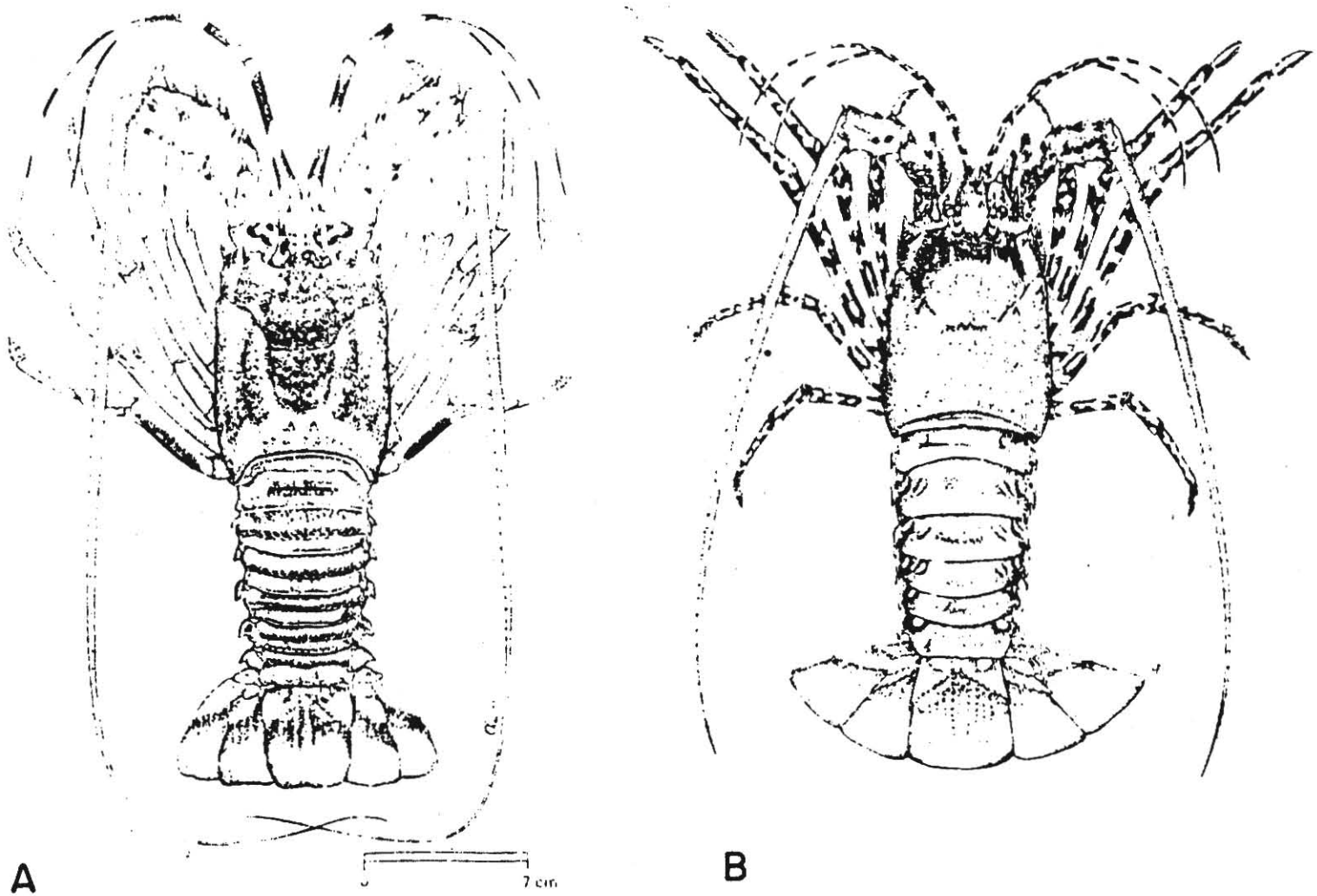


Fig.9 **Lobsters** : A. **Panulirus homarus** B. Panulirus ornatus

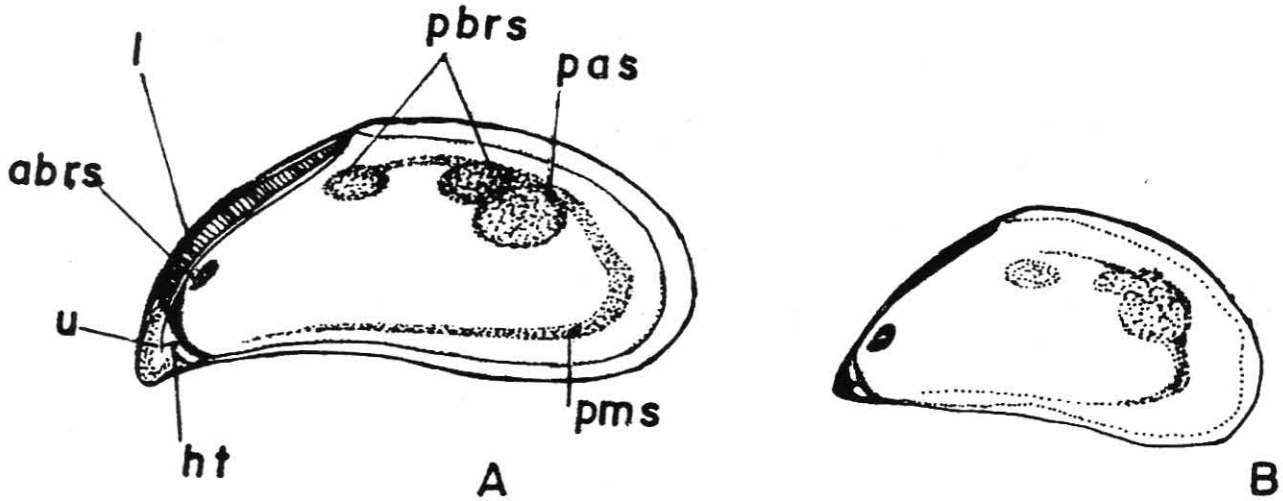


Fig.10 A. Internal view of right valve of P. viridis

B. Internal view of right valve of P. indica
ht = hinge teeth, U = umbo, abrs = anterior byssal retractor muscle scar, l = ligament pbrs = posterior byssal retractor muscle scar, Pas = posterior adductor muscle scar, Pms = patrial muscle scar

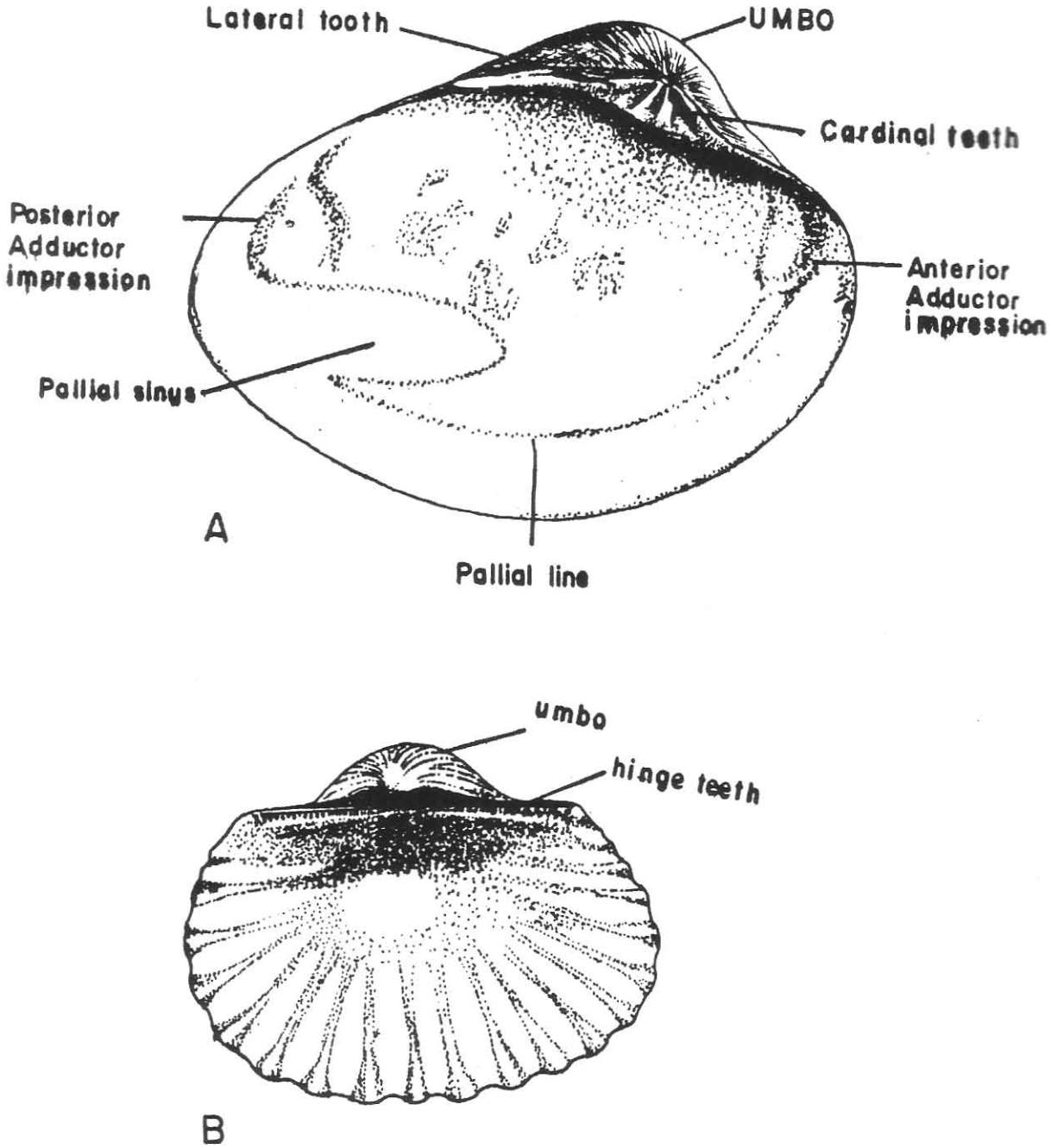


Fig. 11 (A). Inner view of the left valve of Katelysia opima (Gmelin) and (B). Anadara granosa (Right valve)

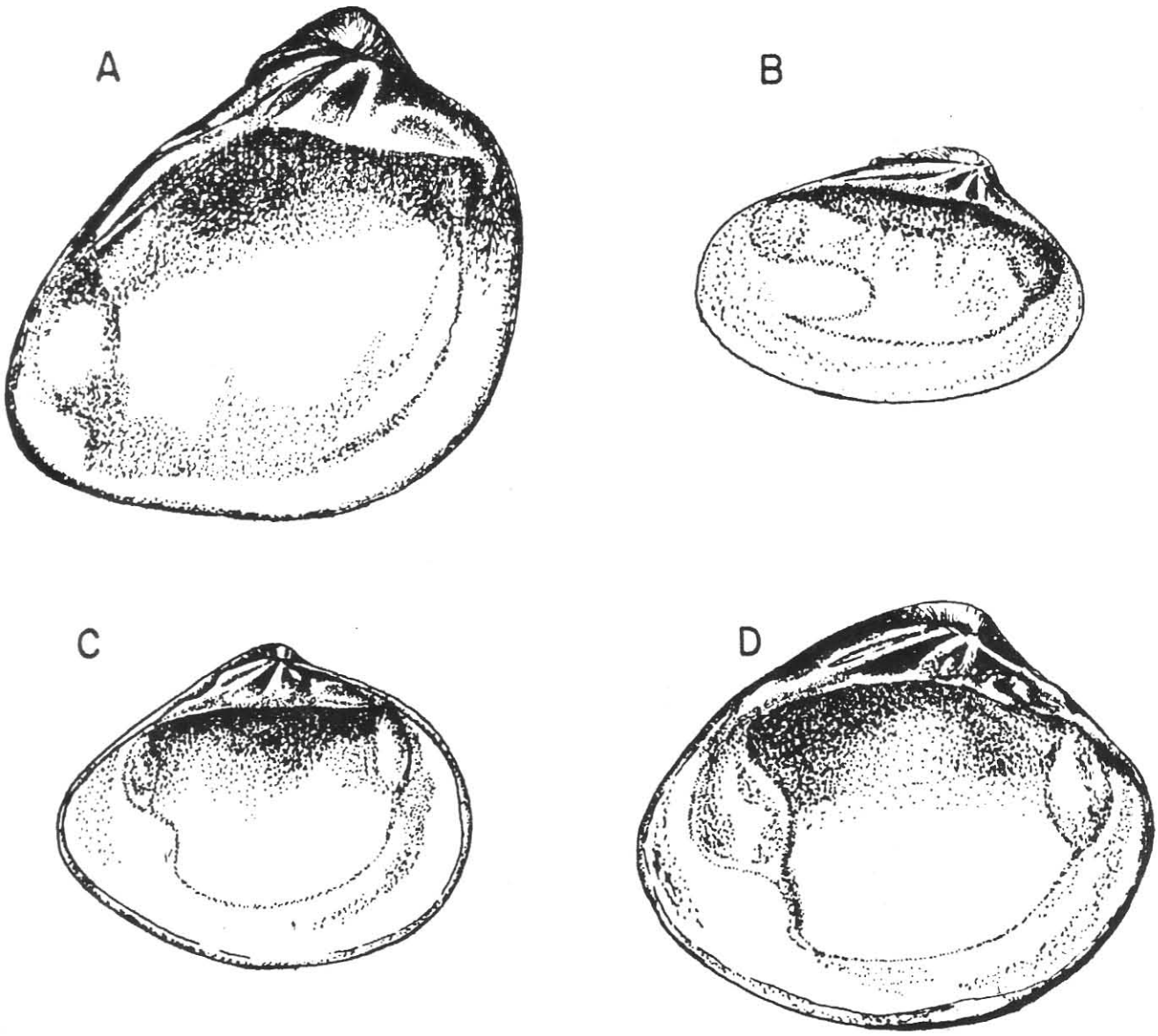


**Fig. 12** Inner view of the left valve of (A). Villorita cyprinoides (Gray), (B). Paphia malabarica, (C). Meretrix casta and (D). Meretrix meretrix

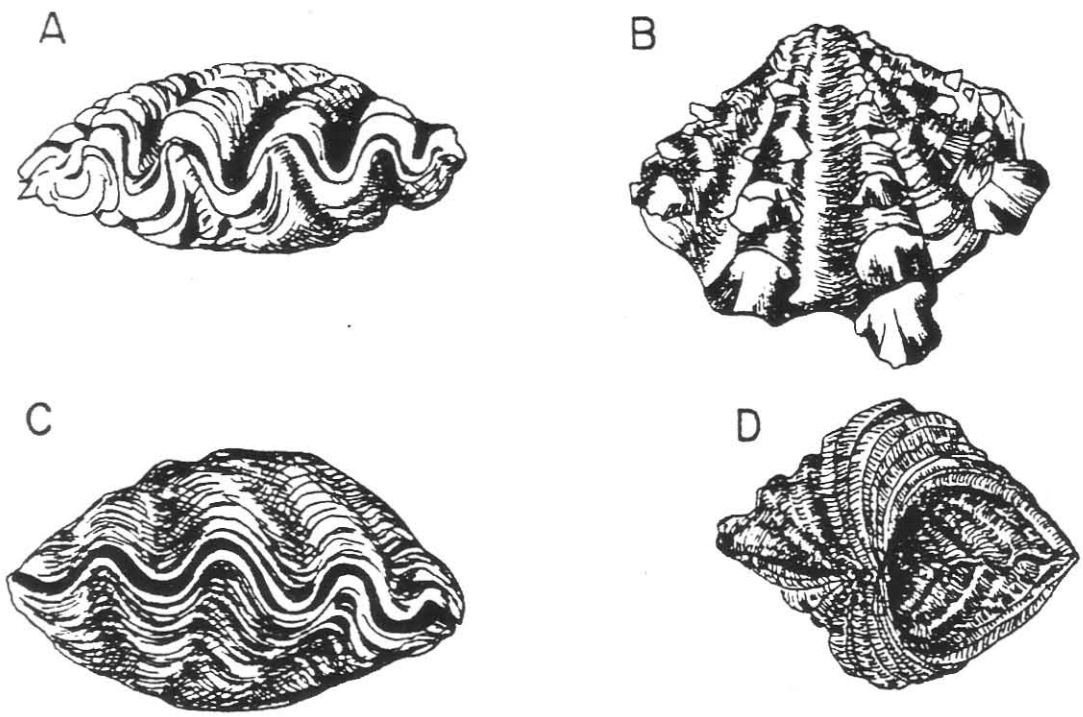


Fig. 13 External view of the shell of (A). Tridacna maxima, (B). Tridacna squamosa, (C). Tridacna crocea and (D). Hippopus hippopus

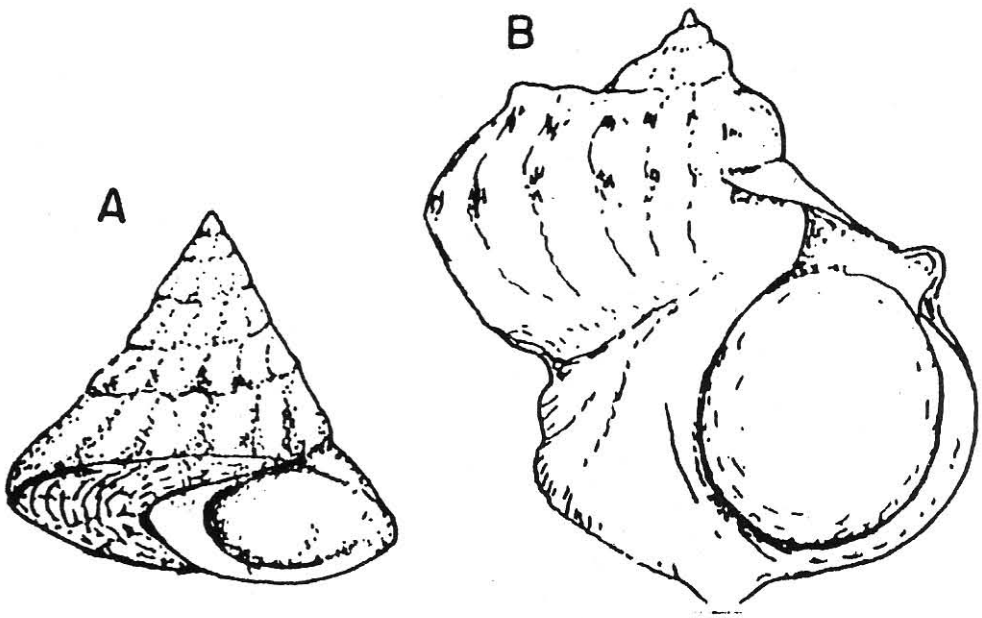


Fig.14 Gastropods : A. Trochus niloticus Linnaeus

B. Turbo marmoratus Linnaeus

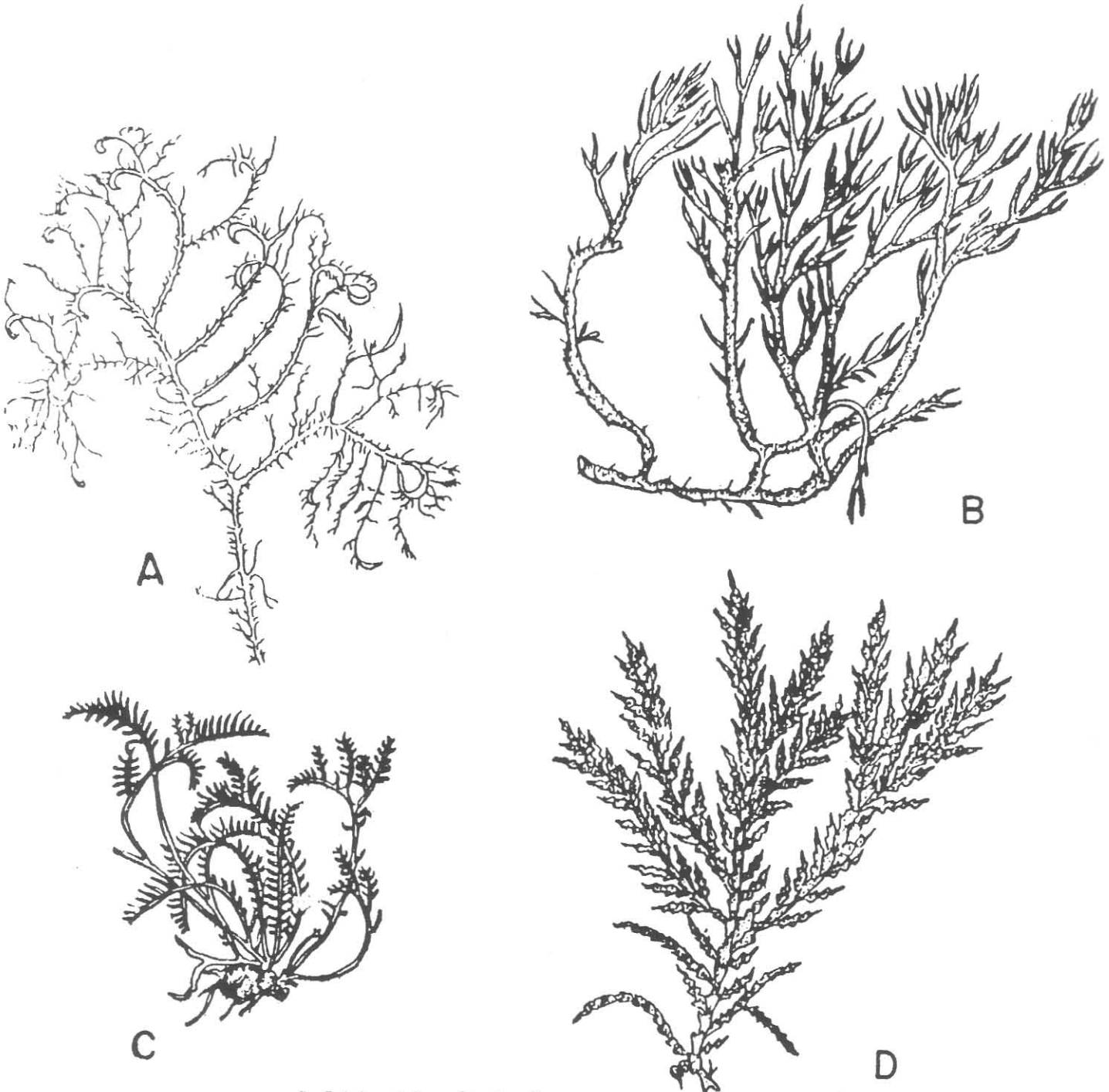


Fig.15 Cultivable Red algae

A. Hypnea musiformis
B. Gracilaria edulis
C. Acanthophora spicefera
D. Gelidiella acerosa