13 Classification, Biodiversity and Conservation of Marine Crabs

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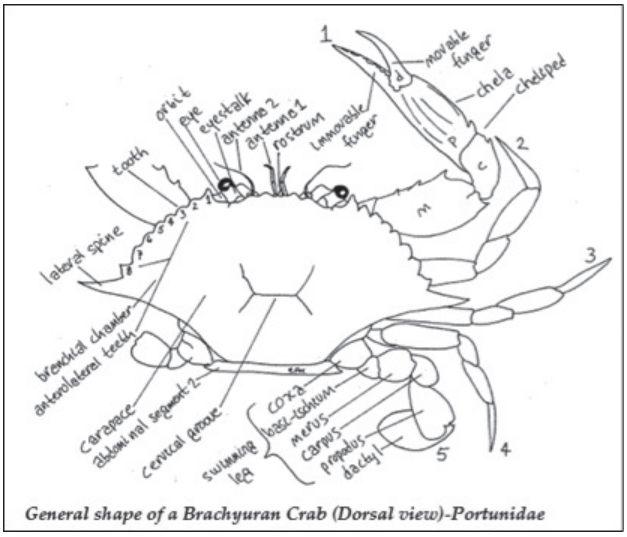
One of the best known and most intensely studied groups is the true crabs of the infraorder Brachyura. Brachyuran crabs belong to the Order Decapoda, the most diverse group of crustaceans alive today (Ng et al., 2008).The known size of crabs now ranges from a maximum leg span of approximately 4 m in the giant Japanese spider crab *Macrocheira kaempferi* and a maximum Carapace width of 46 cm in the giant Tasmanian crab *Pseudocarcinus gigas* (as cited in Schmitt, 1965) to a minimum of 1.5 mm across the Carapace for a mature ovigerous female pinnotherid, *Nannotheres moorei*, the smallest known species of crab (Manning and Felder, 1996).

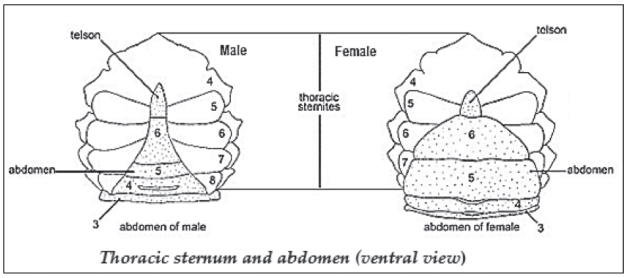
Every living thing is classified into one of the three domains. Archaea, Bacteria, and Eukarya are the three domains. The eight levels of classification are domain, kingdom, phylum, class, order, family, genus, and species. True crabs are classified as follows:

Phylum:Arthropoda
Subphylum:Crustacea
Class:Malacostraca
Order:**Decapoda**
Suborder:Pleocyemata
Infraorder: **Brachyura** Linnaeus, 1758

The basic crab design consists of an expanded Carapace (formed by a fusion of the head and some thoracic somites), and a strongly reduced abdomen that is tightly tucked underneath the thorax. In addition, the first pereiopods of brachyurans are fully chelate, and the walking legs are placed at the sides of the body. True brachyuran crabs are often confused with hermit and porcelain crabs belonging to the infraorder Anomura. In general, most anomuran crabs have only three pairs of walking legs clearly visible, with the last pair being very small and normally positioned under the abdomen and not visible externally.



General shape of a Brachyuran Crab (Dorsal view)-Portunidae



Thoracic sternum and abdomen (ventral view)

Fishery Resources and their distribution

In India, most of the edible crabs caught from marine and brackish water environments belong to the family Portunidae. In the Indian Ocean, the crab fauna of Portunidae family is included under sub families, Podophthalmidae (Borradaile), Catoptrinae (Sakai), Portuninae (Rafinesque), Caphyrinae (Alcock), Carcininae (Macleay) and Polybiinae (Ortmann). Most of the edible crabs caught from marine and brackishwater environments belong to the sub family Portuninae. In the seas around India, five genera of Portuninae have been reported by various authors. They are *Scylla, Portunus, Charybdis,*

Lupocyclus and *Thalamita*. Among them the first three genera contribute to the commercial crab fishery Commercially important species are *Scylla* spp. (Mud crabs), *Portunus pelagicus (blue swimmer crab), P. sanguinolentus (three spotted crab), Charybdis feriatus (crucifix crab), C. lucifera* (Yellowish brown crab), *C.natator (line crab) and Podophthalmus vigil* (long eye-stalk crab; sub fly., Podophthalmidae).

Distribution of commercially important species along the Indian Coast

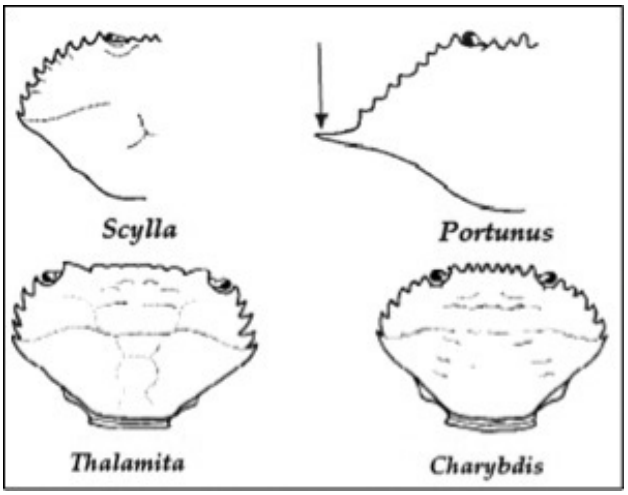
State	Crabs	State	Crabs
Gujarat	1. *Portunus sanguinolentus*		5. *C. smithi*
	2. *Charybdis feriatus*		6. *C. annulata*
	3. *P. pelagicus*		7. *C.lucifera*
Maharashtra	1. *C. feriatus*		8. *C. helleri*
	2. *P. sanguinolentus*		9. *Podopthalmus vigil*
	3. *P. pelagicus*		10. *P. gladiator*
Karnataka	1. *C. feriatus*		11. *S. serrata*
	2. *P. sanguinolentus*	Andhra Pradesh	1. *P. pelagicus*
	3. *P. pelagicus*		2. *P. sanguinolentus*
Kerala	1. *P. pelagicus*		3. *C. feriatus*
	2. *P. sanguinolentus*		4. *Scylla serrata*
	3. *C. feriatus*		5. *S. olivacea*
	4. *C. lucifera*	Orissa	1. *P. pelagicus*
	5. *Podopthalmus vigil*		2. *P. sanguinolentus*
	6. *Scylla serrata*		3. *C. feriatus*
Tamil Nadu	1. *P. pelagicus*		4. *Scylla serrata*
	2. *P. sanguinolentus*		5. *S. olivacea*
	3. *C. feriatus*	West Bengal	1. *S. olivacea*
	4. *C. natator*		2. *S. serrata*

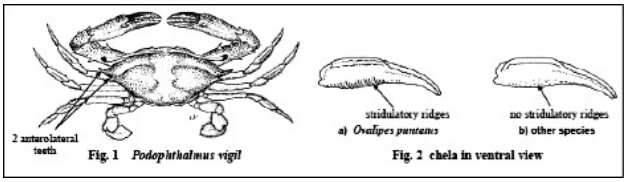
Portunidae

Carapace hexagonal, transversely ovate to transversely hexagonal, sometimes circular; dorsal surface relatively flat to gently convex, usually ridged or granulose; front broad, margin usually multidentate; usually 5 to 9 teeth on each anterolateral margin, posterolateral margins usually distinctly converging.Endopodite of second maxillipeds with strongly developed lobe on inner margin. Legs laterally flattened to varying degrees, last 2 segments of last pair paddle-like. Male abdominal segments 3 to 5 completely fused, immovable.

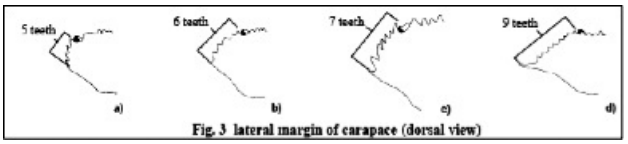
Key to species of interest to fisheries occurring in the area

1a. Carapace with 2 anterolateral teeth; eyes very long, reaching lateral edge of Carapace (Fig. 1) *Podophthalmus vigil*
1b. Carapace with more than 2 anterolateral teeth; eyes normal in size 2
2a. Carapace rounded; ventral surface of palm with stridulatory (sound-producing) ridges (Fig. 2a) ..... *Ovalipes punctatus*
2b. Carapace transversely ovate; palm without any stridulatory (sound-producing) ridges (Fig. 2b) 3
3a. Five to 7 teeth on each anterolateral margin (Fig. 3a-c) 4
3b. Nine teeth on each anterolateral margin (Fig. 3d) 12

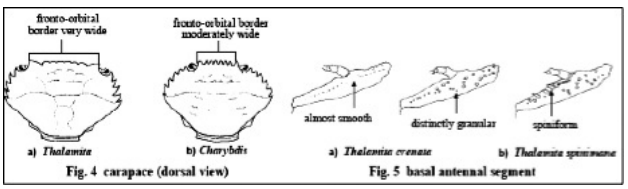




4a. Width of frontal-orbital border not much less than greatest width of Carapace; 5 teeth on each anterolateral margin (first



tooth sometimes with accessory denticle) (Fig. 4a) 5
4b. Width of frontal-orbital border distinctly less than greatest width of Carapace; 6 or 7 teeth on each anterolateral margin (Fig. 4b) 6
5a. Basal antennal segment with a smooth or granulated ridge (Fig. 5a) ..... *Thalamita crenata*
5b. Basal antennal segment with several sharp spines (Fig. 5b) ..... *Thalamita spinimana*
6a. Posterior border of Carapace forming an angular junction with posterolateral border (Fig. 6a); merus of cheliped without



distal spine on posterior border ..... *Charybdis truncate*
6b. Posterior border of Carapace forming a curve with posterolateral border (Fig. 6b); Merus of cheliped with distal spine on posterior border..... 7
7a. Carapace with distinct ridges or granular patches behind level of last pair of anterolateral teeth (Fig. 7a)..... *Charybdis natator*
7b. Carapace without distinct ridges or granular patches

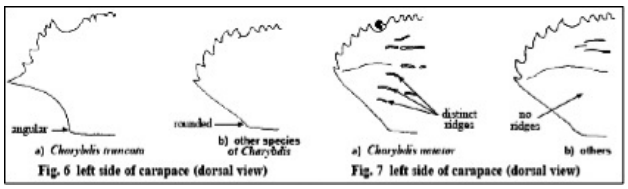


Fig. 6 left side of carapace (dorsal view) Fig. 7 left side of carapace (dorsal view)

behind level of last pair of anterolateral teeth (Fig. 7b)..... 8
8a. Merus of cheliped with 2 spines on anterior border; palm with 2 spines on upper surface (Fig. 8a) *Charybdis anisodon*
8b. Merus of cheliped with 3 or 4 spines on anterior border; palm with more than 2 spines on upper surface (Fig. 8b).... 9
9a. First anterolateral tooth not truncate or notched (Fig. 9a) *Charybdis annulata*

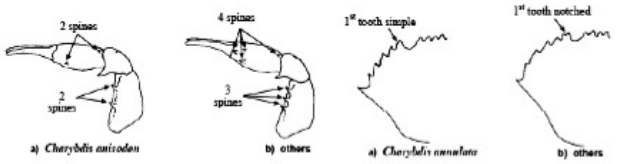


Fig. 8 right cheliped (dorsal view) Fig. 9 lateral margin of carapace (dorsal view)

9b. First anterolateral tooth truncate or notched (Fig. 9b) 10
10a. Palm of cheliped with 4 spines on upper surface (Fig. 10a); male abdominal segment 4
keeled (Fig. 11a) .....*Charybdis feriatus*
10b. Palm of cheliped with 5 spines on upper surface (Fig. 10b); male abdominal segment 4 not keeled (Fig. 11b) 11

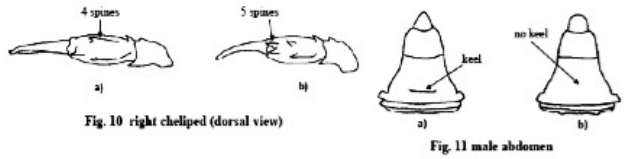


Fig. 10 right cheliped (dorsal view) Fig. 11 male abdomen

11a. Palm with well-developed spines (Fig. 12a); male abdominal segment 6 with convex lateral borders (Fig. 13a); last anterolateral tooth smallest and spiniform, not projecting beyond preceding tooth (Fig. 14a) ..... *Charybdis japonica*
11b. Palm with poorly developed spines (Fig. 12b); male abdominal segment 6 with lateral borders parallel in proximal half (Fig. 13b); last anterolateral tooth elongate, projecting laterally beyond preceding tooth (Fig. 14b).. *Charybdis* affinis
12a. Last anterolateral tooth subequal in size to others (Fig. 15a)..... 13
12b. Last anterolateral tooth at least 2 times larger than others (Fig. 15b) 16
13a. Carpus of cheliped with only 1 low to very low granule

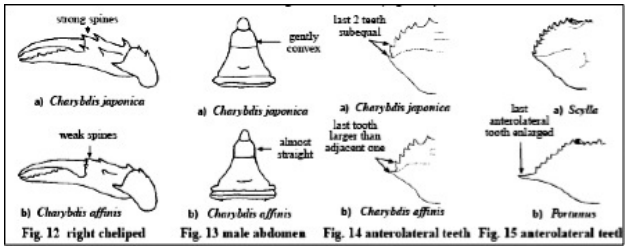


Fig. 12 right cheliped Fig. 13 male abdomen Fig. 14 anterolateral teeth Fig. 15 anterolateral teeth

on outer surface, never spiniform
(Fig. 16a); colour of palm usually with at least some patches of orange or yellow in life 14
13b. Carpus of cheliped with 2 distinct spiniform or sharp granules or spines on outer surface
(Fig. 16b); colour of palm in life green to purple 15
14a. Frontal margin usually with sharp teeth (Fig. 17a); palm usually with distinct, sharp
spines (Fig. 18a) .....*Scylla paramamosain*
14b. Frontal margin usually with rounded teeth (Fig. 17b); palm usually with reduced, blunt spines (Fig. 18b) .....*Scylla olivacea*
15a. Frontal margin usually with rounded teeth (Fig. 19a); sharp granules on palm and carpus never spiniform; colour in life: Carapace usually very dark green to black, outer surface of palm purple and never with marbled pattern, last legs marbled only in males ..... *Scylla tranquebarica*
15b. Frontal margin usually with sharp teeth (Fig. 19b); sharp granules on palm and carpus often spiniform; colour in life: Carapace usually green to olive-green, outer surface of palm green and often with marbled pattern, last legs marbled both in males and females..... *Scylla serrata*
16a. Carapace with 3 purple to red spots on posterior half. . . *Portunus sanguinolentus*
16b. Carapace marbled or with uniform coloration 17
17a. Front with 4 teeth (Fig. 21a); inner margin of merus of

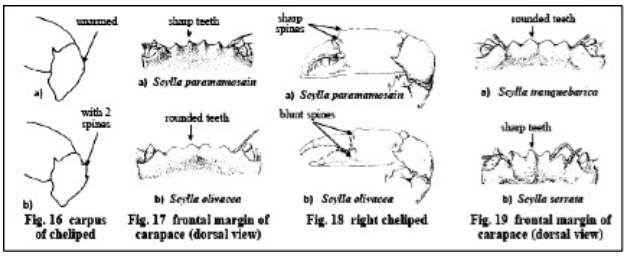


Fig. 16 carpus of cheliped Fig. 17 frontal margin of carapace (dorsal view) Fig. 18 right cheliped Fig. 19 frontal margin of carapace (dorsal view)

cheliped with 3 spines (Fig. 22a) ..... *Portunus pelagicus*
17b. Front with 3 teeth (Fig. 21b); inner margin of merus of cheliped with 4 spines (Fig. 22b) .....*Portunus trituberculatus*

Fig. 21 frontal margin of carapace (dorsal view) Fig. 22 merus of cheliped (inner margin)

Key – P.K.L.Ng .1998. FAO species identification guide for fishery purposes – Crabs –Portunidae .

Portunus pelagicus (Linnaeus, 1758) (Flower crab).

Carapace rough to granulose, front with 4 acutely triangular teeth; 9 teeth on each anterolateral margin, the last tooth 2 to 4 times larger than preceding teeth. Chelae elongate in males; larger chela with conical tooth at base of fingers.
Colour: males with blue markings, females dull green/ greenish brown.

Portunus sanguinolentus **(Herbst, 1783)(Three-spot swimming crab).**

Carapace finely granulose, regions just discernible; 9 teeth on each anterolateral margin, the last tooth 2 to 3 times larger than preceding teeth. Chelae elongated in males; larger chela with conical tooth at base of fingers; pollex ridged.
Colour: olive to dark green, with 3 prominent maroon to red spots on posterior 1/3 of Carapace.

Charybdis feriatus **(Linnaeus, 1758) (Crucifix crab)**

Carapace ovate; 5 distinct teeth on each anterolateral margin.
Colour: distinctive pattern of longitudinal stripes of maroon and white, usually with distinct white cross on median part of gastric region; legs and pincers with numerous scattered white spots.

Charybdis natator **(Herbst, 1789) (Ridged swimmimg crab)**

Carapace with densely covered with very short pubescence which is absent on several distinct transverse granulated ridges in anterior half.

Colour: orangish red overall, with ridges on Carapace and legs dark reddish brown.

Podophthalmus vigil **(Fabricius, 1798)**

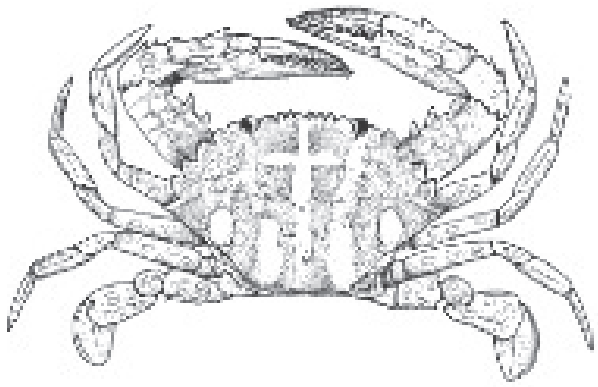
Carapace distinctly broader than long; anterior margin much broader than posterior margin, with posterolateral margins converging strongly towards narrow posterior Carapace margin; orbits very broad. Eyes very long, reaching to or extending beyond edge of Carapace.
Colour: Carapace green; chelipeds and parts of legs violet to maroon in adults.

Scylla **spp.**

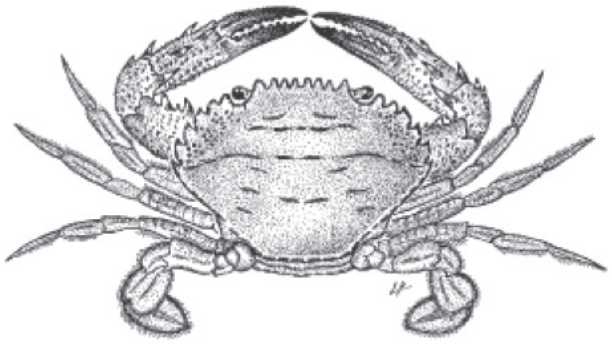
The taxonomy of the genus *Scylla* has been terribly confused and is still difficult. Recent research in Australia (Keenan et al., 1998) has clearly shown, using morphological, DNA, and allozyme data, that there are 4 species of *Scylla*.

Scylla serrata **(Forsskål, 1775) (Giant mud crab)**

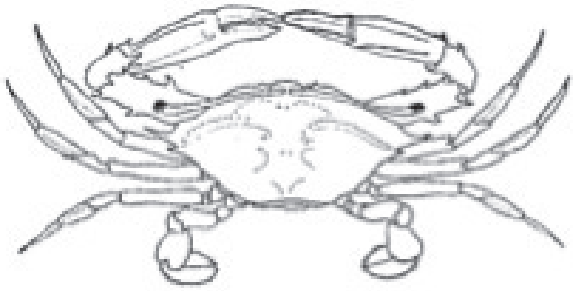
Carapace smooth, with strong transverse ridges; H-shaped



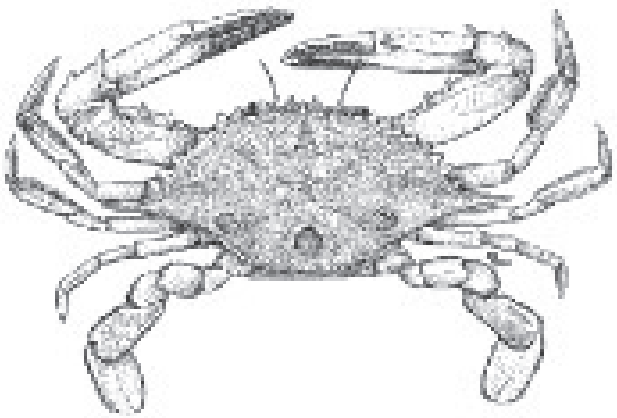
Charybdis feriatus (Linnaeus, 1758)



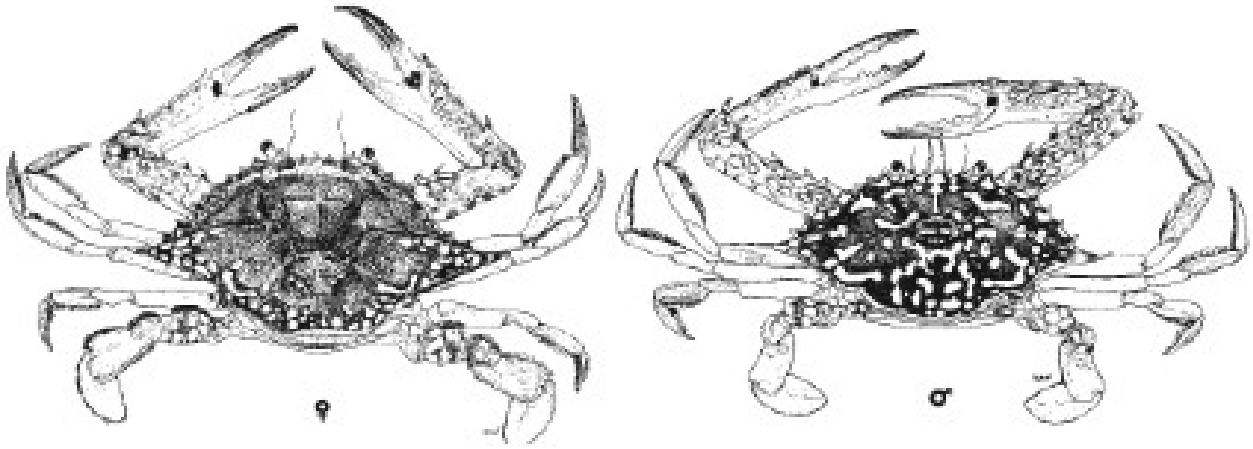
Charybdis natator (Herbst, 1789)



Podophthalmus vigil (Fabricius, 1798)



Portunus sanguinolentus (Herbst, 1783)



Portunus pelagicus (Linnaeus, 1758)

gastric groove deep; relatively broad frontal lobes, all more or less in line with each other; broad anterolateral teeth, projecting obliquely outwards, colour green to greenish black; legs may be marbled. Well- developed spines present on outer surface of chelipedal carpus and anterior and posterior dorsal parts of palm.

Scylla tranquebarica **(Fabricius, 1798) (Purple mud crab)**

Colour varies from brown to almost black in coloration, and has very well-developed spines on the outer surfaces of the chelipedal carpus and the palm (as seen in *S. serrata*). It differs from *S. serrata*, however, by having the frontal teeth more acutely triangular, the median pair projecting slightly forwards of the lateral pair, and the anterolateral teeth gently curving anteriorly, giving the Carapace a less transverse appearance.

Scylla olivacea **(Herbst, 1796) (Orange mud crab)**

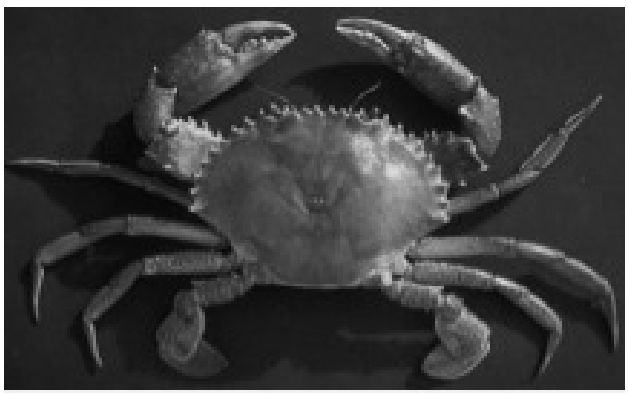
Carapace brownish to brownish green in colour (sometimes orangish), palm orange to yellow. It has a smoother, more evenly convex Carapace with very low transverse ridges, a shallow H-shaped gastric groove, the median pair of the frontal lobes more rounded and projecting slightly forwards of the lateral ones, the anterolateral teeth gently curving anteriorly, giving the Carapace a less transverse appearance. It also has very low spines on both the outer surface of the chelipedal carpus and the dorsal surface of palm.

Scylla paramamosain Estampador, 1949 (Green mud crab)

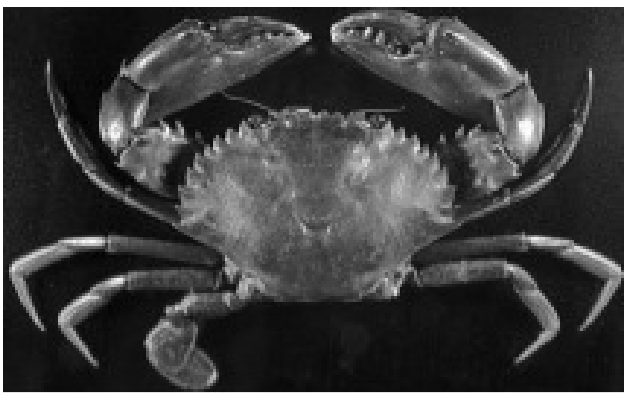
Carapace usually green to light green, palm green to greenish blue with lower surface and base of fingers usually pale yellow to yellowish orange. Frontal margin usually with sharp teeth, palm usually with distinct, sharp spines.

Diversity of Species along west coast

A total of 226 species of brachyuran crabs belonging to 130 genera and 39 families have been recorded from the different maritime states of the west coast of India. Highest species diversity recorded in Kerala (93 species) followed by Maharashtra (92 species). However, generic diversity is more in Maharashtra (64 genera) than in Kerala (63 genera). Of the 39 families, Mathildellidae and Geryonidae are found

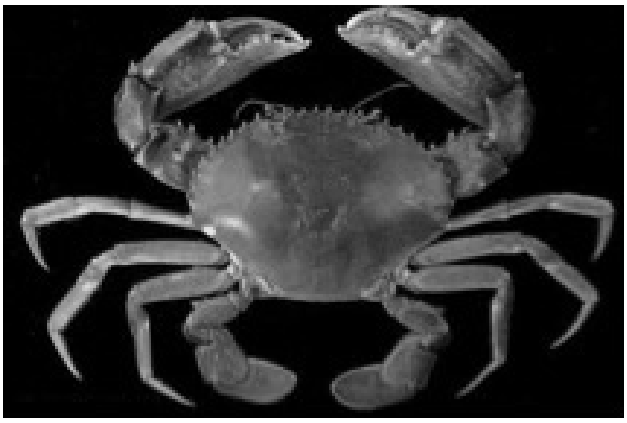


Scylla serrata (Forsskål, 1775)



Scylla tranquebarica (Fabricius, 1798)

Scylla olivacea (Herbst, 1796)



Scylla paramamosain Estampador, 1949

exclusively in Kerala while two families namely, Pseudoziidae and Trapeziidae, known only from Maharashtra and the family Gecarcinidae from Goa. Among the states in the west coast of India, three brachyuran families, viz., Homolodromiidae, Atelecyclidae and Goneplacidae are recorded only from the state of Kerala; their representatives do not occur in the east coast but are found only in the Andaman and Nicobar Islands and Lakshadweep within Indian territorial waters. Among the 39 families, the family Portunidae contains the maximum number of species (28) followed by Xanthidae (23 species) and Leucosiidae (22 species). The genus *Charybdis* supports the maximum number of species (11) in the west coast (Dev Roy, 2013). The complete list is annexed at the end of the chapter.

Conservation

At present, there is no ban on fishing immature and the berried crabs and the minimum size at capture is not implemented in India. As a conservation measure, only possibility is to educate fishermen to release the juvenile, berried and soft crabs to the sea while they are alive. The governments should take steps to implement ban during peak spawning seasons to prevent indiscriminate fishing. The best method to ensure a sustainable fishery throughout the year as well as to improve the quality of the yield is to ban fishing and marketing of undersized and berried crabs (Josileen, 2007). Recently CMFRI has suggested minimum legal size (MLS) at fishing for important fishery resources for Kerala state (Mohammed et al., 2014).

None of the Indian brachyuran crabs is in the IUCN list; terrestrial hermit crab *Birgus latro* and Horse Shoe crab of Limulidae family are only coming in this category.

Coconut crab-*Birgus latro*

Order: Decapoda
Family:Coenobitidae
Genus:*Birgus* Leach, 1816

The coconut crab, *Birgus latro*, is a species of terrestrial hermit crab, also known as the robber crab or palm thief. It is the largest land-living arthropod in the world, and is probably at the upper size limit for terrestrial animals with exoskeletons in recent Earth atmosphere, with a weight of up to 4.1 kg (9.0 lb). It can grow to up to 1 m (3 ft 3 in) in length from leg to leg. It is found on islands across the Indian Ocean and parts of the Pacific Ocean as far east as the Gambier Islands, mirroring the distribution of the coconut palm; it has been extirpated from most areas with a significant human population, including mainland Australia and Madagascar.

The coconut crab is the only species of the genus *Birgus*, and is related to the terrestrial hermit crabs of the genus *Coenobita*. It shows a number of adaptations to life on land. Like hermit crabs, juvenile coconut crabs use empty gastropod shells for protection, but the adults develop a tough exoskeleton on their abdomen and stop carrying a shell. Coconut crabs have organs known as "branchiostegal lungs", which are used instead of the vestigial gills for breathing. They cannot swim, and will drown if immersed in water for long. They have developed an acute sense of smell, which has developed convergently with that of insects, and which they use to find potential food sources. Mating occurs on dry land, but the females migrate to the sea to release their fertilised eggs as they hatch. The larvae are planktonic for 3–4 weeks, before settling to the sea floor and entering a gastropod shell. Sexual maturity is reached after about 5 years, and the total lifespan may be over 60 years.

Patankar and D'souza (2012) categorized the coconut crab *Birgus latro*, as Data Deficient on the IUCN Red List, and described the conservation needs of the species on the Nicobar Islands in the eastern Indian Ocean. The species is threatened with extinction across most of its range and in India it is found only on a few islands in the Andaman and Nicobar archipelagoes. Athough the coconut crab is legally protected under the Indian Wildlife Protection Act none of the villagers were aware of this. They surveyed six islands and recorded the presence of 17 and 14 crabs on two islands, respectively

and on four islands villagers reported the presence of the crab prior to the tsunami of 2004, and on two of these islands the species may now be locally extinct. A small population size and a fragmented distribution in areas of coconut plantations suggest that the species is threatened.

It occurs on oceanic atolls and islands in the Indo-Pacific region and is reported to grow up to 35 cm in length and weigh up to 5 kg. The species' only dependence on the sea is for releasing eggs, which hatch in contact with seawater; the planktonic larvae then migrate onto land where they develop into long-lived adults (Reese & Kinzie, 1968). In many parts of its range the coconut crab is hunted for consumption. A slow

Photo: Vardhan Patankar

growth rate and long life span combined with high levels of exploitation and habitat degradation make the species susceptible to overexploitation (Fletcher & Amos, 1994) and in many countries the crab is virtually extinct (Schiller, 1992). The coconut crab is afforded the highest level of legal protection in India, categorized under Schedule-I of the Indian Wildlife Protection Act. However, this categorization was based on secondary data rather than field investigations of the species.

Horseshoe crab

Phylum: Arthropoda
Subphylum: Chelicerata
Class: Merostomata
Order: Xiphosura
Family: Limulidae Leach, 1819

Horseshoe crabs resemble crustaceans, but belong to a separate subphylum, Chelicerata. They are closely related to arachnids such as spiders, scorpions and ticks. Horseshoe crabs are fascinating creatures. They live primarily in and around shallow ocean waters on soft sandy or muddy bottoms. They occasionally come onto the shore to mate. In recent years, a decline in the population has occurred as a consequence of coastal habitat destruction in Japan and overharvesting along the east coast of North America. Because of their origin 450 million years ago, horseshoe crabs are considered as living fossils.

The Limulidae are the only recent family of the order Xiphosura, and contain all four living species of horseshoe crabs:

Carcinoscorpius rotundicauda, the mangrove horseshoe crab, found in Southeast Asia.
Limulus polyphemus, the Atlantic horseshoe crab, found along the American Atlantic coast and in the Gulf of Mexico.
Tachypleus gigas, found in Southeast and East Asia.
Tachypleus tridentatus, found in Southeast and East Asia.

Tachypleus gigas and *Carcinoscorpius rotundicauda* are found within Indian limits. The distribution of *T. gigas* and *C. rotundicauda* is restricted to north-east coast of Orissa and Sunderbans area of the West Bengal, respectively. The occurrence of both species at the same place has not been observed. Mature pairs of both speices, in amplexus, migrate towards the shores for breeding purpose, throughout the year. *C. rotundicauda* prefers nesting in mangrove swamps whereas, *T. gigas* breeds on a clean sandy beach (Chatterjee and Abidi, 2001).

The larger female horseshoe crab can reach up to 60 cm in length and can weigh up to 5 kg. The 'U' or horseshoe-shaped Carapace (shell) is smooth and brown, although in some environments the Carapace is covered with *epiphytic* plants and *epizooic animals*. This is usually observed toward the end of the horseshoe crab's lifespan of approximately 19 years. During its formative years, the horseshoe crab sheds its Carapace periodically, or molts, to accommodate its growing body. The new skeleton is flexible so that it can accommodate the increased body size. The new Carapace then hardens and its color forms during tanning of its protein component.

Underside of a horseshoe crab showing the legs and book gills

The body is divided into an anterior cephalothorax and a posterior abdomen. The spike-shaped tail, or telson, functions as a tool for digging in sand and a lever if the animal finds itself upside down. The tail might not always be effective however. The horseshoe crab is equipped with 4 pairs of jointed walking legs (*pedipalps*) each ending in a claw. The fifth pair is larger and allows the animal to lurch forward. The middle segment of each leg is covered with spines used to chew food before it is passed forward and into the mouth located at the base of the legs. Interestingly, locomotion and feeding are closely related, since the animal can chew only when it moves.

Horseshoe crabs have 10 eyes located all over their bodies, most located on the back or sides of the animal. Some contain only photoreceptors such as the eyes located on their tails. The eyes found on the back each have about 1,000 photoreceptor clusters or *ommatidia*, each with a lens, cornea and photoreceptor cells. Horseshoe crabs have the largest rods and cones of any known animal that are about 100 times the size of humans'. In spite of the number of eyes, horseshoe crabs still have "poor" eyesight used only to sense light and locate mates.

Horseshoe crabs' respiration is conducted through 6 pairs of appendages attached to the underside of the abdomen called *gill books*. The first pair, called the *operculum*, protects the other five pairs, which are respiratory organs and houses the opening of the genital pores through which eggs and sperm are released from the body.

Exploitation

Humans capture the horseshoe crabs primarily for bait and to use in fertilizer. A protein found in the blood of horseshoe crabs is used to detect impurities in intravenous medications; the animals are apparently not harmed during blood extraction. Horseshoe crab blood has also been used in cancer therapy research, leukemia diagnosis and to detect vitamin B12 deficiency. Another interesting fact is that horseshoe crabs are quite literally "blue blood." Oxygen is carried in the blood of the horseshoe crab by a molecule that contains haemocyanin, which contains copper causing the blood to turn blue when exposed to air. Most red-blooded animals carry oxygen in iron-rich hemoglobin causing their blood to turn red when exposed to air.

This valuable creature is a potential source of bioactive substance, a diagnostic reagent, the Limulus Amoebocyte Lysate (LAL) from its blue blood. The reagent is highly sensitive and useful for the rapid and accurate assay of gram negative bacteria even if they are present in a very minute quantity. The indiscriminate exploitation of horse shoe crab for medicinal and other purposes, has threatened it with extinction all over the world. In USA, large numbers of brooder crabs are sacrificed every year for the preparation of LAL on commercial scale. In addition to this, the LAL is also useful in lipopolysaccharides assay and water quality research. These resulted in considerable depletion of the population of horse-shoe crab in USA. Japan was the first country to realise the declining trend and subsequently took measures for conservation by declaring horse shoe crab as a national monument (Chatterjee and Abidi, 2001).

Suggested readings

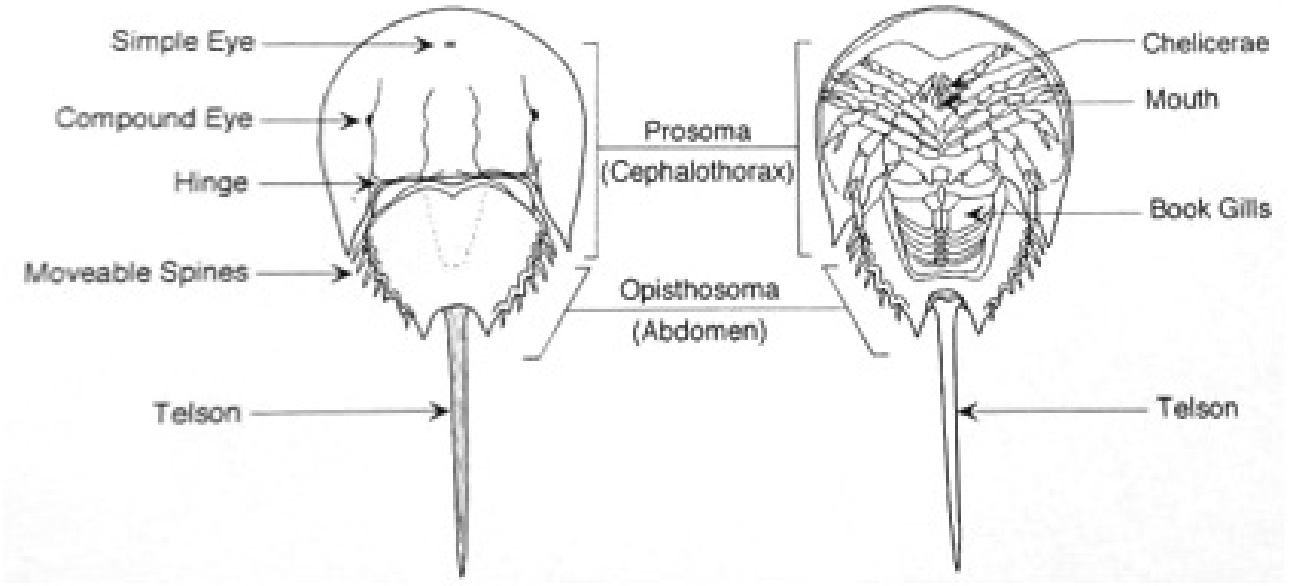
Chatterjee, A and S.A.H. Abidi. 1993. The Indian Horse Shoe crab- A living fossil. Journal of Indian Ocean Studies 1: 43-48.

Carpenter, K.E. and Niem, V.H. (eds). 1998. FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, crustaceans, holothurians and sharks. 687-1396 p.

Dev Roy, M. K. 2013. Diversity and Distribution of Marine Brachyuran Crab Communities Inhabiting West Coast of India.In K. Venkataraman et al. (eds.), Ecology and Conservation of Tropical Marine Faunal Communities. 147-169.

Ehlinger, G. 2011. *Limulus polyphemus*- "Comprehensive Description". Indian River Lagoon Species resource- © Smithsonian Marine Station at Fort Pierce.

Jeyabaskaran R and Ajmal Khan S. 2007. Diversity of brachyuran crabs in Gulf of



Horseshoe crab Anatomy

Willie Heard, 2001. ©ProjectOceanograph

Mannar (Southest coast of India). In: Biodiversity Conservation of Gulf of Mannar Biosphere Reserve (Kannaiyan S, Venkataraman K, eds), National Authority, Chennai, India. 68-82.

Josileen Jose and N. G. Menon, 2007. Fishery and growth parameters of the blue swimmer crab *Portunus pelagicus* (Linnaeus, 1758) along the Mandapam coast, India. J. Mar. Bio. Ass. India, 49 (2): 159-165.

Keenan, C.P., P.J.F. Davie, and D.L. Mann. 1998. A revision of the genus *Scylla* De Haan (Crustacea: Decapoda: Brachyura: Portunidae). *Raffles Bull. Zool.*, 46(1): 217-241.

Mohamed,K.S., Zacharia, P. U., Maheswarudu, G. Sathianandan, T.V, Abdussamad, E. M., Ganga U., Pillai, S.Lakshmi, Sobhana, K.S, Nair, Rekha J, Josileen, Jose, Chakraborty Rekha, D., Kizhakudan Shoba Joe and Najmudeen, T. M. 2014. Minimum Legal Size (MLS) of capture to avoid growth overfishing of commercially exploited fish and shellfish species of Kerala. *Marine Fisheries Information Service; Technical and Extension Series*, 220: 3-7.

Ng, P.K.L. 1998. FAO species identification guide for fishery purposes – Crabs – Portunidae.

Ng, P.K.L., D. Guinot and P. J. F. Davie. 2008. Systema brachyurorum: part I. An annotated checklist of extant brachyuran crabs of the world. *The raffles bulletin of zoology* 17:1–286.

V. Patankar, V. and E. D'souza. 2012. Conservation needs of the coconut crab *Birgus latro* on the Nicobar Islands, India Fauna & Flora International, Oryx, 46(2), 175–178.

Radhakrishnan, E.V., Mary K. Manisseri and G. Nandakumar. 2007. Status of research on crustacean resources. In: Mohan Joseph Modayil and N.G. K. Pillai (Eds.) *Status and Perspectives in Marine Fisheries Research in India*, Central Marine Fisheries Research Institute, Kochi : 135-172.

Stephenson W. 1972. An annotated check-list and key to the Indo-West Pacific swimming crabs (Crustacea:Decapoda: Portunidae).Bulletin of the Royal Society of New Zealand,10:1-64.

Zaldívar-Rae, J., R.E. Sapién-Silva, M. Rosales-Raya, and H. J. Brockmann. 2009. American horseshoe crabs *Limulus polyphemus* in Mexico. In: Biology and Conservation of Horseshoe Crabs. J. Tanacredi, M. Botton, and D. Smith (eds.). Springer Science. Pp. 97-113.