13

Molluscan Taxonomy

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The molluscs belong to the large and diverse phylum Mollusca, which includes a variety of familiar animals well-known as decorative shells or as seafood. These range from tiny snails, clams, and abalone to larger organisms such as squid, cuttlefish and the octopus. These molluscs occupy a variety of habitats ranging from mountain forests, freshwater to more than 10 km depth in the sea. They range in size from less than 1 mm to more than 15 m (for example the giant squid) and their population density may exceed 40,000/m^2 in some areas. In the tropical marine environment, molluscs occupy every trophic level, from primary producers to top carnivores. India has extensive molluscan resources along her coasts. In the numerous bays, brackish waters and estuaries and in the seas around the subcontinent; molluscs belonging to different taxonomic groups, such as, mussels, oysters, clams, pearl-oysters, window-pane oysters, ark-shells, whelks, chanks, cowries, squids and cuttlefish have been exploited since time immemorial for food, pearls and shells.

Three classes of the phylum Mollusca namely, Gastropoda, Bivalvia and Cephalopoda are of fisheries interest. About 3270 species have been reported from India belonging to 220 families and 591 genera. Among these the bivalves are the most diverse (1100 species), followed by cephalopods (210 species), gastropods (190 species), polyplacophores (41 species) and scaphopods (20 species). The first three orders are exploited by Indian fishermen from time immemorial. Presently over 150,000 tonnes of cephalopods, over 100,000 t of bivalves and nearly 20,000 t of gastropods are exploited from Indian waters. The importance of molluscs in the coastal economy of India is often overlooked. For example, the cephalopod fishery is now a US$ 250 million industry and is one of the mainstays of the Indian trawl fleet in terms of revenue. The bivalve exports amount to US$ 1.2 million and gastropod exports amount to US$ 1.8 million per annum.

CEPHALOPOD TAXONOMY

Cephalopods are found to occur in all the oceans of the world from the tropics to the polar seas and at all depths ranging from the surface to below 5000 m. Chambered nautilus, cuttlefishes, squids and octopus are the four major groups of cephalopods, which belong to the highly evolved class of phylum Mollusca. Cephalopods are the third largest molluscan class after bivalves and gastropods and consist of more than 800 species (Lindgren *et al.,* 2004). Of these less than a hundred species are of commercial importance. About 210 species cephalopods have been reported from India. There are about 80 species of cephalopods of commercial and scientific interest distributed in the Indian Seas.

Systematic position of potentially important cephalopods of India

Class	Cephalopoda	
Sub class	Nautiloidea	
Family	Nautilidae	*Nautilus pompilius*
Subclass	Coleoidea	
Order	Teuthoidea	
Suborder	Myopsida	
Family	Loliginidae	
Genus	*Uroteuthis*	*Uroteuthis (Photololigo) duvaucelii*
		U. (P.) sibogae

		U. (P.) singhalensis
		U.(P.) edulis
		U. (P.) chinensis
Genus	*Sepioteuthis*	*Sepioteuthis lessoniana*
Genus	*Loliolus*	*Loliolus (Loliolus) hardwickei*
		Loliolus (Nipponololigo) uyii
		L.(N.) sumatrensis
Suborder	Oegopsida	
Family	Onychoteuthidae	
Genus	*Onchoteuthis*	*Onchoteuthis banksii*
Family	Ommastrephidae	
Subfamily	Ommastrephinae	
Genus	*Sthenoteuthis*	*Sthenoteuthis oualaniensis*
Family	Thysanoteuthidae	
Genus	*Thysanoteuthis*	*Thysanoteuthis rhombus*
Order	Sepiodidae	
Family	Sepiidae	
Genus	*Sepia*	*Sepia pharaonis*
		Sepia aculeata
		Sepia prashadi
		Sepia elliptica
		Sepia trygonina
		Sepia brevimana
		Sepia arabica
		Sepia kobiensis
		Sepia prabahari

		Sepia ramani
		Sepia omani
Genus	*Sepiella*	*Sepiella inermis*
Family	Sepiolidae	
Genus	*Euprymna*	*Euprymna stenodactyla*
Order	Octopoda	
Suborder	Incirrata	
Family	Octopodidae	
Genus	*Amphioctopus*	*Amphioctopus aegina*
		Amphioctopus neglectus
		Amphioctopus marginatus
		Amphioctopus rex
Genus	*Cistopus*	*Cistopus indicus*
Genus	*Haplochlaena*	*Haplochlaena maculosa*
Genus	*Callistoctopus*	*Callistoctopus luteus*
Genus	*Octopus*	*Octopus vulgaris*
		Octopus lobensis
Genus	*Pteroctopus*	*Pteroctopus keralensis*
Family	*Argonautidae*	
Genus	*Argonauta*	*Argonauta hians*
		Argonauta argo

Classification

Cephalopods (Class Cephalopoda) are represented by two extant subclasses, Nautiloidea (Nautilus and Allonautilus) and Coleoidea, and one extinct subclass, Ammonoidea. Members of the subclass Coleoidea includes two subdivisions, the Belemnoidea, which is the primitive form of cephalopods possessing ink sac and ten equally sized arms, became extinct during the cretaceous period and Neocoleoidea (cuttlefish, squid and octopus) where the shell has been internalized and reduced, completely lost. As a

consequence, members of Neocoleoidea rarely fossilize and very few information pertaining to the origin and relationships of living coleoid cephalopods is available from the fossil record. The major division of Coleoidea is based upon the number of arms or tentacles and their structure. Presently, living coleoids can be segregated into two superorders, Decapodiformes and Octopodiformes (Berthold and Engeser, 1987). The Decapodiformes has fourth arm pair modified into long tentacles. The Decapodiformes contains two orders; the order Teuthoidea, which includes two suborders [Myopsida (closed-eye squids) and Oeopsida (open-eye squids)] and the order Sepioidea which includes families like Idiosepiidae (Pygmy squid), Sepiidae (Cuttlefish), Sepiolidae (Bobtail squids), Spirulidae (Ram's horn squid), and Sepiadariidae (Bottletail squids). The Octopodiformes includes the orders Octopoda (pelagic and benthic octopuses) and Vampyromorpha (vampire squid). Octopodiformes has modifications to second arm pair; it is drastically reduced as a sensory filament in the Vampyromorphida, while octopoda species have totally lost that arm pair. The Octopoda contains two suborders; Cirrata (deep- sea finned octopuses) and Incirrata (pelagic and benthic octopuses including the argonautiods and blanket octopuses).

Squids possess elongate, cigar-shaped body with posteroexternal fins, and eight cirumoral arms, not joined at the base with a web, with two or more rows of stalked suckers bearing chitinous rings (and/or hooks) extend the length of the mantle. They also posses two long tentacles with tentacular club of two or more rows of suckers (and or hooks) at the distal end. The cuttlefish possess a broad sac-like body with lateral fins that are either narrow and running over the entire length (Sepiidae) or are short, round and flap-like (Sepiolidae). In both cases the posterior ends of the fins are free (Sub-terminal) and separated by the posterior end of the mantle; ten circumoral appendages, the longest (fourth) pair of tentacles are retractile into pockets at the ventrolateral sides of head. The eight arms frequently bear four rows of stalked suckers with chitinous rings. Both eyes are covered with a transparent membrane; shell is thick, chalky, calcareous (cuttlebone of sepia) or thin, chitinous (Sepiolidae). Octopus possess a short, sac-like body with either no lateral fins or with separate paddle-like fins in some deep sea forms, and eight circumoral arms with no tentacles, with the bases connected by a web and un-stalked suckers, without chitinous rings, along the length of the arms (Fig.1-4)

Subclass Nautiloidea

Shell complete external, smooth, coiled and chambered, more than 10 (63 - 94) circumoral appendages without suckers, a funnel bilobed, two pairs of gills, and the absence of an ink sac.

Family Nautilidae

The ''chambered or pearly nautiluses '' comprises single family and genus and six species. They have approximately 100 sucker-less tentacles, simple eye without lenses, and thick rigid hood used to protect the animal when retracted within the shell.

Subclass Coleoidea

This subclass includes all living cephalopods – squids, cuttlefish and octopuses, other than chambered nautiluses. Key diagnostic characters are shell internal, calcareous, chitinous or cartilaginous, 8-10 circumoral appendages with suckers, only one pair of gills (dibranchiate) and funnel tube-like.

Order Teuthoidea

This order contains the squids, characterized by internal shell (gladius or pen) chitinous feather or rod shaped, eight arms; two contractile but not retractile, pocket absent, tentacles lost secondarily in some, fin on the mantle and stalked suckers with or without chitinous hooks, with horny rings and constricted necks; fin lobes fused posteriorly. Eyes either covered or open and without supplementary eyelid.

Suborder Myopsida

Myopsid squids are characterized by eyes entirely covered by a transparent corneal membrane. Eye cavity communicates with the exterior through a tiny hole. Arms and tentacles have suckers only, no hooks. Mantle locking apparatus is simple (linear) and the gladius is pen-like.

Suborder Oegopsida

Oegopsid squids (Oceanic squid or Open-eyed squids) are characterized by eyes not covered with a corneal membrane and open to the surrounding medium, arms and tentacles bear suckers and / or hooks. Mantle locking apparatus ranges from simple to complex to fused.

Family Loliginidae

***Sepioteuthis lessoniana* (Ferussac *in* Lesson, 1831)**

Body elongate, cylindrical in outline; fins marginal, wide and muscular, very long almost running along entire length of mantle; elliptical in shape.

***Uroteuthis (Photololigo) duvaucelii* (Orbigny, 1835)**

Body elongate, mid-rib of gladius clearly visible through mantle skin; fin length in adults

upto 60 per cent of mantle length; tentacular clubs large median manal sucker ring with 14 – 17 teeth; Arm sucker rings with broad, large, square teeth (5 to 9) on the distal margin; in males, more than half the length (up to 75 %) of the left ventral arm hectocotylized, papillae not fused (Fig.5).

***U. (P.) sibogae* (Adam, 1954)**

Mantle long, narrow and slender, no ridge but chromatophore concentration ventrally along midline; fins narrow and less than 60 per cent of mantle length; less than half of left ventral arm hectocotylized distally in males; gladius narrow, sharply accumulate posteriorly.

***U. (P.) singhalensis* (Ortmann, 1891)**

Mantle is long, slender, cylindrical, and it tapers posteriorly into as sharply-pointed tip. Mantle bout 4-7 times as long as wide. Mantle with a ridge along midline in males; The tentacles are short and slender. Clubs are rather short. Left ventral arm IV is hectocotylized distally in mature males for 40 - 45% of its length. The chitinous sucker rings are smooth or wavy proximally, while the distal margin bears 6-11 (most commonly 9) plate-like, truncate, squared teeth (Fig. 5).

***U. (P.) edulis* (Hoyle, 1885)**

Mantle more or less stout, elongate and slender. Fins large, rhombic with the anterior margin slightly convex, the posterior margin gently concave and the lateral angles rounded. Fins become slightly longer than wide in adult specimens (up to 70% of mantle length), Gladius long, somewhat narrow, Arms somewhat long (25- 45% of mantle). More than half of left ventral arm hectocotylized distally in males (Fig. 5).

***U. (P.) chinensis* (Gray, 1849)**

Fin length in adults greater than 60% of mantle length. Hectocotylized portion of the left arm IV from 33% to 50% of total arm length. Arm sucker rings with 10-15 stout, pointed, conical teeth distally, the proximal margin smooth; occasionally with rudimentary teeth only. Although the record of this species along the Indian east coast is available in the literature, this species is not recorded in the cephalopod samples of Institute (Fig. 5).

***Loliolus (Loliolus) hardwickei* (Gray, 1849)**

Small squids. Mantle length of adults less than 60 mm; fins heart shaped; vane of gladius conspicuously broad at midlength.

***Loliolus (Nipponololigo) uyii* (Wakiya and Ishikawa, 1921)**

Body short and stout; mid rib of gladius clearly visible through dorsal mantle skin as a median dark line; fins 55-65 per cent of mantle length; Tentacular clubs have median manal suckers with smooth rings; in males left ventral arm hectocotylized almost the entire arm; papillae on ventral margin fused with membrane.

***L. (N.) sumatrensis* (D'Orbigny, 1835)**

Body short, sub-cylindrical, gradually decrease in width posteriorly to blunt point, head small with large eyes; fins 60-65% of mantle length; fin rhomboidal in shape; arm sucker ring with 6-9 broad, squared teeth; in male left ventral arm hectocotylized upto 87%.

Onychoteuthidae

***Onchoteuthis banksii* (Leach, 1817)**

Oceanic squids with muscular body; head with nuchal folds on the dorsal side at posterior end; rachis of gladius visible as a longitudinal ridge middorsally along the entire length of mantle; tentacular clubs with two rows of hooks, marginal suckers lacking.

Thysanoteuthidae

***Thysanoteuthis rhombus* Troschel, 1857**

Funnel locking cartilage shaped consisting of a narrow longitudinal groove and a short transverse groove branching from it medially. Fins broad and rhombus-shaped occupying nearly entire length of mantle.

Ommastrephidae

***Sthenoteuthis oualaniensis* (Lesson, 1830)**

Funnel and mantle cartilages of the locking apparatus fused together. An oval photophoric patch present middorsally near anterior margin of mantle; muscle of mantle ventrally without embedded light organs; two intestinal photophores present.

Order Sepioidea

This order includes the cuttlefishes, characterized by an oval body shape, compressed dorsoventrally and framed along both sides of the body by narrow fins that do not attach at the posterior end. The arms bear 2 to 4 rows of suckers. The tentacles are totally retractile into pockets. The internal shell, cuttlebone (calcareous) lies dorsally in the body below the skin. The shell is oval in shape, thick, containing several gas and water filled chambers for buoyancy control.

Family Sepiidae

Small to medium- sized animals characterized by an oval body; flattened dorsoventrally, calcareous internal shell, head free from dorsal mantle, Fins marginal and narrow, light organ absent.

Family Sepiolidae

Small animals characterized by saccular body, wide, round bottomed; fins circular; internal shell lacking; dorsal mantle and head united by a nuchal commissure; saddle-shaped light organ present on ink sac.

Genus Sepia

Body without a glandular pore at posterior extremity; cuttlebone mostly with a spine (rostrum) at posterior end.

***Sepiella inermis* (Van Hasselt, 1835) (*in* Ferussac and d' Orbigny, 1834 – 1848)**

Body with a distinct glandular pore at posterior extremely on ventral side; with brownish fluid oozing out; cuttlebone devoid of spine.

***Sepia pharaonis* (Ehrenberg, 1831)**

Body robust, fins broad commencing from edge of anterior mantle margin; tentacular clubs moderately long and well expanded; 5 or 6 suckers in middle row of manus greatly enlarged; cuttlebone broad, thick and with a midventral flattening anteriorly in striated area; striae ' Λ' shaped; inner cone forms a conspicuous yellow flat ledge; a sharp thick spine present; when alive, body brownish, tiger-stripe pattern prominent.

***Sepia aculeata* (Van Hasselt, 1835) (*in* Ferussac and d' Orbigny, 1834 – 1848)**

Tentacular clubs very long, with 10-14 rows of minute sub-equal suckers. Cuttlebone broad and thick with a median longitudinal edge with a faint groove running medially on striated area; inner cone forms a ledge-like callosity (Fig. 6).

***Sepia prashadi* (Winckworth, 1936)**

Body not robust, fin narrow commencing a few mm behind edge of anterior mantle margin; tentacular clubs short, expanded; not more than 3 suckers in middle row of manus greatly enlarged; cuttlebone narrow, midventral groove narrow and distinct, striae anteriorly broadly truncate with lateral corners slightly produced forward; dorsal surface pinkish in colour, a sharp thin spine present; When alive, dusty brownish, transverse stripes less distinct.

***Sepia elliptica* (Hoyle, 1885)**

Tentacular clubs moderately long, with 10 rows of small suckers of uniform size. Cuttlebone thin, elliptical in shape, dorsal surface smooth; two conspicuous lateral ridges more prominent anteriorly resulting in three longitudinal furrows in striated area; spine thick, sharp, long and well curved.

***Sepia trygonina* (Rochebrune, 1884)**

No fleshy projections on head; fins extend upto end of mantle; tentacles with short clubs, suckers in eight rows, about five in third row enlarged. Cuttlebone lanceolite with acuminate anterior tip with edges of outer cone winged giving an arrow head appearance; spine small.

***Sepia brevimana* (Steenstrup, 1875)**

Tentacular club short with 6-8 small subequal suckers. Cuttlebone flat and distinctly acuminate anteriorly, dorsal surface rugose, a shallow median groove in the striated area, the striae 'Λ' shaped with a median shallow groove broadening anteriorly; inner cone and its limbs pinkish in colour; spine small, sharp and slightly curved.

Onychoteuthidae

***Onchoteuthis banksii* (Leach, 1817)**

Oceanic squids with muscular body; head with nuchal folds on the dorsal side at posterior end; rachis of gladius visible as a longitudinal ridge middorsally along the entire length of mantle; tentacular clubs with two rows of hooks, marginal suckers lacking.

Thysanoteuthidae

***Thysanoteuthis rhombus* (Troschel, 1857)**

Funnel locking cartilage shaped consisting of a narrow longitudinal groove and a short transverse groove branching from it medially. Fins broad and rhombus-shaped occupying nearly entire length of mantle.

Ommastrephidae

***Sthenoteuthis oualaniensis* (Lesson, 1830)**

Funnel and mantle cartilages of the locking apparatus fused together. An oval photophoric patch present middorsally near anterior margin of mantle; muscle of mantle ventrally without embedded light organs; two intestinal photophores present.

Order Octopoda

This order includes all octopuses, described by eight arms with 1 or 2 rows of suckers. Most species have web sectors between the arms.

Sub-order Cirrata

Finned or Cirrate octopods are deep sea octopuses characterized by round to tongue-like fins on the mantle and single rows of suckers interspersed by cirri. Mantle aperture is very narrow. Only the left oviduct is developed

Sub-order Incirrata

Incirrate octopuses are characterize by fins lacking, and have 1 or 2 rows of suckers and no cirri.

Family Argonautidae

This family of pelagic octopuses is known as paper nautiluses or Argonauts, the females of which secrete an external shell. This calcareous external shell is brittle and white in colour with fine corrugations. The male is much smaller than the female. Male lacks the external shell and possesses a large modified third left arm which is detached during mating.

Family Octopodidae

This family includes tiny to very large benthic octopuses characterized by eight arms with 1 or 2 rows of sessile suckers and modified third right arm in males, without an external shell; internal shell either vestigial or lacking; no great disparity between males and females in size.

***Amphioctopus aegina* (Gray, 1849)**

Eyes prominent; a single large cirrus posterior to each eye. Ligula small, 5 to 8 per cent of arm; with shallow groove; penis and diverticulum together form U-shaped loop; spermatophores long and unarmed (Fig. 7).

***Amphioctopus neglectus* (Nateewathana and Norman, 1999)**

Medium-sized species characterized by elongate and ovoid body, U-shaped iridescent transverse bar on the head between the eyes, Dark ocellus including blue ring present at base of 2nd and 3rd arm pair, Head relatively wider in males than in female, 1 or 2 papillae present over each eye. Ligula long and slender (Fig. 8).

***Cistopus indicus* (Rapp, 1835 in Ferussac and d' Orbigny, 1834 – 1848)**

Hectocotylized arm only slightly modified, ligula small about 3 per cent of arm. Small water pores leading to embedded pouches between bases of arms (Fig. 9).

***Haplochlaena maculosa* (Hoyle, 1883)**

Body globular smaller in size; skin smooth without reticulate pattern; white fresh dusty brown in colour with prominent bluish rings on mantle, head, web and arms.

BIVALVE TAXONOMY

There are about 10,000 living bivalve species. The bivalve as the name implies, possesses two valves (shells) lying on the right and left sides of the body. Bilateral symmetry is a characteristic feature. The shell is mostly composed of calcium carbonate. Umbo is the first formed part of the valve and is above the hinge. The soft body of the bivalve is covered by the mantle comprising two lobes. The foot is muscular and is ventral. Byssus is a clump of horny thread spun in the foot and helps the sedentary bivalve to attach to hard substrates. In bivalves head is absent. Many bivalves possess a pair of gills, which are respiratory in function and produce water currents from which food is collected (Poutiers, 1998).

Distinctive characters of commercially important species

Mussels

The genus *Perna* (family Mytilidae) is characterized by the absence of anterior adductor muscle, occurrence of one or two well developed hinge teeth, partition of the crystalline sac from the mid-gut, broad partition of the two posterior byssal retractors etc. In India, there are two species of commercially important mussels *viz*. the green mussel (*Perna viridis)* and the brown mussel (*Perna Indica)* contribute to the fishery (Fig. 10).

Perna indica

The outer surfaces of the shell valve and mantle margin are respectively dark brown and brown in colour. Anterior end of the shell is pointed and straight. Ventral shell margin is more or less straight. Middle dorsal margin has a distinct angle/lump while posterior margin is broadly rounded. One large hinge teeth on the left valve and a corresponding depression on the right valve, foot is tongue shaped with byssal threads.

Perna viridis

The outer shell surfaces and mantle margin are respectively green and yellowish green in colour. Shell is large, elongate sub-trigonal. Anterior end of the shell is pointed with the

beak turned down. Ventral shell margin is slightly concave. Middle dorsal margin is angularly convex while posterior margin is broadly rounded. Two small hinge teeth on the left valve and one on the right valve, foot is tongue shaped with byssal threads.

Commercially important bivalves of India

Resources	Common English name	Local name
Clams and Cockles		
Villorita cyprinoides	Black clam	Karutha kakka,(Ma)
Paphia malabarica, Paphia sp.	Short neck clam, textile clam	Manja kakka (Ma), Chippi kallu (Ka), Tisre (Ko)
Meretrix casta, Meretrix meretrix	Yellow clam	Matti (Ta)
Mercia opima	Baby clam	Njavala kakka (Ma), Vazhukku matti (Ta)
Mesodesma glabaratum		Kakkamatti (Ta)
Sunetta scripta	Marine clam	Kadal kakka (Ma)
Donax sp.	Surf clam	Mural, Vazhi matti (Ta)
Geloina bengalensis	Big black clam	Kandan kakka (Ma)
Anadara granosa	Cockle	Aarippan kakka (Ma)
Placenta placenta	Window pane oyster	
Tridacna sp, Hippopus hippopus	Giant clam	Kakka (Ma)

Mussel		
Perna viridis	Green mussel	Kallumakkai, Kadukka(Ma) Alichippalu (Te)
Perna indica	Brown mussel	Kallumakkai, Chippi (Ma)
Pearl oyster		
Pinctada fucata	Indian pearl oyster	Muthu chippi, (Ma, Ta)
Pinctada margeritefera	Blacklip pearl oyster	Muthu chippi (Ma, Ta)
Edible oysters		
Crassostrea madrasensis	Indian backwater oyster	Kadal muringa (Ma); Ali, Kalungu (Te) ; Patti (Ta)
Saccostrea cucullata	Rock oyster	Kadal muringa (Ma); Ali, Kalungu (Te) ; Patti (Ta)
Ka – Kannada, Ko – Konkani, Ma- Malayalam, Mr – Marati, Ta- Tamil, Te- Telugu		

Pearl oysters

Taxonomy

The pearl oyster belongs to the family Pteriidae. This group is characterized by a straight hinge with 1-2 small tooth-like thickening, a cavity below the anterior angle for the byssus and usually a scaly surface of the outer shell valves. The family comprises two commercially important genuses viz. *Pinctada* spp. and *Pteria* spp. (Fig. 11).

In *Pteria* spp., the shell width is much longer than the height and the hinge angle is prominent and pronounced. In *Pinctada* spp., the hinge is rather long and straight, the long axis of the shell is not at right angle at the hinge, the left valve is usually deeper than the right and there is a byssal notch on each valve at the base of the anterior lobe. The colouration of periostracum is changeable and is often brownish with radial markings.

In Indian waters, six species of pearl oysters viz. *Pinctada fucata* (Gould), *P. margaritifera* (Linnaeus), *P. chemnitzii* (Philippi), *P. sugillata* (Reeve), *P. anomioides* (Reeve) and *P. atropurpurea* (Dunken) have been reported.

***Pinctada fucata* (Gould)**

The hinge is nearly as wide as the width of the shell, left valve is deeper than the right, byssal notch slit-like, left valve greatly convex, posterior ear well developed with fairly developed sinus, anterior margin of shell just far in advance in front of anterior ear. Hinge teeth are present in both valves, one each at the anterior and posterior ends of the ligament. The anterior ear is larger than in the other species. The posterior ear is fairly well developed. The outer surface of the shell valves with 6 - 8 radial bands of reddish brown on a pale yellow background. The nacreous layer is thick and has a bright golden, pink or ivory colour with metallic lustre. The non-nacreous margin on the inner surface of valves has reddish or brownish patches.

Pinctada margaritifera (Linnaeus)

The anterior margin of the shell extends in front of the anterior lobe. The anterior ear is well developed whereas the posterior ear and sinus are absent. The byssal notch is broad. The hinge is shorter than the width of the shell and is devoid of teeth. Left valves are moderately convex. The posterior end of the shell meets the hinge almost at a right angle. The outer shell is dark graying-brown with greenish tinge and radially distributed white spots. The nacreous layer is iridescent with a silvery sheen colour and the non-nacreous margin is black colour. Due to the dark marginal colouration of the shell, this pearl oyster is also known as the Black-lip pearl oyster.

Pinctada chemnitzii (Philippi)

The shell is very comparable to that of *P. fucata* with the exception of very less convexity of valves and better developed of posterior ear. The hinge is almost as long as the antero-posterior measurement of the valves. The anterior ear is well developed and the byssal notch is slit-like. Hinge teeth of the anterior and posterior are present, the former is minute and rounded and the latter prominent and ridge-like commencing a little in advance of the posterior area of the hinge ligament. The posterior ear and the posterior sinus are well developed. The outer shells are yellowish externally with about four or more light brownish radial markings. The growth lines of the shell are broad. The nacreous layer is bright and lustrous and the non-nacreous layer is brownish.

Pinctada sugillata (Reeve)

The hinge is noticeably shorter than the anterio-posterior axis of the shell. The antero-posterior measurement is approximately equal to the dorso-ventral measurement. The anterior ear is small and the byssal notch is a fairly wide slit-like. The anterior ears are somewhat bent towards the right. The posterior ear and sinus are poorly developed. The

convexity of the valves is not prominent, especially that of the right valve. The anterior hinge teeth are small and roundish and the posterior one is slightly elongated. The shell valves are dark grey with a tinge of brown with six yellowish radial markings. The lower or posterior regions of valves are light yellow and gray.

Pinctada anomioides (Reeve)

The hinge is shorter than the width of the widest region of the antero-posterior axis of the shell. The hinge and dorso-ventral axis have a ratio of 1:1.4. Hinge teeth are absent or poorly developed. The anterior ear is moderately developed and the byssal notch at its base is deep. The posterior ear and sinus are absent. The outer shell valves are yellowish or grayish with faint radial markings. The nacreous layer is well developed.

Pinctada atropurpurea **(**Dunker)

The shell is roundish with its hinge narrow. The valves are thin, translucent and moderately convex. The nacreous layer is thin and the byssal notch is deep. A poorly developed anterior hinge tooth may be present in some oysters. Externally the shell valves are copper coloured.

Edible oysters

Edible oysters belonging to the family Ostreidae and are found in hard substratum in the bays and creeks near coastal waters. They are attached permanently to the substratum.

Taxonomy

In Indian waters, six species of oysters are reported. They are the Indian backwater oyster *Crassostrea madrasensis* (Preston), Chinese oyster *C. rivularis* (Gould), West coast oyster *C. gryphoides* (Schlotheim), Indian rock oyster *Saccostrea cucullata* (Born), Bombay oyster *Saxostrea cucullata* (Awati and Rai) and the giant oyster *Hyostissa hyotis* (Linnaeus).

Crassostrea madrasensis (Preston)

Shell valves are irregular in shape usually straight/elongate. Shell valves are covered by numerous foliaceous laminae. Left valve is deep while right one slightly concave. Hinge is narrow and elongated. Adductor muscle scar is kidney-shaped and sub central; dark purple in colour. Inner surface of valve is white, glossy and smooth with purplish black colouration on the inner margin.

C. gryphoides (Schlotheim)

Shell valves are elongate and thick. Shell is oblong, narrow in the anterior margin and broader in the posterior margin, laminated, lower valve very thick, especially in the

anterior region below the ligamental area. Adductor muscle scar is broad, more or less oblong or heart shaped and pearly white with striations on the scar are absent or unclear. Upper valve thin flat and opercular, no denticles on the margin. Left valve is cup-like. Hinge region is well developed and has a deep median groove with lateral elevations.

C. rivularis (Gould)

Shell valves large, roughly round, flat, thick and with a shallow shell cavity. Left valve is thick and slightly concave and the right one is about the same size or slightly larger. Adductor muscle scar is oblong and white or smoky white in colour.

Saccostrea cucullata (Born)

Shell more or less trigonal, sometimes oblong, extremely hard and pearshaped. The margins of the valves have well developed angular folds sculptured with laminae. Small tubercles present along the inner margin of the right valve and there are corresponding pits in the left valve. Adductor muscle scar is kidney shaped.

Clam

In Indian waters, a number of species coming under the families viz. Veneridae, Arcidae, Tridacnidae, Corbiculidae, Solenidae, Mesodesmatidae, Donacidae and Tellinidae are exploited from the time immemorial. The cultivable species by and large fit in to the first four aforementioned families (Fig. 14).

Arcidae

Commercially important species under this family is represented by single species, *Anadara granosa*. It is found all along the Indian coast in soft muddy substratum and forms a fishery of some magnitude in the Kakinada Bay (Fig. 15).

Anadara granosa

Shell valves are thick, inflated and dark brown. This species varies from other clams in having taxodont dentition and about 20 prominent ribs with rectangular nodules.

Veneridae

This family is characterized by the hinge with three cardinal teeth, a single anterior tooth on the left valve, and a corresponding depression on the right valve, slightly unequal sized adductor muscle scars (= 2 Nos). This group contains three importance genera, viz. Paphia, Meretrix and Marcia.

Paphia malabarica

Shell is slightly inflated, triangularly ovate and surface is concentrically grooved. The anterior and posterior margins are narrowly rounded. Hinge area is short with narrowly diverging teeth. Pallial sinus is 'U' shaped and very deep. Lunule is relatively short. Shell length is only one and one third times longer than height. The outer shell valves are yellowish brown in colour indistinctly rayed with greyish brown bands or blotched with brownish angular markings.

Villorita cyprinoides

Shell is thick, ovately triangular with strong concentric ridges. Hinge border is very short and thick, always with three oblique cardinal teeth; the anterior in the right valve and posterior in the left valve are less developed. Ridges are more strongly developed in the anterior half. Umbones are prominent and well elevated. Pallial sinus is small. Lunule is narrow and ligament is large. Shell is dark olive brown to blackish brown in colour.

Meretrix casta

Shell is thick, moderately large with a brown horny periostracum. Shell is also smooth and triangularly ovate with devoid of any sculpture. Outer surface of the valves is very fainted rayed with greyish radial lines or pale yellowish brown tinted with dark grey posteriorly.

Meretrix meretrix

Shell varies from *M. casta* in having less elongated lateral tooth, more ovate shell and larger size. Periostracum is thin and of grey or straw colour. Postero-dorsal margin of the outer shell is greyish blue or bluish brown band.

Marcia opima

Shell is thick, inflated, smooth, and triangularly ovate. Pallial line is deeply sinuate. Tip of the pallial sinus is bluntly angular. Lunule is distinct, flattened, and rather broad. Area behind the umbones is clear, flattened and deeply elongated reaching almost upto the hind margin of the shell. Outer surface of shell is pale yellowish brown or straw coloured variously blotched and rayed with purplish grey markings. The inner surface of the valve is white.

Gafrarium tumidum

Shell is thick, strongly inflated and sculptured with thick, nodular radial ribs which tend to bifurcate towards the ventral margin. The interstitial spaces between some of the main

ribs, there are secondary rows of nodules. The pallial line is full and well developed. The outer surface is white with irregular dark spots posteriorly and near the umbo.

Tridacnidae

The tridacnid clams are characterized by large massive shells with broad radial ribs, sometimes having large fluted scales. Border of valves is usually scalloped.

Tridacna crocea

Shell is large, thick, and triangularly ovate with large byssal opening. Shell valves contain 6-10 broad flattened ribs with concentric ridges. Outer shell valves are greyish white flushed with yellow or pinkish orange.

T. maxima

Shell is strongly inequilateral. The shell is similar to that of *T. crocea* except that the 6-12 broad radial ribs have better developed concentric scales. Large byssal gape with distinct plicae is at edges. Ventral border of the valve often deeply scalloped. Shell is greyish white, sometimes tinged with yellow or pinkish orange.

T. squamosa

Shell is large, thick and strongly inflated with small or medium sized byssal gape. Shell valves posses 4-12 strongly convex ribs with riblets in interspaces. Broad, sometime long fluted scales on ribs which may project beyond ventral margin noticeably. Shell is greyish white, sometimes tinged with yellow.

Donacidae

Donax cuneatus

Shell is trigonal, inequilateral. Shell possesses a curved keel extending from the umbo to the postero-ventral corner; there are sharp concentric and fine radiating ones which are conspicuous in the anterior and posterior regions only. The anterior end is broad and rounded while the posterior end is narrow and rounded. Pallial sinus is deep. The outer surface of shell is white covered with pale violet especially towards umbo and the posterior region is darker. The inner surface is of deep violet colour (Fig. 16).

Mesodesmatidae

Mesodesma glabratum

Shell is thick, inequilateral and roughly trigonal. The outer surface of shell has well developed concentric striae. The umbo is small. Hinge has two cardinal teeth and there is an anterior lateral tooth. The pallial sinus is small and angular.

Solenidae

Solen kempi

Shell is small, about six times as long as high. Anterior region is obliquely truncate while posterior region rounded. Cardinal tooth is in right valve with a shallow groove all over its breadth. Dorsal margin of soft body is somewhat concave in the anterior region and convex in the posterior region. Siphon is long and segmented. Foot is long flattened and about half the length of body. Periostracum is yellowish brown and glossy.

GASTROPOD TAXONOMY

Gastropoda is the largest molluscan class with about 35,000 extant species. The gastropods are torted asymmetrical molluscs and usually possess a coiled shell. The soft body normally consists of head, foot, visceral mass and the mantle. Among the marine gastropods, the members belonging to the subclass Prosobranchia, are of major fishery importance (Poutiers, 1998). The shell in this subclass is typically coiled with an opening at the ventral end known as aperture. The aperture is covered by operculum which closes the opening of the shell. The head normally protrudes anteriorly from the shell and bears mouth, eyes and tentacles. The foot is muscular, ventrally located with a flattened base and is used for creeping or burrowing. The visceral mass fills dorsally the spire of the shell and contains most of the organs. The mantle forms mantle cavity which lines and secrets the shell. Asymmetry of the internal anatomy of the gastropods is due to twisting through 180^{o} called the `torsion' which takes place during the first few hours of larval development (Fig. 17).

Classification

Gastropods classification based on different morphological and anatomical features of their bodies and shells has come across several problems. During the 19th century, researchers were proposed several different classifications of the Gastropoda based on the place of the mantle cavity or on the array of various organs and shape of the shells. By and large, all these classification methods used only a restricted number of distinctive characters. At the start of the 20th century, the German researcher, Johannes Thiele (1929 - 1935), put together earlier classifications and proposed Thiele's system of classifications which was used by zoologists for most of the century. He divided the gastropods into three subclasses: Prosobranchia, Opisthobranchia, and Pulmonata. Besides, the Prosobranchia were divided into three orders: Archaeogastropoda, Mesogastropoda, and Neogastropoda.

During current decades, accumulation of numerous new data on the morphology and anatomy of various gastropod groups due to the application of new methods for instance, transmission electron microscopy etc. and finding of new gastropod groups with strange anatomical features in the deep sea region associated with hydrothermal vents have revealed a need for the revision of existed classification. Recent analyses of these characters of existing gastropods have led to a new classification method, which have been supported by outcome from molecular phylogenetics.

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Suggested reading

Jereb, P and Roper, C.F.E. 2005. Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Volume 1. Chambered nautilus, and sepioids. FAO Species Catalogue for Fishery Purposes. No. 4, Vol. 1. Rome, FAO. 262p.

Jereb, P and Roper, C.F.E. 2010. Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Volume 2. Myopsid and Oegopsid squids. FAO Species Catalogue for Fishery Purposes. No. 4, Vol. 2 Rome, FAO. 605p.

Jereb, P, Roper, C.F.E., Norman, M.D. and Julian K. Finn 2014. Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Volume 3. Octopods and Vampire squids. FAO Species Catalogue for Fishery Purposes. No. 4, Vol. 3. Rome, FAO. 370p.

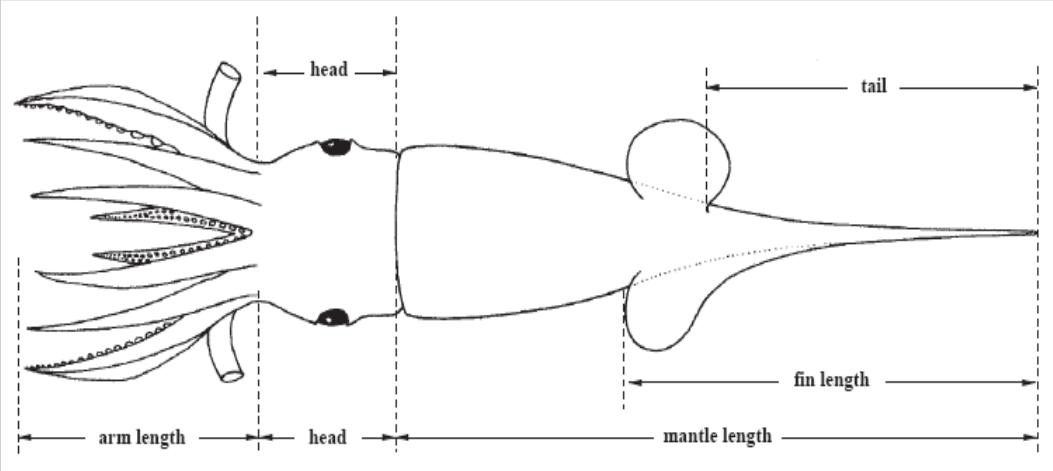


Fig.1. *External morphology of squid*
(Source: Jereb and Roper, 2010)

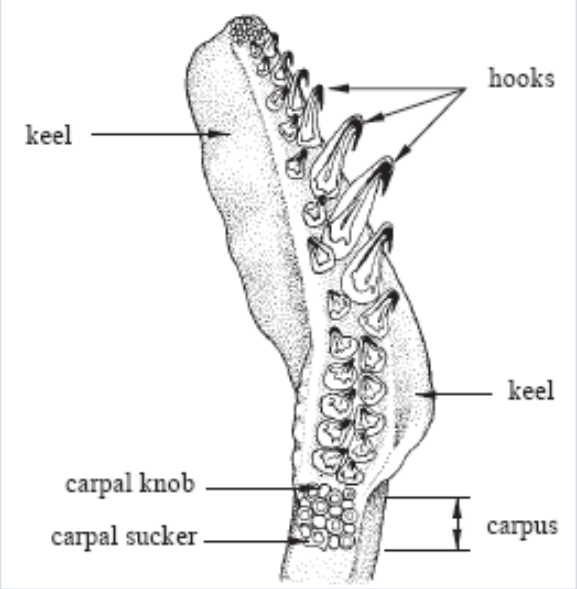


Fig. 2. *Tentacular club of squid*
(Source: Jereb and Roper, 2010)

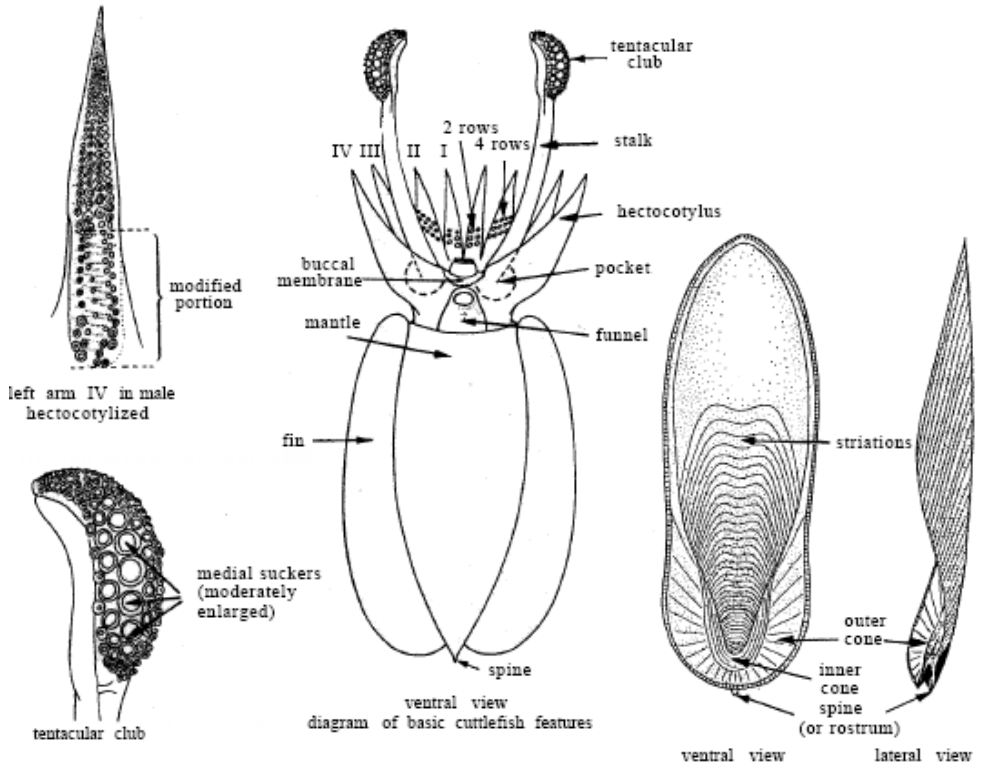


diagram of basic cuttlefish features

Fig. 3. External features of cuttlefish (Source: Roper and Nauen, 1984

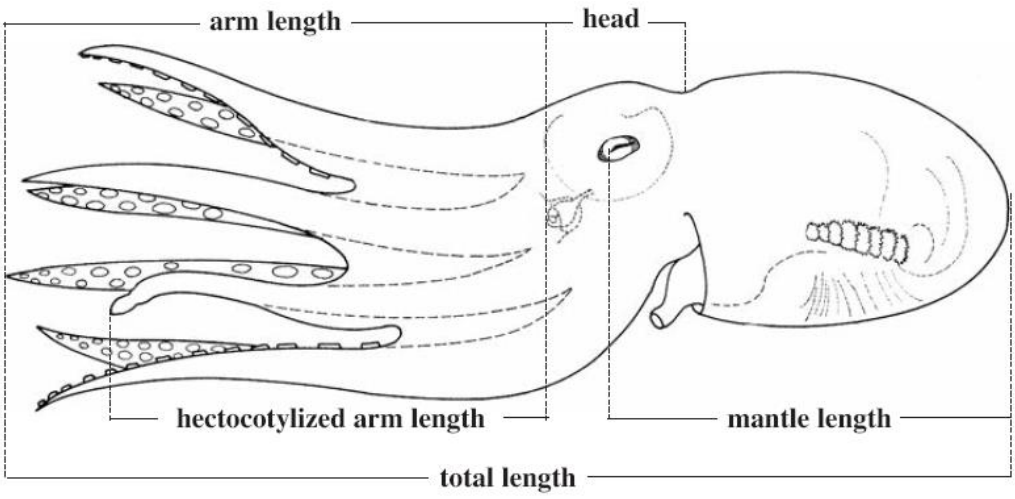
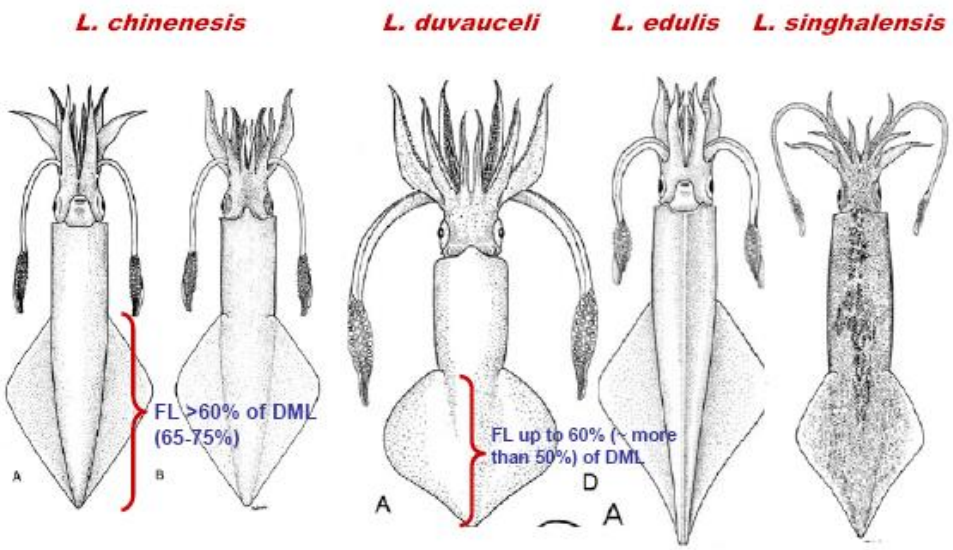


Fig. 4. *External morphology of octopus* (Source: Jereb et al., 2014)

Squids



Arm III Sucker Ring

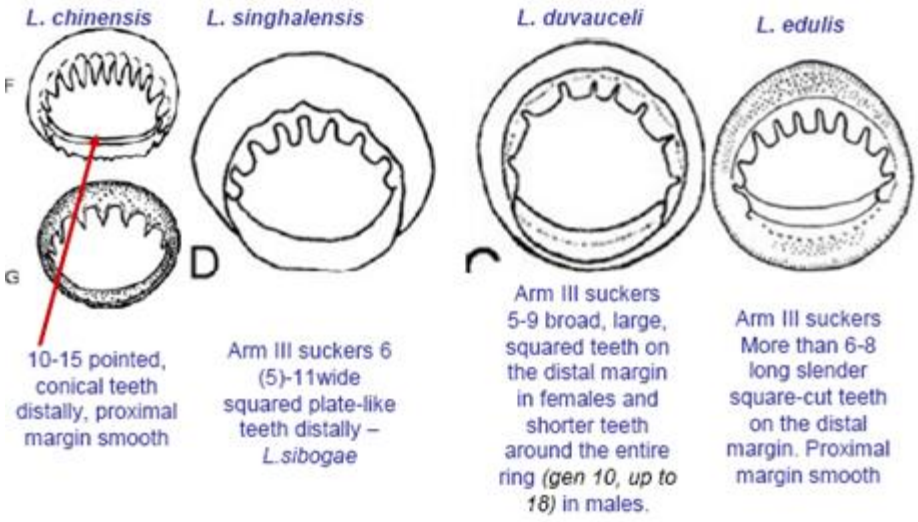


Fig. 5. ***Keys to identify commercially important squids***
(Source: Jereb and Roper, 2006)

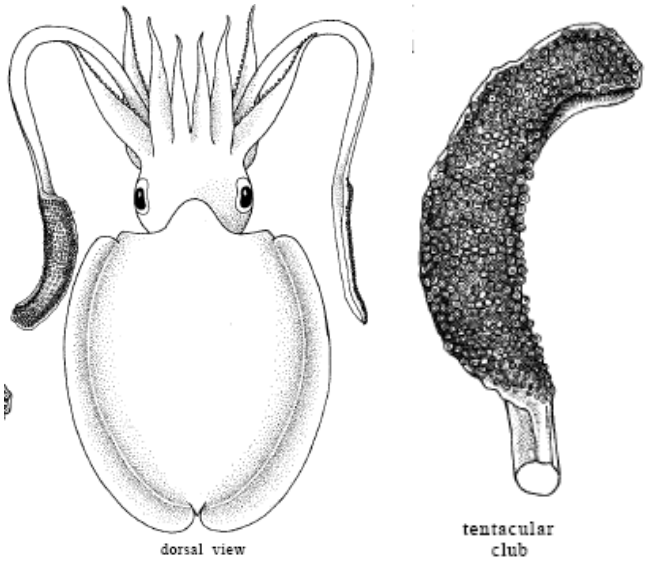


Fig. 6. *Sepia aculeata* (Source: Roper and Nauen, 1984)

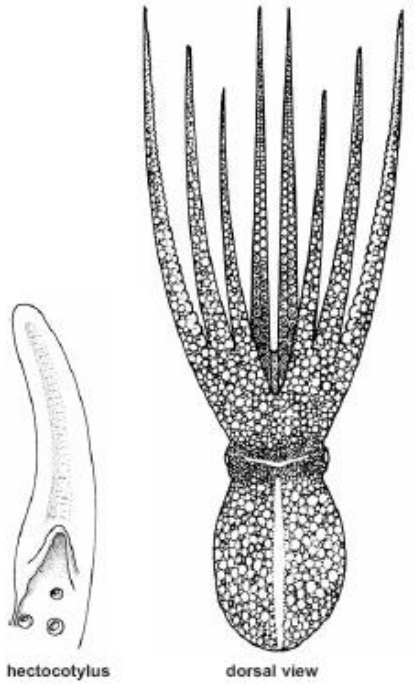


Fig. 7. *Amphioctopus aegina* (Source: Jereb et al., 2014)

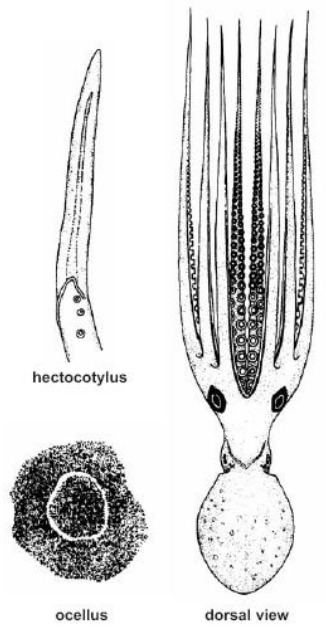


Fig. 8. *Amphioctopus neglectus* (Source: Jereb et al., 2014)

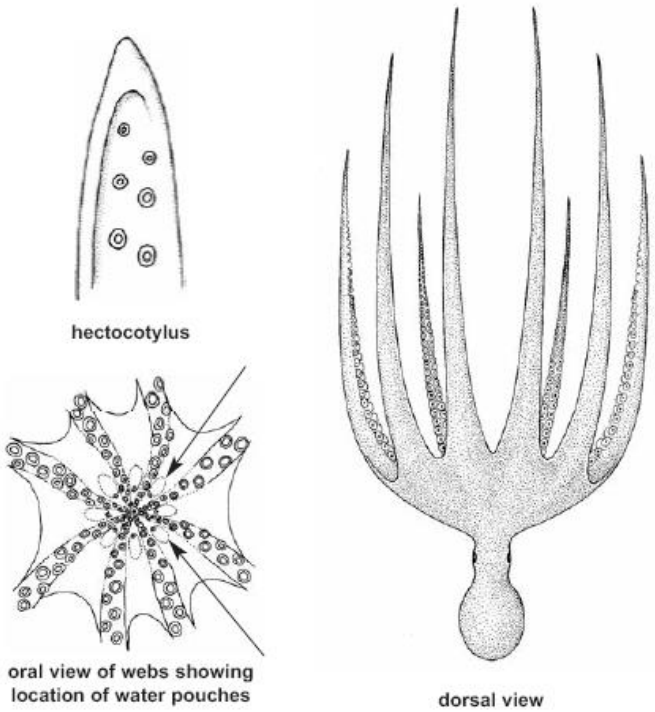


Fig. 9. *Cistopus indicus* (Source: Jereb et al., 2014)

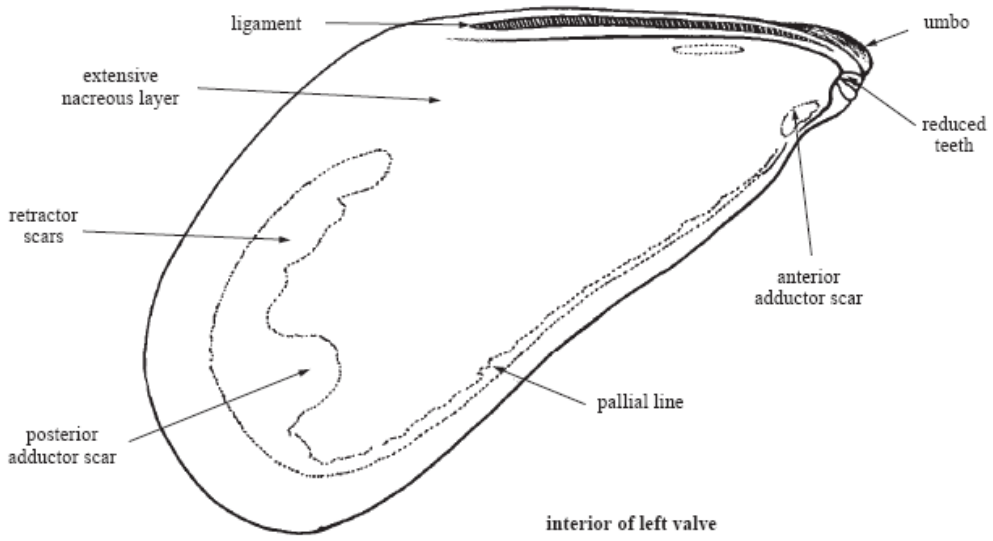


Fig. 10. ***Interior of left valve of mussel*** **(Source: Leal, 2013)**

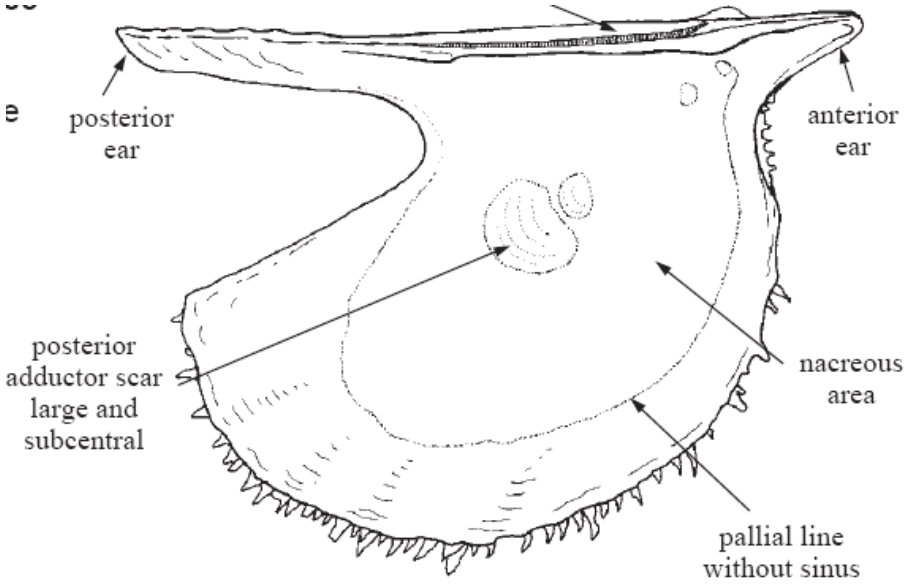


Fig. 11. ***Interior shell markings of pearl oyster*** **(Source: Leal, 2013)**

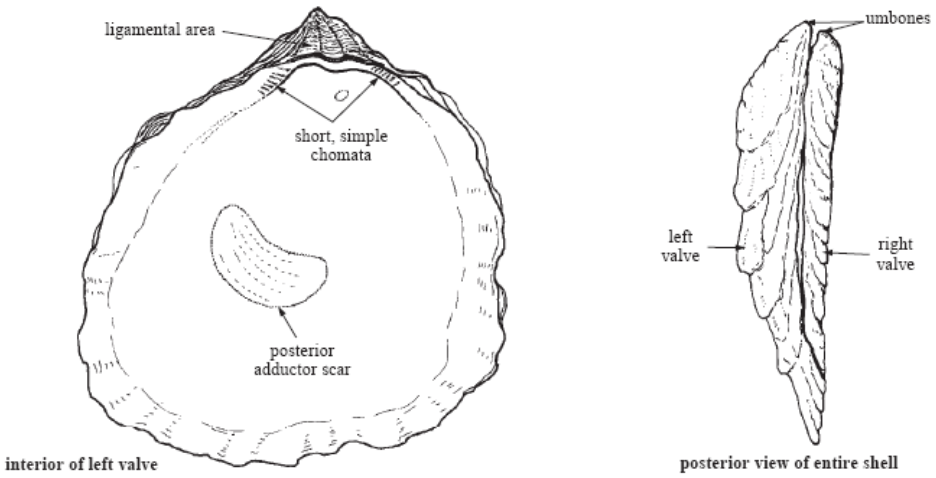


Fig. 12. *External morphology of oyster* (Source: Leal, 2013)

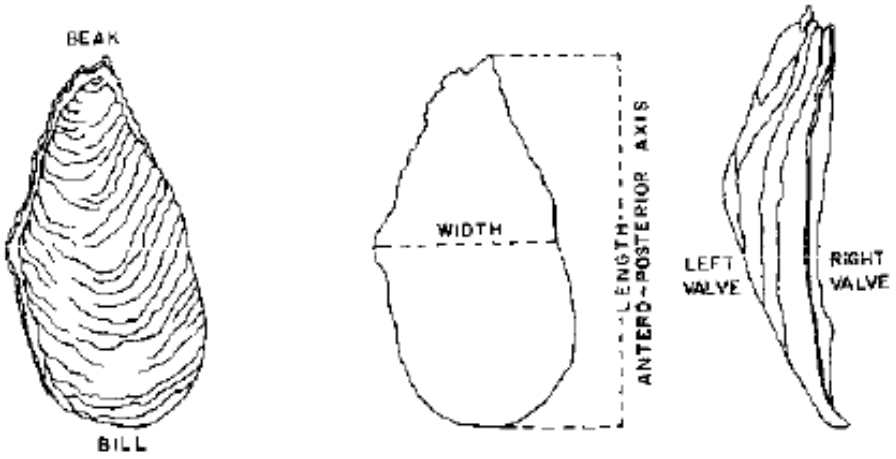


Fig. 13. *Shell valves of an edible oyster* (Source: James and Rengarajan, 1992)

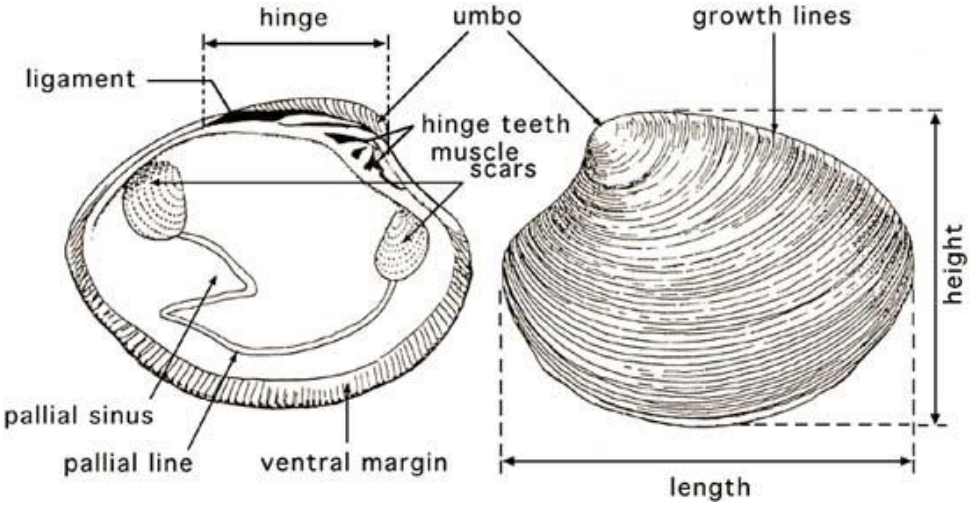


Fig. 14. ***External shell characteristics of clam*** **(Source: Helm et al., 2004)**

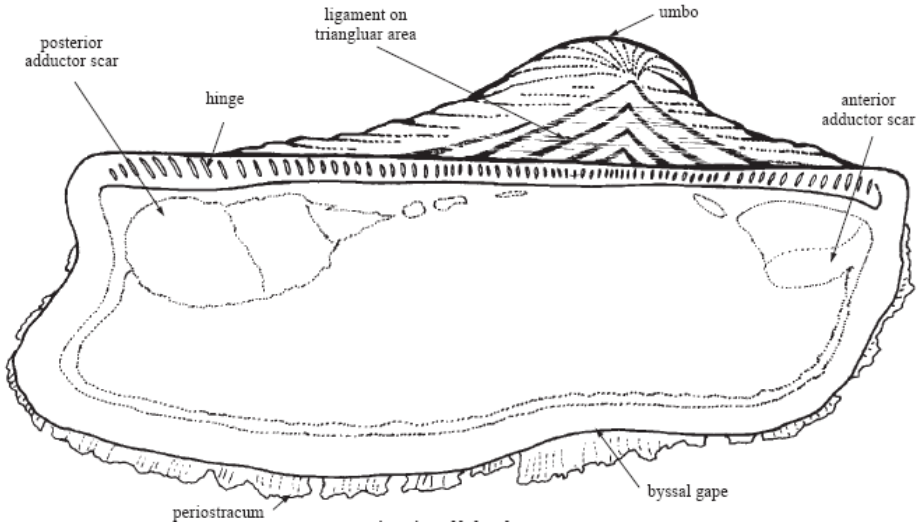


Fig. 15. ***Interior of left valve of ark shell*** **(Source: Leal, 2013)**

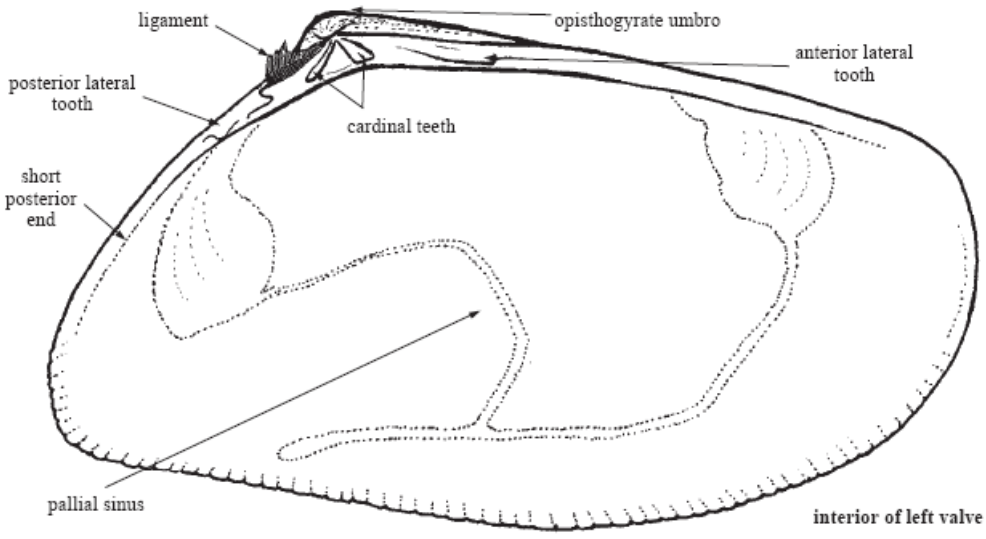


Fig. 16. *Interior of left valve of Donax shell* (Source: Leal, 2013)

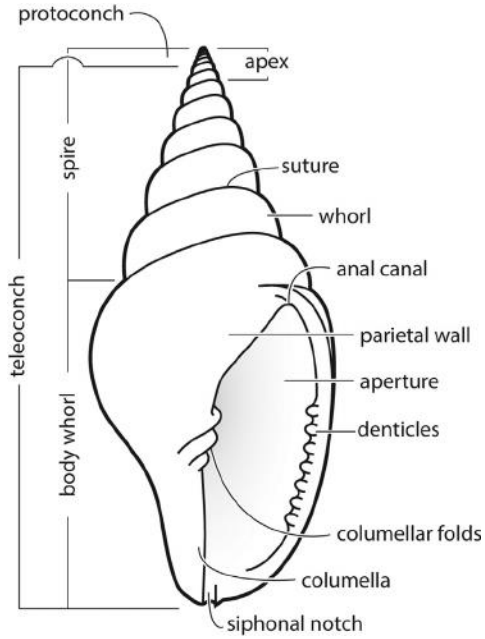


Fig. 17. *External morphology of gastropod* (Source: Harris et al., 2015)