9. These are ammonotelic animals
10. Air bladder is present in many species
11. Bony fishes are usually oviparous. Few are viviparous. (eg. *Gambusia*, *Labestis*)

Class osteichthyes is divided into two sub-classes.

1. Crossopterygii (Lobe — finned fishes)
2. Actinopterygii (Ray finned fishes)

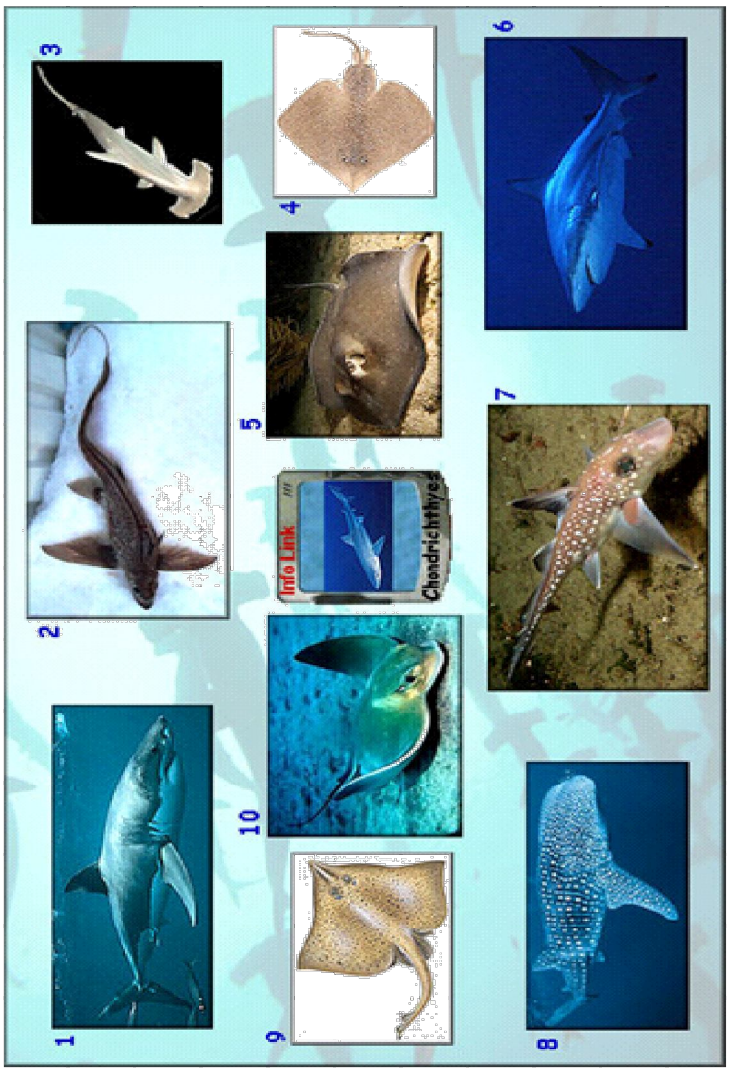


Fig 2.2 Eg. Scolidon (shark), Pristis (Saw fish), Sphyrna (hammer-head shark) Torpedo (Electric ray)

Sub class Crossopterygii

1. First vertebrate animals in which nasal passage connects the mouth cavity to the out side (Osteolepids and lung fishes)
2. Each paired fin is provided with large median lobe and dermal finrays arising on either side of an axis in a pinnate fashion.
3. Caudal fin is diphycercal. Fins are paired and having a scale covered lobe.
4. Lungs are formed by the vertral evaginations of the pharynx.Sub class crossopterygii is divided into two order.

Order Rhipidistia

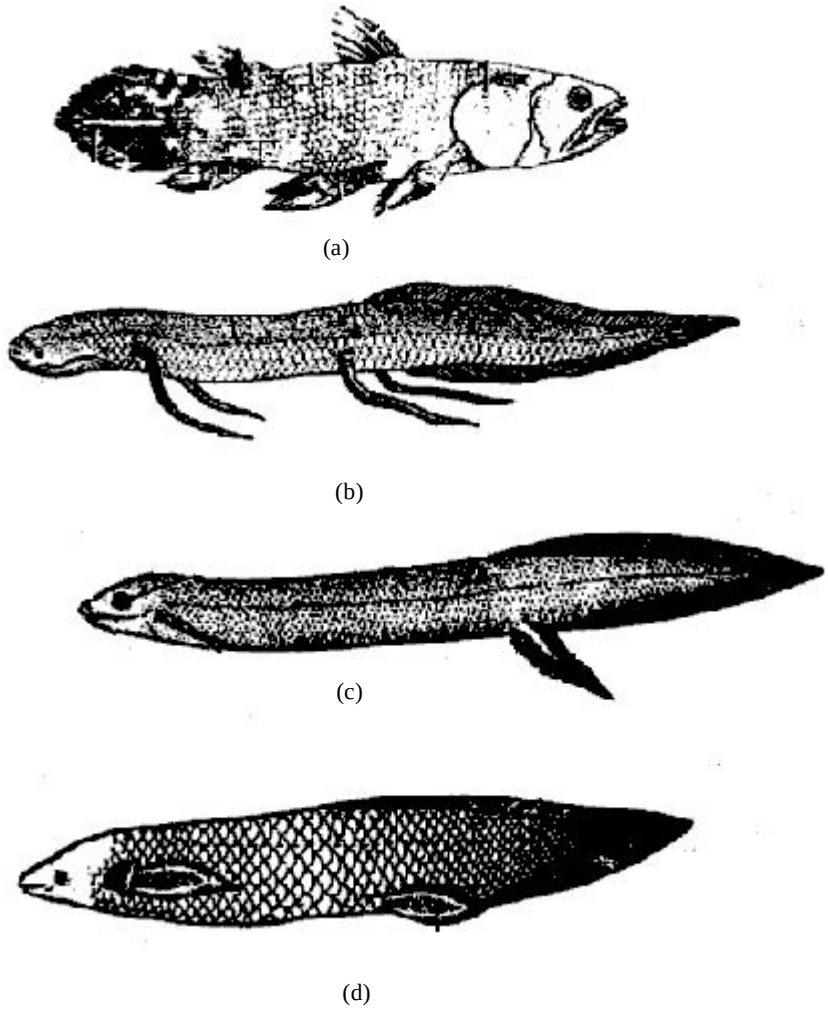
1. These are marine animals
2. Pectoral and pelvic fins are lobed and paddle-like
3. Skin is covered by cycloird scales
4. Spiral valve intestine is absent
5. Includes extinct Osteolepids which had internal nostrils and considered to be ancestors of amphibia and the living fossil fishes coelacanths, eg. *Latimeria chalumnae.*

Order Dipnoi (Lung Fishes)

1. These are fresh water anima1s
2. Body is long and slender
3. Jaws are short, teeth form a pair of plates
4. Pectoral and pelvic fins are slender
5. Skin is covered by cycloid scales
6. Spiral valve in Intestine in present
7. Internal nostrils and one or two lungs and pulmonary arteries and veins are present Eg. Protopterus, Lepidosiren, Neoceratodus.

Sub class Actinopterygii

1. Internal nostrils are absent
2. Paired fins are supported by fin-rays arranged in a palmate fashion.



(a)

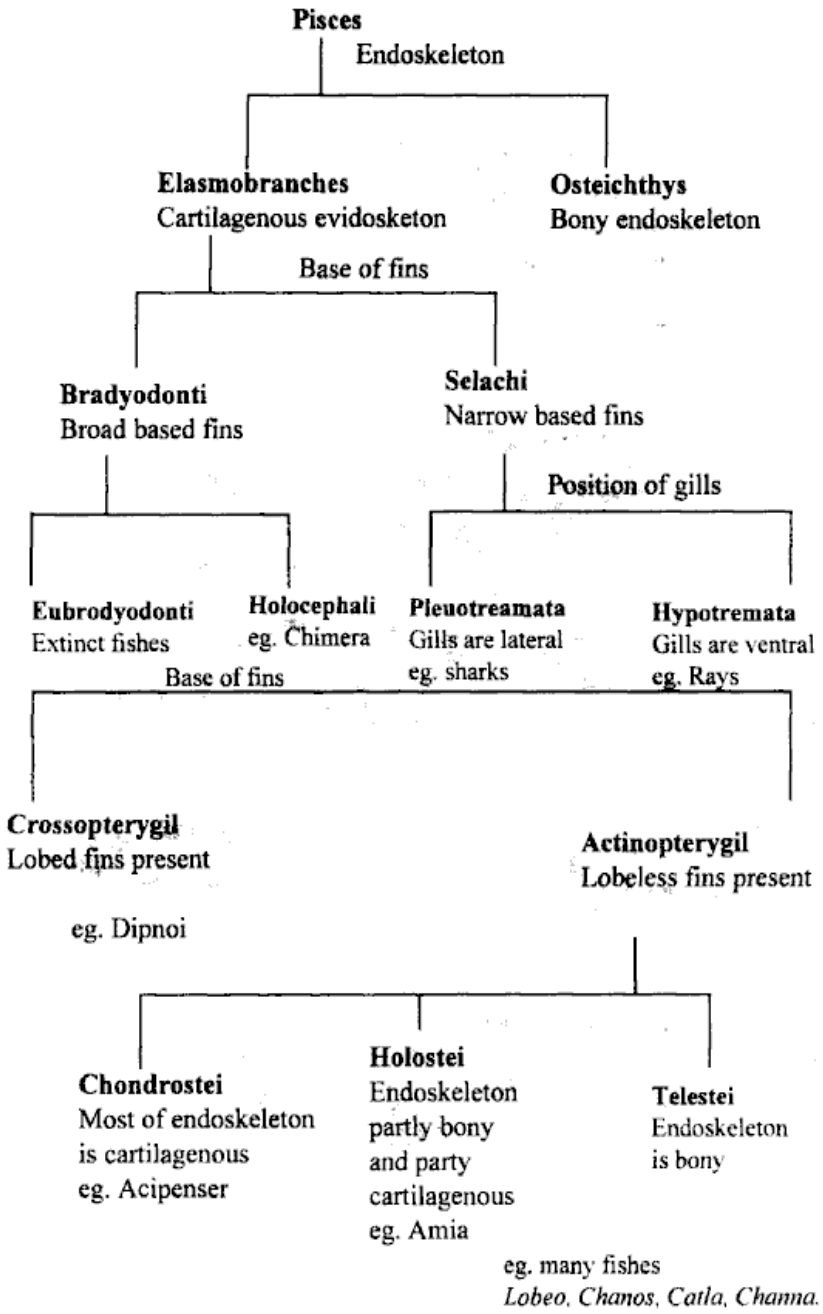
(b)

(c)

(d)

Fig 2.3 Lobed fin fishes
a. Latimeria b. Protopterus c. Lepidosiren d. Neoceratodus

CLASSIFICATION OF FISHES



3. Caudal fin is homocercal

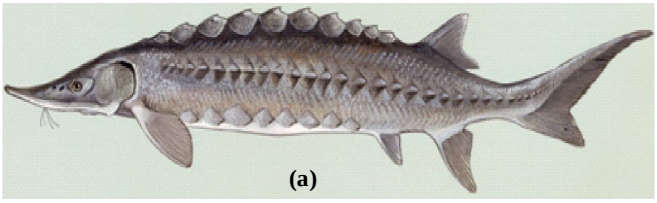
4. Lungs are absent. An air bladder or swim bladder or gas bladder is presen which is hydrostatic in function.

Sub class Actinopterygii is divided into the three superorders

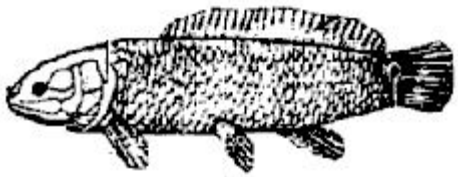
1. Chondrostei 2. Holostei 3. Teleostei

Super order Chondrostei

1. These are fresh water fishes
2. Weak jaws without teeth
3. Endoskeleton is cartilagenous
4. Exoskeleton consists of bony plates covering the body.



(a)



(b)

Fig 2.4 Primitive actionopterygian fishes. a. Acipensor b. Amia

5. Tail is heterocercal
6. Spiral valve is present in the intestine
7. Air bladder with duct is present.Eg.*Acipenser* (Sturgeon), *Polyodon.*

Super order Holostei

(Gr. Holo- complete; osteo=bone)

1. These are known as bow fins.
2. There are found in fresh water of America.
3. Endoskeleton is bony.
4. An air bladder is present above the oesophagus
5. Spiral valve is present in the intestine
6. Air bladder is present with a duct Eg. *Amia, Lepidosteus*

Super order Teleostei

(Gr. Teleo = entire, osteo=bone)

1. Includes a large number of modern bony fishes. Skeleton is fully ossified
2. These are occur in fresh water as well as in sea

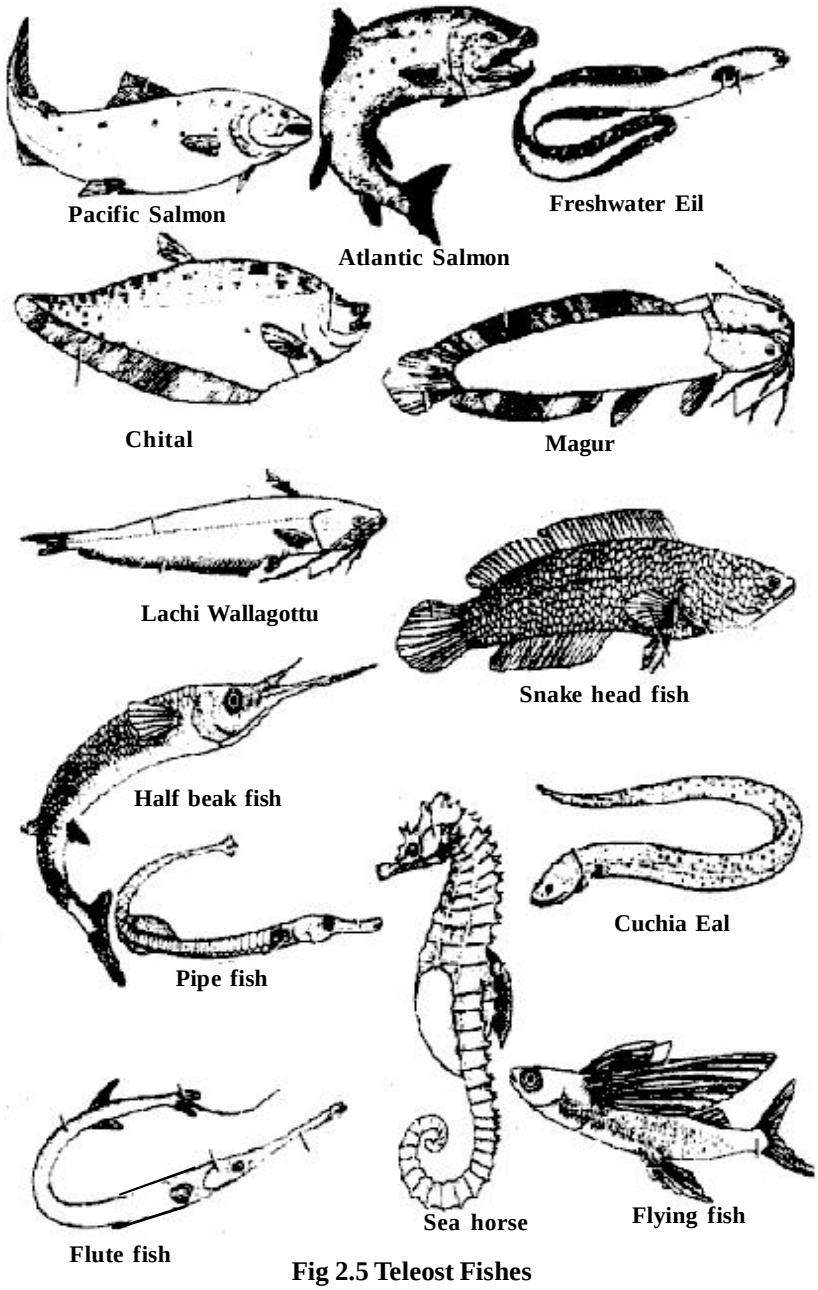


Fig 2.5 Teleost Fishes

Super order Teleoslei is commonly known as advanced ray finned fishes. They are modern fishes. Teleostei is divided in to 30 orders. Some important orders and their examples are listed below.

1. Anguilliformes : eg. *Anguilla* (Eel)
2. Siluriformes : eg. *Wallago attu* (cat fish)
3. Cypriniformes : eg. *Labeo rohita* (Ruhu)
4. Syngnathiformes : eg. *Hippocampus* (Sea horse)
5. Beloniformes : eg. *Exocoetus* (Flying fish)
6. Perciformes : eg. *Anabas* (Climbing perch)
7. Tetradontiformes : eg. *Diodon* (Porcupine fish)
8. Lophiiformes : eg. *Lophius* (Angler or fishing frog)
9. Pleuronectiformes : eg. *Solea* (Flat fish)
10. Channiformes : eg. *Channa* (Murrel)
11. Clupeiformis : eg. *Chanos* (Milk fish)

2.3 Classification and general characters of Prawns

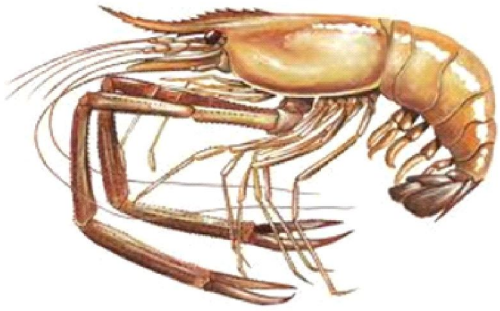


Fig. 2.6 Macrobrachium Resenbergii

Phylum ; Arthropoda

Class : Creustacea

Order : Deca poda

Prawns and shrimps are decapode crustaceans. They are aquatic, and respire with gills. Prawns are freshwater and shrimps are marine crustaceans.

1. Prawns are freshwater animals eg. *Macrobrachium resenbergii, molcolmsonii*. Shrimps are found in both sea and brackishwater eg.

Penaeus monodon, P. indicus, Metpenaeus dobsoni

2. **Symmetry** : These are bilaterally symmetrical.

3. **Coelome** : There are eucoelomates and schizcoelic animals. The coelome is known as haemocoel due to the presence of blood in the coelome.
4. These are triploblastic animals.
5. **Segmentation** : Segmentation is heteronomous and external.
6. **Shape** : Body is elongated, more or less spindle shaped. Abdomen region is in cama (,) shaped.
7. **Size** : The size of adults varies from species to species. The largest prawn (32 cm) is gainst freshwater prawn, *Macrobrachium rosernbergii*. Largest shrimp is *penaeus monodon*.
8. **Body farm** : The body is divided into cephalothrax and abdomen. Cephalothorax is the fusion of head and thorax and consists of 13 segments. Abdomen consists of 6 segments.
9. **Exoskeleton** : Body is covered by a hard protective calcareous plates, known as sclerites. Sclerites are made up of chitinous cuticle. Adjacent sclerites are connected by thin arthroidal membrane, making the movements feasible.
10. **Rostrum** : The sclerites of dorsal (terga) and lateral (pleura) form a laterally compressed and serrated rostrum. The separations of rotram are called denticles which play a major role in identification of species. The denticles are found both dorsally and ventrally as in *Penaeus*_sp or only dorsally as in *Metapenaeus* sp.
11. **Appendages** : Each prawn has 19 pairs of joitned appendages, each pair attached to a segment. They may helpin sencery and feeding, walking and swimming.
12. **Telson** : Last abdominal segment consists of an elongated sharp spine known as Telson.
13. **Integument** : The integument Consists of outer epicuticle, inner endocuticle, epidermis and dermis composed of connective tissue layer with muscle strands and many tegumental glands.
14. **Endoskeleton** : It is absent in prawns.
15. **Digestive system** : Complete alimentary canal, mouth is large and slit-like, stomach is thin-walled and double-chambered, consisting of cardiac and pyloric stomachs. Intestine is a long and narrow tube. Hepatopancrease is a large, bilobed and produce digestive enzymes.

Prawns are deteritivores, feed on debris of bottom, phytoplankton and zooplankton. Intercellular digestion.

16. **Respiratory system**: Branchial respiration by gills. Respiratory system is well developed .

17. **Blood vascular system** : Open or lacunar type of blood vascular system. Blood capillaries are absent and blood flows through the lacunae or sinuses .Heart is neurogenic muscular and triangular in shape. Blood is colourless with leucoçytes and without erythtocytes. The respiratory pigment is haemocyanin Prawn blood has remarkable clotting properties.

18. **Excretory system** : The excretory organs are antennary or green glands, renal or nephroperitoneal sac and integument. Prawns are ammonotelic animals.

19. **Nervous system** : Brain is in the form of supra-oesophageal ganglia. Ventral thoracic mass is found in cephalothorax and a ventral nerve cord is found, sympathetic nervous system is in the form of ganglia and nerves.

20. **Sense organs** : Compound eyes, statocysts, tangoreceptors, chemoreceptors and proprioreceptors are sense organs found in prawns. Eyes are located on ommatophore. Mosaic vision and apposition image are found in prawns.

21. **Endocrine system** : The sinus gland of eye stalk produce growth or moulting inhibitory hormone

22. **Reproductive system** : Prawns are dioecious and sexual dimorphism is well marked. Males are bigger than females. Second chelate legs of males are longer, stronger, stouter and more spiny than in female. Second pleopods of males bear appendix masculine. Gonads are paired. Fertilization is external. The fertilized eggs are placed in thelcum and prawn with fertilized eggs are known as berried prawn. Indirect development, first larval farm is naupleus, second larval form is protozoa, third larval farm is mysis, which developed into post larvae.

23. **Moulting** : Prawns undergo the moulting or ecdysis. During this process, the growth of prawn takesplace.

24. **Migration** : Prawns exhibit breading and feeding migration. Freshwater prawns exhibit breeding migration, migrate from freshwater to brackishwater and back to freshwater. Marine shrimps exhibit feeding migration, migrate from sea to brackishwater.

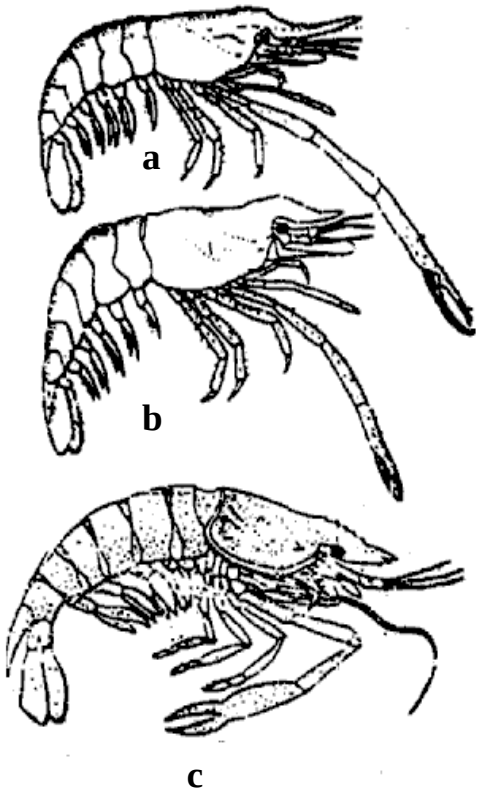


Fig. 2.7a. Freshwater prawns

(a) Macrobrachium rosenbergii

(b) M.molcolmsonii

(c) Palaemon tenuipes

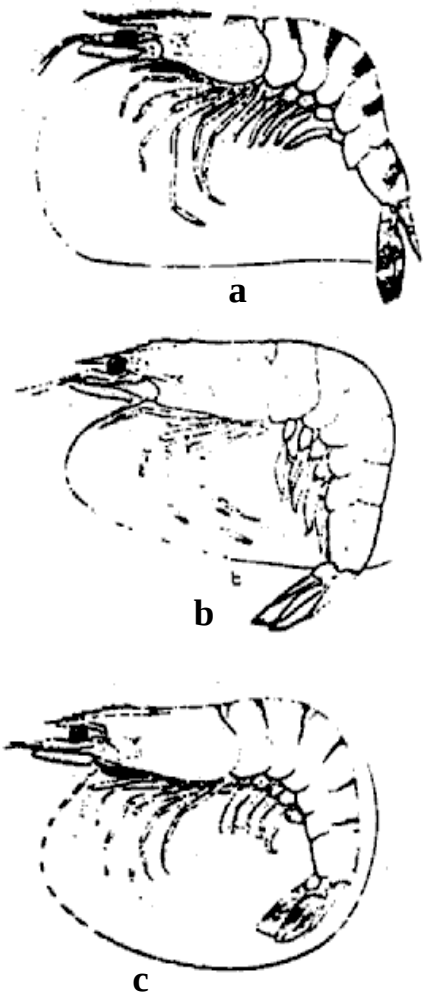


Fig. 2.7 b. Brackishwater prawns

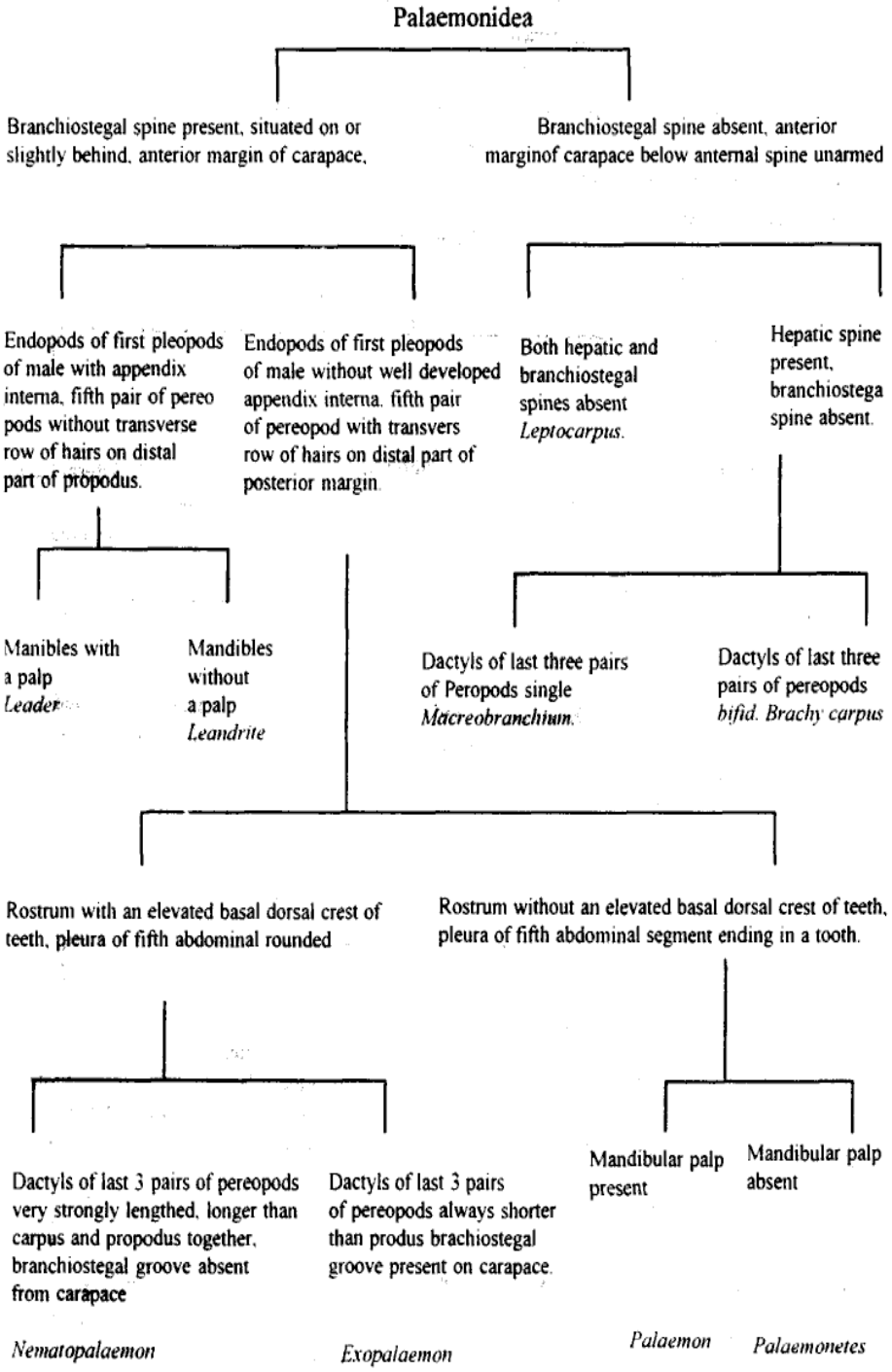
a) Penaeus monodon

(b) P.indicus

(c) P.semisulcatus

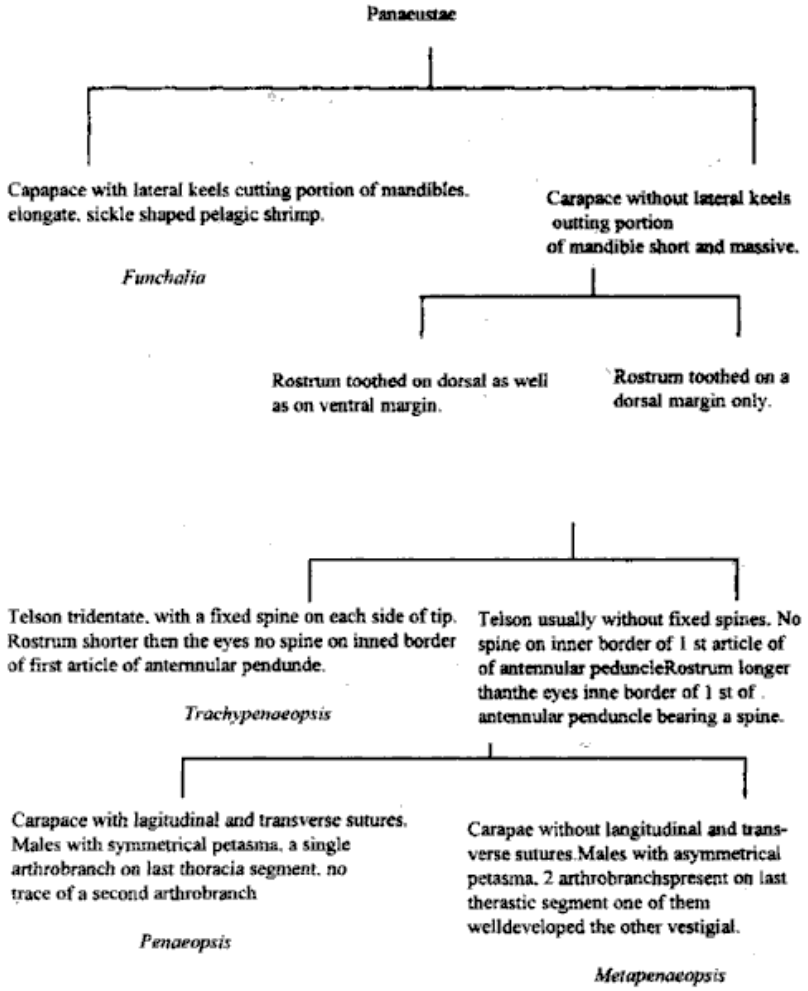
Classification of Prawns

2.3.1Key to the identification of genera from family palaemonidea



Key to the identification of different generaiof family penaeudae.

- Rostrum tooth are well developed
- carapace without postorbital spine and with a short carvical groove ending well below dorsal midline.
- Last two pairs of pereopods well developed.
- Third two pairs of pereopods well developed.
- Endopods of second pair of pleopods in males bearing appendix masaulina only (lacking of appendix interna and muscular projection)
- Last three pleurae are keeled dorsally
- Telson sharply pointed.



1. Exhibits great diversity in their structure and shape
2. Skin in covered by cycloid or cteniod scales
3. Mouth in small. Tail is symmetrical or homocercal
4. Four pairs of gill slits are present. Spiracle is absent
5. Air bladder is present, having hydrostatic function
6. They are ammonotelic animals
7. Spiral valve is absent in intestine
8. Heart has bulbous arteriosus in place of conus arteriosus

2.4 Meristic characters and measurements, Meristic Counts

Meristic charecters are countable charecters i.e. counting of Finerays, Barbles, etc.Fishes can be identified up to species level with the help of marphometric and meristic characters.

Body Measurements

For the identification of fishes body measurement and fin formula are most important. With the help of the above the fish can be identified up to species level easily. The following are the different measurements used for fish identification.

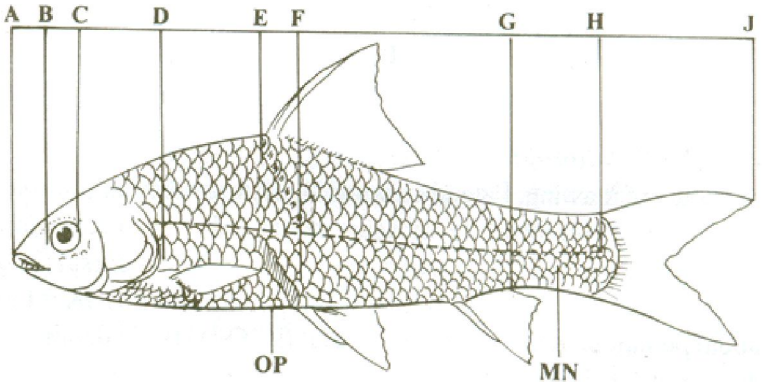


Fig 2.8 fish measurements

1. Total length (A-B): It is measured from tip of the snout to end of caudal fin.
2. Standard length (A-C): It is measured from tip of the snout to base of the caudal fin.

3. Head length (A-D): It is measured from tip of the snout to end of opercu lum.

4. Snout length (A-E): It is measured from tip of the snout to the anterior margin of the eye.

5. Predorsal length (A-F): It is the distance between tip of the snout to origin of the dorsal fin.

6. Pre pectoral length (A-M): It is the distance between tip of the snout to origin of pectoral fin.

7. Pre pelvic length (A-N): It is the distance between tip of the snout to origin of pelvic fin.

8. Pre anal length (A-P): It is the distance between tip of the snout to origin of anal fin.

9. Length of caudal peduncle (G-C): It is the distance measured from the posterior base of the anal fin up to origin of caudal fin.

10. Height of the caudal peduncle (J-K): It is measured vertically through the body at caudal peduncles narrowest part.

11. Height of the body (H-I): It is measured vertically through the body at its deepest part.

12. Diameter of Eye (E-L): It is measured from one margin of the orbit to other.

13. Inter orbital length: It is distance between two orbits on dorsal surface.

14. Fin meeasurements: The lenght of pectoral fin, pelvic and caudal fin is measured long their longest fin ray.

15. Profile of the body: It gives the outline of the body of fish, along its dorsal and ventral surfaces.

16. Barbles: The number of barbles ranges from 1-4 pairs. These are named according to their position as nasal, rostral, maxillary and mandibular.

17. Branchiostegal rays: These are slender bony rods found on inner sur face of operculum.

18. Lateral line (L.l): This line is found on both the lateral sides of the body. It is a longitudinal row of perforations of sense organs. It may be com plete, incomplete or interrupted.

19. Scales: The scales are supposed to be identify card of fish. These are also useful in identification of fish up to species level. The scales are counted along the lateral line and their number is written after the abbre viation as Ll. In case the lateral line is absent, the scales are counted along the row where the lateral line might has been located and their number is written after the abbreviation as L.r. the transverse rows of scales are counted from the anterior base of dorsal fin to the ventral line and their number is mentioned after the abbreviation as L.tr. In this case the scales above and below the lateral line are separated by an oblique (/) stroke. Pre dorsal scales are counted from anterior extremity to the origin of dorsal fin.

20. Fin formula: Fin formula is constructed after counting the fin rays of pectoral(P), Pelvic(V), Dorsal(D), ANAL(A), and caudal(C) fins and lateral line scales. This formula provides scientific information to con firm the actual identity of a particular fish. The number after the abbre viation of fin denotes number of fin rays. An oblique (/) stroke indicates the spiny and soft rays of fin. The vertical stroke indicates the separa tion of two fins, ex rayed dorsal and adipose dorsal fins.

Short Answer Type Questions

1. Write two important characteristics of Elasmobranche fishes
2. Define sexual diamorphism in fishes. Give one example.
3. What are lung fishes. Give examples.
4. Define Ammonotelic animals. give one example
5. Which types of scales present in sharks
6. What are the paired fins in fishes.
7. What are the vitamins present in Fishes.
8. Mention the uses of Caudal fin Fishes.
9. Write the modifications of fishes for aquatic life.
10. Mention the uses of Lateral life organ in fishes.

Long Answer Type Questions

1. Describe the general characters of fishes.
2. Discuss the general characters of prawns.

3. Give the detailed account of classification of fishes.
4. Write down the classification of bony fishes.
5. What are the differences between Condricthes and Ostichhs fishes.
6. Write about the Dipnoi fishes with examples.

UNIT 3

Ecosystem

Structure

3.1 Introduction to Ecosystem

3.2 Types of Ecosystems and Biotic and Abiotic Systems.

3.3 Energy flow in Ecosystems

3.4 Food chains and Food web

3.5 Trophic levels of Ecological piramids

3.6 Productivity of Ecosystem

3.7 Limnology of Pond Ecosystems

3.1 Introduction to Ecosystem

Ecology embraces an interrelationships of organisms with the environment, the organisms and environments in a single location constitute *ecosystem* (Tansley, 1935). Ecological system or ecosystem comprises specific unit of all the organisms occupying a given area thereby producing distinct tropic structure, biotic diversity and material cycles. The term ecosystem was first of all coined by A.G. Tansley (1935) and defined it as an "integrated system resulted from interaction of living and non-living factors of the environment". As the term *ecosystem* indicates *'eco'* meaning environmental and "system" implying an interacting inter-dependent complex. Thus ecosystem may be defined as any

unit which includes all the organisms (i.e., communities) in a given area, which interacts with the physical environment resulting in the flow of energy and biotic diversity as well as material cycle.

Ecosystem is the basic functional unit of ecology embracing biotic communities and abiotic environment both influencing each other. Every ecosystem encompasses interacting organisms that transform and transmit energy and chemicals.

In nature, different types of ecosystem exist constituting giant ecosystem so called biosphere. There are mainly two categories:

1. Natural ecosystem: These operate under natural conditions independently without any major interference by man. into terrestrial type (e.g. grassland, desert, forest, etc.) and aquatic including freshwater (ponds, rivers, etc.) and marine (sea, estuary, etc.) ecosystems.

2.**Artificial ecosystem**: These are man-made ecosystem being maintained by artificial means. In them, natural balance is disturbed by addition of energy and planned manipulations. Cultivation of crops (maize, rice, wheat crops) represents man-made ecosystem.

Ecosystems are also classified into terrestrial and aquatic ecosystems.

Aquatic ecosystems are usually, divided into

(i) fresh water

(ii) marine water, and

(iii) estuarine water.

There are two categories of fresh water ecosystems (a) lentic or standing or stagnant water including ponds, lakes and reservoirs (b) lotic or running Water are those which occur in fast running streams, springs, rivers and brooks. Fresh water ecosystems have low percentage of dissolved salts. They have fluctuating physical and chemical factors affecting the flora and fauna.

3.2 Types of Ecosystem and Biotic and Abiotic Components

3.2.1 Pond Ecosystem

A pond as a whole serves a good example of a freshwater ecosystem. A pond indeed exhibits a self-sufficient, self-regulating system. This would become clear if you examine a bottle full of pond water or a scoop full of bottom mud, which shall show the living organisms (plants as well as animals) and a mixture of inorganic and organic compounds. Some larger forms of life are also present in

pond. Thus, whole system becomes much complex indeed. However, we may study the pond as an ecosystem by making its convenient division in some basic components, as shown in Figure 3.1 These components are as follows.

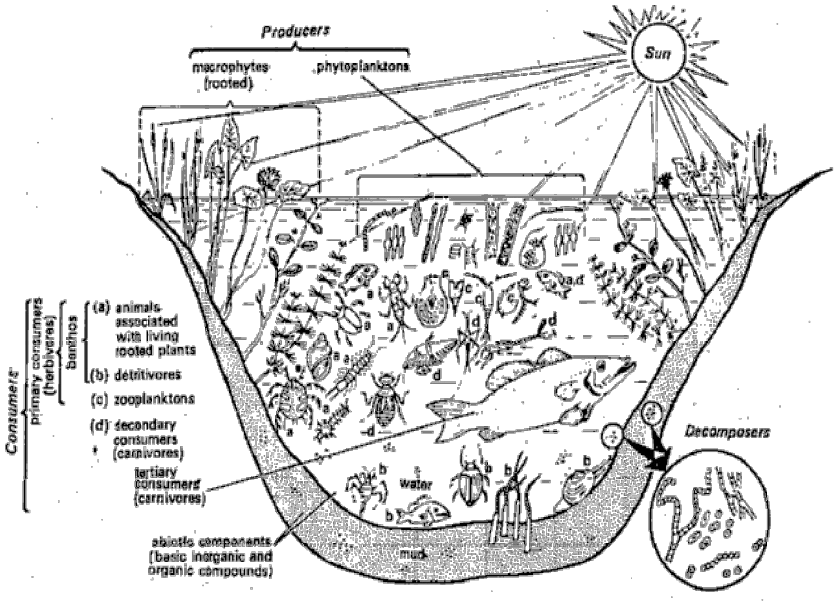


Fig. 3.1 Diagram of the pond ecosystem, showing its basic structural units- the abiotic (inorganic and, organic compounds) and biotic (producers, consumers and decomposers) components.

Abiotic Components

The chief substances are heat, light, pH value of water, and the basic inorganic and organic compounds, such as water itself, carbon dioxide gas, oxygen gas, calcium, nitrogen, phosphates, amino acids, humic acid etc. some proportions of nutrients are in solution state but most of them are present as stored in particulate matter as well as in living organisms. . Amounts of various organic compounds (carbohydrates, proteins, lipid etc.) are also estimated for biomass determination.

Biotic Components

The various organisms that constitute the biotic component are as follows:

Producers

These are autotrophic, green plants-and some photosynthetic bacteria. The producers fix radiant energy and with the help of minerals derived from the water and mud, they manufacture complex organic substances as carbohydrates, proteins, lipids etc. producers are of the following types

i. Macrophytes

These are mainly rooted larger plants which include partly or completely submerged Eg.*Trapa, Typha, Eleocharis, Sagittaria, Nymphaea, Potamogenton, Chara, Hydrilla, Vaillisneria, Utricularia, Marsilea, Nelumbo* etc. Besides them some free-floting forms as *Azolla, Salvinia, Wolffia, Eichhornia, Spiroclella,*. etc. also occur in the pond.

ii. Phytoplanktons

These are minute, floating or sustpended lower plants. Majority of them are such filamentous algae as *Zygnema, Ulothrix, Spirogyra, Cladophora* and O*edogonium.* Besides them there are also present some *Chiorococcales, Closterium, Cosmarium, Eudorina, Pandorina, Pediastrum, Scendesmus, Volvox, Diatom, Anabaena, some chroococcajes, Gloeotrichia, Microcytstic, Oscillotoria, Chiamydonionas, Spriulina* etc. and also some flagellates.

Consumers

They are heterotrophs which depend for their nutrition on the organic food manufactured by producers, the green plants. Most of the consumers are herbivores, a few as insects and some large fish are carnivores feeding on herbivores. Some fish also feed on other carnivores as well. The consumers in a pond are distinguished as follows:

Primary consumers (herbivores)

Also known as primary macroconsumers, these are herbivores feeding directly on living plants (producers) or plant remains.

These may be large as well as minute in size. The herbivores are further differentiated as:

(i) **Benthos**: These are (i) the animals associated with living plants (producers), (ii) thos bottom forms which feed upon the plant remains lying at the bottom of pond. These are known as detritivores, labeled as 'b' in the diagram. Benthic populations include fish, insect larvae, beetles, mites, mollusks, crustaceans etc. weight of benthic fauna is estimated in different zones of the pond, and the biomass expressed as g/m^2 of water.

(ii) **Zooplanktons**. These are chiefly the rotifers *as Brachinous, Asplanchna, Lecane* etc., although some protozoans as *Euglena, Coleps, Dileptus* etc., and crustaceans like *Cyclops, Steno cypris* etc. are also present. They feed chiefly on phytoplanktons.