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Marine Molluscan Taxonomy and Biology - An Overview

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Introduction

Molluscs are a phylum of soft-bodied invertebrates which includes Gastropoda (snails, limpets whelks and slugs), Bivalvia (oysters, mussels, clams, scallops, and cockles) and Cephalopoda (squids cuttlefishes, and octopuses). Of these, the gastropods, with large and diverse group (about 80% of all molluscs). The remaining groups such as Monoplacophora (cap-shaped neopilinids), Polyplacophora (chitons), Scaphopoda (tuskshells), Solenogastres (crawling worm-molluscs), and Caudofoveata (shell-less burrowing worm-molluscs) are known to a much lesser extent (Haszprunar and Wanninger, 2012). Brief description about the major groups of molluscs is shown in Table 1.

Molluscs are originally originated in marine water, spread to freshwater and on to the land. Freshwater and landforms are almost equal to the marine forms. Molluscs primarily inhabit in the intertidal and littoral zones of the sea, occasionally descend to a greater depth upto 10,000 m. Molluscs belonging to different taxonomic groups have been exploited for food, pearls, and shells. The estimate number of species of molluscs vary from different parts of the world, however, estimates number of existing species are about more than 1,00000 (Haszprunar and Wanninger, 2012). About 5070 species have been reported from India belonging to 290 families and 784 genera which are recorded from Gulf of Mannar (428 species), Lakshadweep (424 spp.), Gulf of Kutch (350 spp.), Orissa coast (337 spp), West Bengal coast (425 spp.) and Andaman & Nicobar Islands (1434 spp). Nearly 3,370 species of molluscs are recorded from marine habitat (Venkataraman and Wafar, 2005). Among these, gastropods are the most diverse, followed by bivalves, cephalopods, polyplacophores and scaphopods. At present over 1.5 lakh tonnes of cephalopods, over 1 lakh tonnes of bivalves and nearly 20,000 t of gastropods are exploited from Indian waters. The large number of marine gastropods (19 species)

Table 1. Major taxonomic groups of molluscs (Source: Haszprunar and Wanninger, 2012)

Gastropoda	Comprises more than 1,00000 species that inhabit all marine, freshwater and terrestrial habitats and size range from 0.5 mm to 100 cm in body length. All types of feeding habits (filter-feeders, herbivores, predators, ecto- and endoparasites, and detritovores) and all mode of reproduction are found in this group.
Bivalvia	Includes more than 20,000 extant species (1mm to over 150 cm) that live in all kinds of marine and freshwater habitats. They are not only filter feeder, but also include detritivorous and carnivorous bivalves. Some of them also use symbiotic zooxanthellae for nourishment. Most are epibenthic or burrow in soft bottoms, some burrow in limestone, wood (eg. shipworms). Fertilization is mostly external. Trochophore, veliger and glochidia type larvae are known in this group.
Cephalopoda	Comprises only about 1,000 extant species that inhabit exclusively marine and range from 3 cm up to 7m in body length. Some members (Nautiloidea and Ammonitoidea) have external

	shells, while all other (Coleoidea) have internal, reduced / lost shells. All bear 8 - 10 arms (about 80 arms in Nautilus) for capturing prey. Fertilization is external.
Scaphopoda	Includes about 800 marine species of 2mm to 20 cm body length. They burrow in sand or mud and feed chiefly on foraminiferans. Fertilization is external and they have lecithotrophic (trochophore-like) larvae.
Monoplacophora	Comprises less than 30 extant species with a size range from 1-40 mm long. They inhabit from about 200 m down to 7000 m depth. Dorsal surface is protected by a single cup-shaped shell and the mode of feeding is more or less similar to those of chitons.
Polyplacophora	Includes about 1000 extant marine species with range from 3mm to 30 cm body length. Dorsal side is protected by eight serial plates. They are mostly either herbivorous or detritovorous. They have strong rasping tongue for food uptake. Fertilization is external and they have lecithotrophic (trochophore-like) larvae.
Solenogastres	Includes small marine group (280 species) of 1mm to 30 cm body length covered with cuticle with spicules or scales. They live interstitially and feed on cnidarians. The mode of reproduction is through copulation and they have lecithotrophic (modified trochophore or pericalymma - type) larvae.
Caudofoveata	Comprises small marine group (180 species) of 2mm to 15 cm body length covered with cuticle with spicules or scales. They burrow in sand or mud and lose their foot sole entirely. They have lecithotrophic (modified trochophore type) larvae.

Table 2. List of scheduled marine molluscs from India

Endangered list of molluscs	
Class: Gastropoda	
1	*Cassis cornuta* (Linnaeus, 1758)
2	*Charonia tritonis* (Linnaeus, 1758)
3	*Conus milneedwardsi* Jousseaume,1894
4	*Cypraecassis rufa* (Linnaeus, 1758)
5	*Tudicla spirillus* (Linnaeus, 1767)
6	*Staphylaea limacina* (Lamarck, 1810) (= *Cypraea limacina*)
7	*Leporicypraea mappa* (Linnaeus, 1758) (= *Cypraea mappa*)
8	*Talparia talpa* (Linnaeus, 1758) (= *Cypraea talpa*)
9	*Pleuroploca trapezium* (Linnaeus, 1758) (= *Fasciolaria trapezium*)
10	*Harpulina arausiaca* (Lightfoot, 1786)
11	*Dolomena plicata sibbaldi* (G.B. Sowerby II, 1842) (= *Strombus plicatus sibbaldi*)
12	*Ophioglossolambis digitata* (Perry, 1811) (= *Lambis crocea*)
13	*Lambis millepeda* (Linnaeus, 1758)
14	*Lambis scorpius* (Linnaeus, 1758)
15	*Lambis truncata* ([Lightfoot],1786)
16	*Harpago chiragra* (Linnaeus, 1758) (= *Lambis chiragra*)
17	*Harpago arthriticus* (Roding 1798) (= *Lambis chiragra arthritica*)
18	*Rochia nilotica* (Linnaeus,1767) (= *Trochus niloticus*)
19	*Turbo marmoratus* Linnaeus, 1758

Class: Bivalvia

1 *Hippopus hippopus* (Linnaeus, 1758)

2 *Tridacna maxima* (Roding, 1798)

3 *Tridacna squamosa* Lamarck, 1819

4 *Placuna placenta* (Linnaeus, 1758)

Class:Cephalopoda

1 *Nautilus pompilius* Linnaeus, 1758

followed by bivalves (4 species) and cephalopod (1 species) has been placed in the endangered list which is a major cause of concern (Table 2). The collection, possession and trading of these scheduled molluscs (Table 2) or their products (live or dead) are prosecuted and will attract a punishment of severe imprisonment upto 7 years along with heavy fine under section 50, 51 of wildlife (Protection) Act 1972.

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 3). The main species occurring in commercial catches are *Uroteuthis (Photololigo) duvaucelii* (= *Loligo duvauceli*), *Sepia pharaonis*, *S. aculeata* and *Amphioctopus neglectus* (= *Octopus membranaceous*).

Table 3. Commercially exploited cephalopods from Indian Seas

(Source: Mohamed and Venkatesan, 2017)

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

Bivalves

Various groups of bivalves such as clams, oysters, mussels, and windowpane oysters are exploited along the Indian coast for food and shells (Table 4).

Table 4. 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

Molluscan Fisheries in India

Cephalopods are the most important group of molluscs with estimated all India production of about 2, 61,663 tonnes in 2017 which was 11.6 % more compared to the previous year. They are landed either as by-catch or as a targeted fishery. Targeted fishery is mostly carried out in mechanized trawlers operating upto 200 m depth, and beyond in some areas.

Bivalve fishery is the next in importance and fishing is practiced in limited extent mostly at a subsistence level in various estuaries and coastal seas. Clams and cockles contribute 73.8%, followed by oysters (12.5%), mussels (7.5%) and windowpane oysters (6.2%) (Mohamed and Venkatesan, 2017). The annual average clam production is about 57,000 t, oysters about 18,800 t, and marine mussels about 14,900 t (Mohamed and Venkatesan, 2017). At present, there was no fishery for marine pearl oysters, but it was the major fisheries before 1962 in the Gulf of Mannar area. Scallops occur in certain area in stray numbers and do not contribute in fishery, whereas the windowpane oyster formed considerable fishery till a few year back (Mohamed and Venkatesan, 2017).

Gastropods in India are exploited for both as food and as curios. Among gastropods, the sacred chank is most important with annual production of over 1,000 t till a few years back (Mohamed and Venkatesan, 2017). The fishing of top shell *viz., Rochia nilotica* and *Turbo marmoratus* has been banned as they have been declared as endangered. One species of Abalone *viz., Haliotis varia* occur in stray numbers and are not fished. Mining for subsoil shell deposits was carried out from time immemorial especially in the Ashtamudi and Pulicat Lakes for industrial purposes.

Mollusc biology

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 filterfeeders , omnivores, predators, grazers, detritovores , ecto- and endoparasites, and various kind 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 molluscs 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). Size at first maturity (Lm) and peak spawning seasons of some of the studied species is given in Table 5. 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). Similar studies in other commercial cephalopods are not availableTable 5.Biology of the commercially important cephalopods (Source: Silas *et al*, 1985ab; Abdussamad et al., 2004; Abdussamad & Somayajulu, 2004; John Chembian, 2013, Sajikumar (unpublished))

Table 5.Biology of the commercially important cephalopods (Source: Silas et al, 1985ab; Abdussamad et al., 2004; Abdussamad & Somayajulu, 2004; John Chembian, 2013, Sajikumar (unpublished))

Species	Lm (mm)	Spawning period	Peak Spawning	Region/coast
U.(P) duvaucelii	76 (M);86 (F)	Throughout the year	Feb & Jun - Sep (Chennai) Jan, Jul & Sep (Waltair)	East coast
	113 (M);118 (F)		Feb-Mar, May-Jul, Sep-Oct (Kochi)	West coast
S. lessoniana	102 (M);98 (F)	Jan-Jun		East coast
U.(P) singhalensis	126(M);135(F)	Jan-Mar; Oct&Dec		West coast
S. aculeata	102-118 (F)	Throughout the year (Mandapam) Mar-Jun &Nov (Portonovo) Feb-Dec (Chennai) Nov-Jul (Waltair) Aug-Mar(Kakinada)	Aug-Sep(Mandapam) Feb, Jun-Aug &Oct-Dec(Chennai) Apr, Jul, & Nov-Dec (Waltair) Nov-Dec (Kakinada)	East coast
	130-132(F)	Nov-Dec (Kochi) May, Aug, Sep,& Dec (Mumbai)		West coast
S.pharaonis	120 (F)(Waltair)	Jan-Feb, Apr & Sep-Dec(Waltair) Aug-Mar(Kakinada)	Sep-Dec, Feb, & Apr-Jun Nov-Dec (Kakinada)	East coast
	138 (F) (Chennai)	Throughout the year (Chennai)		
	160 (F) (Vizhinjam) 157(F) (Kochi)	Jan, Mar-Apr, Sep-Oct, Dec (Vizhinjam) Feb, Apr, Jun, Oct & Dec (Kochi)	Oct-Dec, Mar-Apr	West coast
S. brevimana	63(F) (Chennai) 59(F) (Waltair)	Jan-Feb & Jul-Dec		East coast
S. elliptica	93-96 (M&F)	Aug-April & Jun (Kochi)		West coast
S. inermis	52(Waltair)	Apr,Jun-Sep & Nov-Dec (Waltair)		East coast
	61 (Chennai)	Feb-Mar, & Jul-Dec (Chennai)	Sep, Dec & Mar (Chennai)	
	50 (Portonovo)	Mar-Oct (Portonovo) Apr-Nov (Kakinada)		
	83(Kochi)	Apr, Sep-Dec (Kochi)	Sep & Oct (Kochi)	West coast
S. oualaniensis	128 (M);170 (F)	Throughout the year	Oct-Dec & Mar-May	West coast
T. rhombus		Oct -Feb		West coast

Fecundity studies on Indian cephalopods are few. Individuals of *U.(P) duvaucelii* produced 5300 eggs on an average (Rao, 1988) while, fecundity estimate of *S. inermis* (69 - 71 mm DML) was ranged between 470 - 850 eggs (Unnithan, 1982). There was good correlation between length, ovary weight, and fecundity in *U.(P) duvaucelii*. In *S. lessoniana* (120 - 196 mm DML), total number of ripe eggs was from 180 to 1054 egg (average 497 eggs) (Venkatesan and Rajagopal, 2013). Fecundity, ovary weight and nidamental gland weight showed strong correlation, while fecundity, DML, and body weight showed relatively weak correlation.

Biology of commercially important bivalves

The biology of commercially important species of bivalves from India is given in Table 6. 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

Table 4. The biological details of the commercially important bivalves (Source: Kripa and Appukuttan, 2003)

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

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.

Literature cited:

Abdussamad, E.M., Meiyappan, M.M., and Somayajulu, K.R., 2004. Fishery, population characteristics and stock assessment of cuttlefishes, *Sepia aculeata* and *Sepia pharaonis* at Kakinada along the east coast of India. *Bangladesh J. Fish. Res.*, 8(2):143-150.

Abdussamad, E.M. and Somayajulu, K.R., 2004. Cephalopod fishery at Kakinada along the east coast of India: Resource characteristics and stock assessment of *Loligo duvauceli*. *Bangladesh J. Fish. Res.*, 8(1):61-69.

Asokan, P.K. and Kakati, V.S. 1991. *Embryonic development and hatching of Loligo duvaucelii Orbigny (Loliginidae, Cephalopoda) in the laboratory. Indian J. Fish.,* 38 (4): 201-206.

Gosling E. 2003. *Bivalve molluscs—biology, ecology and culture.* Fishing News Books, Oxford, 443 pp.

Haszprunar, G. and Wanninger, A., 2012. "Molluscs," Current Biology, vol. 22, no. 13, pp. R510-R514.

John Chembian, A. 2013. Studies on the biology, morphometrics and biochemical composition of the ommastrephid squid, *Sthenoteuthis oualaniensis* (Lesson, 1830) of the south west coast of India. Ph. D. Thesis, Cochin University of Science and Technology, Kochi, India.

Kripa, V and Appukuttan, K.K., 2003. *Marine Bivalves.* In: Mohan Joseph, M., and Jayaprakash, A. A., (eds.), *Status of Exploited Marine Fishery Resources of India*. ICAR-CMFRI, Cochin, p. 211-220.

Meiyappan, M.M., Srinath, M., Prabhakaran Nair, K., Satyanarayana Rao, K., Sarvesan, R., Syda Rao, G., Mohamed, K.S., Kuber Vidhyasagar, Sundharam, K.S., Lipton, A. P., Natarajan, P., Radhakrishnan, G., Narasimham, K.A., Balan, K., Kripa, V. and Sathianandan, T.V. 1993. *Stock assessment of the Indian squid Loligo duvauceli Orbigny. Indian J. Fish.*, 40 (1&2): 74-84.

Meiyappan, M.M and Srinath, M., 1989. *Growth and mortality of the Indian squid (Loligo duvauceli) off Cochin, India.* In: *Contributions to tropical fish stock assessment in India:* FAO/DANIDA/ICAR National Follow-up Training Course on Fish Stock Assessment, 2 - 28 November 1987, Cochin.

Mohamed, K.S. 1993. *Spawning congregations of Indian squid Loligo duvauceli (Cephalopoda Loliginidae) in the Arabian Sea off Mangalore and Malpe. Indian J. Mar. Sci.*, 22:172-175.

Mohamed, K.S. 1996. *Estimates of growth, mortality and stock of the Indian squid Loligo duvauceli orbigny, exploited off Mangalore Southwest coast of India. Bull. Mar. Sci.*, 58 (2): 393-403.

Mohamed, K.S., and Joseph, M., 2005. Cephalopod taxonomy and biology. In. Appukuttan, K.K., (ed.), Winter school training manual on *Recent advances in mussel and edible oyster farming and marine pearl production,* ICAR-CMFRI, Kochi, p. 28-37.

Newell, R.I.E., Hilbish, T.J., Koehn R.K. and Newell. C.J. 1982. Temporal variation in the reproductive cycles of *Mytilus edulis* L. (Bivalvia, Mytilidae) from localities on the east coast of the United States. *Biol. Bull.,* 162: 299-310.

Sastry, A. N. 1979. Pelecypoda. (Excluding Ostreidae). In: Giese A. C. and Pearse, J. S. (Eds.), *Reproduction of marine invertebrates*, *Vol 5. Mollusca: Pelecypoda and lesser classes*. Academic Press, New York, p. 113-292.

Silas, EG, 1985. *Cephalopod bionomics, fisheries and resources of the Exclusive Economic Zone of India*. *ICAR - CMFRI Bull.*, 37.

Silas EG, Satyanarayana Rao, K., Sarvesan, R., Nair, K.P., Kuber Vidhyasagar, Meiyappan, M.M., Appanna Sastri, Y., and Narayana Rao, B. 1985a. Some aspects of the biology of squids. In: Silas EG (ed), *Cephalopod bionomics, fisheries and resources of the Exclusive Economic Zone of India*. *ICAR -CMFRI Bull.*, 37: 38-48.

Silas EG, Sarvesan, R., Nair, K.P., Appanna Sastri, Y., Sreenivasan, P.V., Meiyappan, M.M., Kuber Vidhyasagar, Satyanarayana Rao, K., and Narayana Rao, B. 1985b. Some aspects of the biology of cuttlefishes. In: Silas EG

(ed), *Cephalopod bionomics, fisheries and resources of the Exclusive Economic Zone of India*. *ICAR - CMFRI Bull.*, 37: 38-48.

Sunil Mohamed, K. and Venkatesan, V. 2017. Marine molluscan diversity in India – Exploitation, conservation, In Somi, K., Mini, K.G., and Sathianandan, T.V., (eds.), Summer school training manual on *advanced methods for fish stock assessment and fisheries management*, Lecture Note Series No. 2/2017, ICAR-CMFRI, Kochi, pp. 56-81.

Oommen, V.P., 1977. Studies on the food, feeding and fishery of certain cephalopods from the west coast of India. *Bull. Dep. Mar. Sci. Univ. Cochin*, 8: 73-152.

Rao, K.V. 1954. Biology and fishery of Palk bay squid *Sepioteuthis arctipinnis* Gould. *Indian J. Fish.,* 1: 37-66.

Rao G S. 1988. Biology of inshore squid *Loligo duvauceli* Orbigny, with a note on its fishery off Mangalore. *Indian J. Fish.,* 35 (3): 121-30.

Unnithan, K. A. 1982. Observations on the biology of cuttlefish *Sepiella inermis* at Mandapam. Indian J. Fish., 29(1-2): 101 - 111.

Venkatesan, V. and Rajagopal, S., 2013. Fecundity of Bigfin squid, *Sepioteuthis lessoniana* (Lesson, 1830) (Cephalopoda: Loliginidae). *Jordon J. Biol. Sci.,* 6(1): 39 - 44.

Venkataraman, K. and Wafar, M. 2005. Coastal and marine biodiversity of India. *Indian J. Mar. Sci.,* 34(1): 57 - 75.

Sajikumar, K.K., *et al.*,(Unpublished). Distribution, age and growth of Diamondback squid, *Thysanoteuthis rhombus* Troschel, 1857 (Cephalopoda: Thysanoteuthidae) from tropical Arabian Sea.