Chapter

08

Molluscan Biology and Taxonomy

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The molluscs belong to the large and diverse phylum Mollusca, which includes a variety of soft-bodied invertebrates well-known as decorative shells or as seafood. 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. Three classes of the phylum Mollusca namely, Gastropoda (snails, limpets, whelks and slugs), Bivalvia (oysters, mussels, clams, scallops, and cockles) and Cephalopoda (squids, cuttlefishes, and octopuses) 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).

Commercially exploited molluscs of India

Cephalopods

Three groups of cephalopods viz., Squids (order Teuthoidea), Cuttlefishes (order Sepiiodea) and Octopuses (order Octopodidea), are exploited from Indian seas (Table 1). The main species occurring in commercial catches are *Uroteuthis (Photololigo) duvaucelii* (= *Loligo duvauceli*), *Sepia pharaonis, S. aculeata* and *Amphioctopus neglectus (= Octopus membranaceous)*

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.

Table 1. Commercially exploited cephalopods from Indian Seas

Species	Common Name	Distribution
Squids		
Uroteuthis (P.) duvaucelii	Indian squid	All along Indian coast
Loliolus (N) uyii	Little squid	Chennai & Visakhapatnam
U (P) edulis	Swordtip squid	SW coast
U (P) singhalensis	Long barrel squid	SW & SE coast
Loliolus (L) hardwickei	Little Indian squid	All along Indian coast
Sepioteuthis lessoniana	Palk Bay squid	Palk Bay & Gulf of Mannar
Sthenoteuthis oualaniensis	Purple-back Flying squid	Oceanic Indian EEZ
Thysanoteuthis rhombus	Diamond squid	Oceanic Indian EEZ
Cuttlefishes		
Sepia pharaonis	Pharaoh cuttlefish	All along Indian coast
S. aculeata	Needle cuttlefish	All along Indian coast
S. elliptica	Golden cuttlefish	Veraval & Kochi
S. prashadi	Hooded cuttlefish	SW & SE coast
S. brevimana	Shortclub cuttlefish	Chennai & Visakhapatnam
Sepiella inermis	Spineless cuttlefish	All along Indian coast
Octopuses		
Amphioctopus neglectus	Webfoot octopus	SW & SE coast and islands
A. marginatus	Veined octopus	SW & SE coast and islands
A. aegina	Marbled Octopus	SW & SE coast and islands
O. lobensis	Lobed octopus	SW & SE coast and islands
O. vulgaris	Common octopus	SW & SE coast and islands
Cistopus indicus	Old woman octopus	SW & SE coast and islands

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 suckers-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 too 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 up to 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.

***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.

***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.

***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.

***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 up to 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; 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.

***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 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.

***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.

***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.

***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.

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) sibogæ
		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*
		Cistopus taiwanicus
Genus	*Haplochlaena*	*Haplochlaena maculosa*
Genus	*Callistoctopus*	*Callistoctopus luteus*
Genus	*Octopus*	*Octopus vulgaris*
Genus	*Pteroctopus*	*Pteroctopus keralensis*
Family	Argonautidae	
Genus	*Argonauta*	*Argonauta hians*
		Argonauta argo

Bivalves

Various groups of bivalves such as clams, oysters, mussels, and windowpane oysters are exploited along the Indian coast for food and shells (Table 2).

Table2. Commercial important bivalves of India

Resource	Common name
Clams and cockles	
Villorita cyprinoides	Black clam
Paphia malabarica, Paphia sp	Short neck clam, textile clam
Meretrix casta, Meretrix meretrix	Yellow clam
Mercia opima	Baby clam
Mesodesma glabaratum	
Sunetta scripta	Marine clam
Donax sp	Surf clam
Geloina bengalensis	Big black clam
Tegillarca granosa (= Anadara granosa)	Cockle
Placuna placenta	Window pane oyster
Tridacna sp, Hippopus hippopus	Giant clam
Mussel	
Perna viridis	Green mussel
Perna indica	Brown mussel
Pearl oyster	
Pinctada fucata	Indian pearl oyster
Pinctada margaritifera	Blacklip pearl oyster
Edible oyster	
Crassostrea madrasensis	Indian backwater oyster
Saccostrea cucullata	Rock oyster

Biology of Molluscs

Molluscs are extremely large group and diverse in all phases of life. They occur in all marine habitats of the world including deep-sea hydrothermal vents, freshwater environments upto 40° C, land (gastropod alone) and permanent ice (Haszprunar and Wanninger, 2012). They range in size from 0.4 mm (omalogyrid gastropods) to more than 15 m (Architeuthis squids) (Haszprunar and Wanninger, 2012). Their longevity can range from a few months to up to more than 150 years (Deep sea giant bivalves) (Haszprunar and Wanninger, 2012). They mostly crawl or glide through cilia or muscle waves with mucous (Haszprunar and Wanninger, 2012). Some animals can permanently cement to the substrate, such as giant clam and edible oyster while some can attach to the substrate through byssus thread such as mussels. Modes of feeding are also diverse including filter feeders, omnivores, predators, grazers, detritovores, ecto- and

endoparasites, and various kinds of symbioses with bacteria, plankton (Zooxanthellae), and algae.

The body of theoretical molluscs comprises five fundamental parts – the foot, the head, the visceral mass, the mantle and the shell. The alimentary tract or system of theoretical mollusks consists of ingestion, digestion, absorbtion and assimilation of food. The system starts with mouth which leads to the buccal cavity having pair of jaws in each side. Pharynx, located at the anterior of the buccal cavity, is occupied by the odontophore which supports the tongue like structure called radula. Ducts from one or two pairs of salivary glands are present at the anterior of pharynx which in some species (*Conus* sp) are modified into organs to secret venom used to paralyze or kill the prey. The tract goes on with the esophagus and then enlarges in a stomach where the food has been partially digested as threads of particles linked together by mucus. Food is mostly digested in the ducts of two large digestive glands by tiny cilia (whiplike structure). These digestive glands occupy almost all the space within the visceral mass. Digestion of molluscs takes place both extracellularly and intracellularly. Extracellular digestion occurs especially in the stomach while, intracellular digestion takes place especially in the hepatopancreas. These organs (stomach / hepatopancreas) do the dual functions – secretion of digestive enzymes and absorption of food particles. The structure of posterior portion of the stomach is conical in many molluscs and a translucent rod shape in bivalves. This structure is known as crystalline style which secrets enzymes to digest certain carbohydrates. After the stomach comes the intestine which opens at the anus into the pallial cavity.

Circulatory system in molluscs is open except cephalopods. Heart, made up of two dorsal auricles/atria and a single ventricle, gets only oxygenated blood from gills and send it to different regions of the body through posterior aorta. Blood/hemolymph transport through blood vessels directly to the openings or spaces between the organs. Respiratory pigments in molluscs are of two main types' viz., red hemoglobin and blue, copper containing hemocyanin. Excretory system removes the waste materials that are formed from the breakdown of assimilated food chiefly nitrogenous waste such as ammonia and urea. This function is carried out by one or more kidneys which are diverse in the various groups of molluscs. In primitive group, these organs are linked to the pericardial cavity and at least one of the excretory

passages is modified to form a gonoduct for transfer of gametes. Excretory system opens into the pallial chamber. Pallial chamber is also an important structure which mediates between the animal and its external environment.

Respiratory system in molluscs is generally formed by the pair of gills in the pallial chamber. However, most of the gastropods have single gill. Gills are the site of gas exchange and look like a feather, with a central axis. Gills are of different forms in different group of the molluscs depending on their environment and feeding habits. Land snails do not possess gills instead they have primitive form of lung.

Molluscs show various mode of reproduction. Most of them are either gonochoristic or hermaphroditic. Percentage of gonochoristic and hermaphroditic species are more or less equal (Haszprunar and Wanninger, 2012). Few of them occasionally show parthenogenesis. Majority of the molluscs, especially gastropods and cephalopods transfer sperm by means of copulatory organs, whereas, many species, especially gastropods, scaphopods and chitons shed their gametes liberally into the water. Their egg sizes range from about 80 µm (many bivalves and gastropods) to 2 cm (Nautilus spp) (Haszprunar and Wanninger, 2012).

Larvae of them are either intracapsular or direct development into miniature form or planktotrophic or lecithotrophic. Larvae may look different from adult form. Typical molluscan larvae are veligers which are usually more or less modified form of Trochophore larvae. Example of special type of larvae is glochidium of freshwater unionoids which is well known as parasite on fish gills.

Biology of commercially important cephalopods

All cephalopods are active predators that feed on live prey, mainly fishes and crustaceans. Fish always occurs in the diet of squid U.(P.) duvaucelii of all sizes (Mohamed and Joseph, 2005). The fondness of crustacean diet diminishes with increase in size and there is indication of cannibalism above 80 mm DML (Oommen, 1977). Cephalopods are one of the major preys for a variety of marine fishes including tunas, billfishes, cetaceans, and whales (Silas, 1985). Many researchers have observed the high proportion of empty stomachs in samples and fatigue in feeding during spawning (Oommen, 1977).

The characteristic of length weight relationship of Indian cephalopods has been reported to be hypoallometric with the 'b' value is lower than 3 (Meiyappan et al., 1993). This relationship is also significantly different for males and females (Mohamed, 1996).

Cephalopods along the Indian coast are reported to spawn almost throughout the year. The earlier work on the reproductive biology of the Palk Bay squid *Sepioteuthis lessoniana* has been carried out by Rao (1954). Later on, the maturity of three species of squids and six species of cuttlefishes has been reported by Silas et al. (1985ab). Maturity stages for biological studies of squids and cuttlefishes have been standardized (Silas, 1985) and described as four-point (Immature, Maturing, Mature, and Spent) maturity scale. This maturity scale has been used by all workers on Indian cephalopods.

Mature and partially spawned individuals of *U. (P) duvaucelii* are found throughout the year along both the coasts, but along the west coast, peak spawning has been observed during post monsoon i.e. Sep-Nov. (Silas et al., 1985a; Mohamed, 1993). This species forms large congregation during this season and becomes vulnerable to the purse seine fleet operating along Karnataka coast (Mohamed, 1993) and also to cast netters along coastal water of Alleppey (Meiyappan and Srinath, 1989). This squids congregate for spawning in near shore waters after which the female migrate to the shallow subtidal regions with hard substratum for laying the fertilized eggs (Mohamed, 1993). Fertilized eggs from the subtidal regions of Karwar seas have been collected for rearing (Asokan and Kakati, 1991). Based on sex ratio (M 80:F20) of such squid schools, it would be easy to conclude that female was semelparous. However the evidence such as relatively low GSI levels and the occurrence of mature females over a wide range of size classes, suggests that this species is multiple spawner and not a semelparous species (Mohamed, 1993). Biology of the commercially important cephalopods (Source: Silas et al, 1985ab; Abdussamad et al., 2004; Abdussamad & Somayajulu, 2004; John Chembian, 2013.

Biology of commercially important bivalves

The biology of commercially important species of bivalves from India is given in Table3. Physical factors such as temperature and salinity are the important factors for influencing the reproductive cycles and spawning in bivalves (Sastry, 1979). In addition to temperature, food supply and latitudinal distribution effects the reproductive cycle of bivalves (Newell et al., 1982).

The number of spawning events and duration of spawning period can also differ greatly with respect to species, geographic area and environmental conditions (Gosling, 2003). In general, an environment play an important role to influence the growth, reproduction and recruitment of bivalves and same species shows different growth rates and spawning periods in different areas (Kripa and Appukuttan, 2003). They found that the combination of different hydrographic parameters like salinity, availability of settlement substrate and current pattern are responsible for controlling the spat fall, population growth, zonation and species dominance. Although, most of bivalves are gonochoristic, in certain bivalves like oysters hermaphroditism has been observed.

Table 3. The biological details of the commercially important bivalves (Source: Kripa and Appukuttan, 2003)

Species	L_m	Spawning period	L_{max}	Length (mm) in I yr	II yr	III yr	Distribution
V.cyprinoides	20 - 25	May-June & Nov	52	30	41	-	West coast
P. malabarica	20	Sep-Feb	55	43.1	-	-	West coast
P. viridis	15.5-28	Dec-Jan		91.5	117	129	East coast
		Jul-Nov		96	117	129	West coast
C. madrasensis	12-14(M)	Nov-Feb	128	86	112		East coast
	24-26(F)	Jul-Sep		70-80	90-110	120-130	West coast
		Feb-Apr					
M. casta	11-17.	Throughout the year	55	42.6			East &West coast
M. meretrix	21-26	May-June	91	47	61.5		East coast
		Feb - Sep					
M. opima	11-20.	Dec	53.8	30	43.5		East coast
		May-Aug		22	31	43	West coast
T. granosa	20-24	Throughout the year	73.4	41.1	55.3	66.3	East coast

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 180^0 called the `torsion' which takes place during the first few hours of larval development.

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 20^{th} 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.

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