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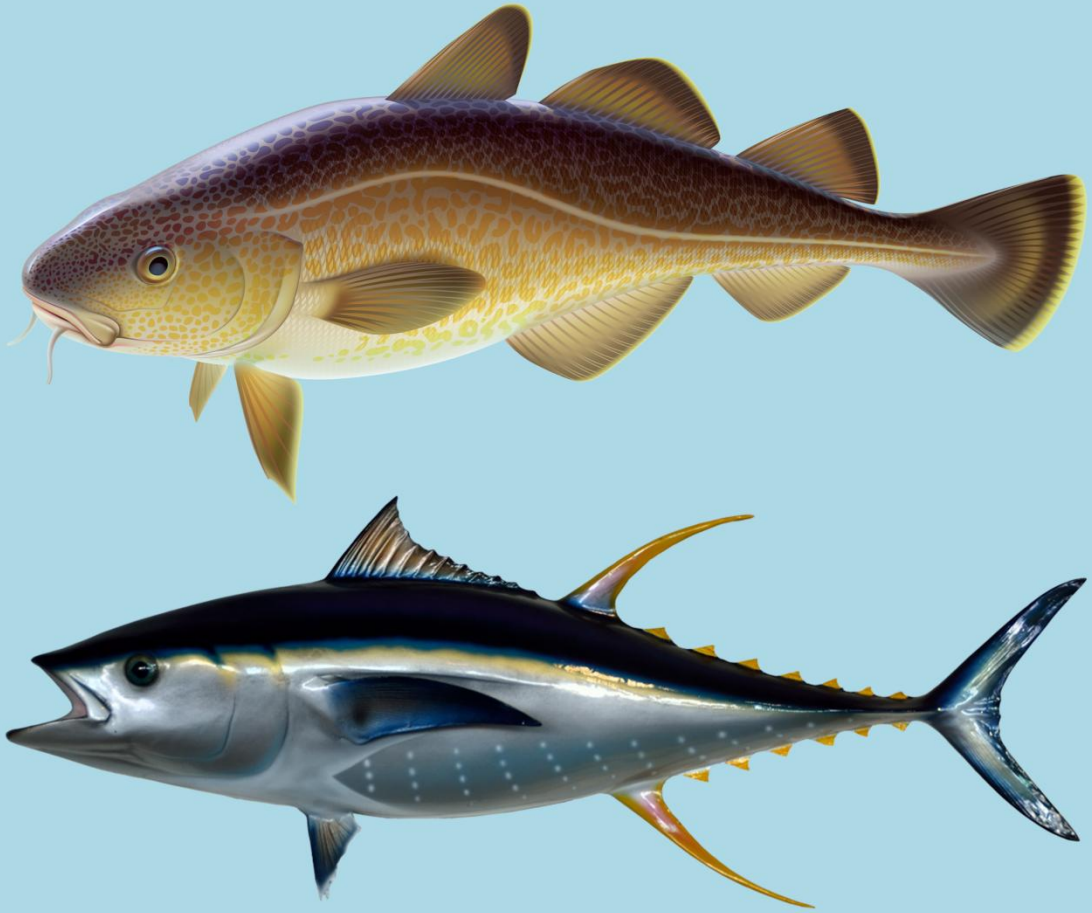
Fish Biology



Gayatri Shankarrao Madakai

Madhuri Dharmendra Sawant

Priyanka Vilas Ramgude

Prof. Dr. Vishwas Yashvant Deshpande

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PREFACE

We are very happy to present the book 'Fish Biology'. This book has been conceptualized and published with an intention to help & enhance interest in students to get a basic knowledge about fish & fisheries.

Recently, the fishery business has been playing an important role in the Indian economy as it provides earning & employment to millions of fishermen & farmers including coastal states and other regions.

We observed that science students are unable to understand the fishery subject due to lack of knowledge of basic concepts related thereto. We, authors of this book, desire to introduce the fishery subject in simple and basic language along with the diagrams, paints & level of the topics designed to match typical course of fishery syllabi.

We hope this book will be helpful to undergraduates, graduates, farmers and the general public who are looking for information on a wide variety of topics in fisheries science. This book is also aimed at researchers who need up-to-date reviews of topics that intrude on their research field but may not be central to it. The information should also be useful to managers and decision makers who need to appreciate the scientific background to the resources they are trying to manage and conserve.

This book contains the topics of fish and technology in fisheries which elaborates the relations between students and fisheries concepts.

We would like to express our gratitude to the Department of Zoology & Fisheries, Yashwantrao Chavan Institute of Science, Satara (Autonomous) and Prof. Dr. V. Y. Deshpande for extending their valuable guidance & directions to design and conceptualize this Book.

We wish the students all the best future.

Author

Introduction to Fisheries

Fishes are cold blooded vertebrates which are adapted to aquatic habitat by means of gills for respiration and fins for locomotion. The branch of applied biology which deals with study of breeding, development and modern fishery methods & processing is known as 'Fisheries'.

The main objective of fishery science is to use fish as food for man. The food sources from agriculture are not rapidly increasing in proportion to the rapid growth of human population, hence there is scarcity of protein rich food and hence aquatic animals are used as food. Fresh fish is easily digested, tasty and nutritious. It is rich in proteins, all essential amino acids, minerals, vitamins and iodine constant also. Hence fishes are mainly used as food by people. In the foreign countries like England, /Germany, Burma, Japan etc generally about 10-12 kg of fishes are consumed per head by the people but in India per head consumption of fishes is less than 5 kg. Primary fishery start from capture of fish with the help of gears. But cultural fisheries are recent development which has great significance in the fresh water and marine water habitat of in India.

History of Fisheries:

The agricultural farming and fisheries have evolved rather parallel in the history of human civilization. It is believed that hunting or catching of fish was common in pre-historic times in the late Old Stone Age (i.e. 40,000 years B.C.). At the residential places near rivers, lakes and ocean fin fishes & shell fishes have been found in large number. In that period fishes were preserved by primitive older method such as sun drying & smoke drying method.

At the new Stone Age (10,000 years B.C.) evidence of Salmon fish show the history of fishing. At the Bronze Age (3500 year B.C.) fish capturing tools were developed and by our ancestors and salting method was applied for storage or preservation. In Roman and Greek civilization, fishes became important food of poor and rich people. In the Iron Age (about 1000 years B.C.) it became great fishing trade, in capturings, dried, smokes & salted fishes were common. In the middle age (about 500- 1500 A.D.) Herring fisheries were common in Antarctic Ocean. The Chinese were first human to use ice for fish preservation. In England fish preservation by ice was commonly used, while in 19th century scientific consideration of fishery industry was started after world war-I. Sudden mere shortage of has occurred, so that firstly keen interest taken in study of nutritive value of fish. Recently modern fishery science has emerged out as a result of mixture of different basic sciences such as ecology, biochemistry, toxicology, microbiology, pathology and economic.

History of Indian Fisheries:

In India interest in fish and fishery dates back to the Third Millennium B.C. and evidences of fish being used as food are available from excavations of the Indus valley civilization in 1127 AD. The son of king Vikramaditya king Somesvara composed a book recording the common sport fishes of India and grouped them into marine and riverine forms.

As early as in 1822 Hamilton Buchnan gave an excellent, illustrated taxonomic account of the 'Fishes of Gangetic System' & removed various confusion caused by regional names of fishes. After Hamilton, the epoch making contribution of Francis Day's 'Fishes of India' (1878) and 'Funa of British India', Burma and Ceylon (1889).

The credit for developing a sustained interest in highlighting the rich India Piscian fauna largely goes to Rai Bahadur and Dr.Sunder Lal Hora, formal Director of Zoological Survey of India. They contributed to study of taxonomy on ecological bias and while doing so a long series of paper have been published.

J. S. Dutta Munshi and M. P. Srivastava of Bhagalpur University recently brought out and exhaustive treatise on 'Nature history of fishes and systematic of fresh water fishesh of India (1988).

Based on many researches on fishery science a brilliant monograph on fish culture in India was brought out in 1957 by K.H.Alikunhi. It was in1975 when a comprehensive volume on fish and fisheries of India was authored by Dr. V.G Jhingaran, the director, CIFRI Barrackpore (W.B) this book has Painstakingly blended into an integrated great mass of scientific knowledge on India fishes and fisheries accumulated over decades.

Inland Fisheries:

In India there is about 3.3 millions sq. hector area of the water bodies. In India fisheries activities were mainly carried out in stream, pond, lake, reservoir, and rivers and estuarine. The fishes, arthropods and mollusks are mainly capture from the fresh water bodies which is called as 'capture fisheries'. Culture fisheries are also carried out in fresh water bodies which form inland culture fisheries.

Inland Capture Fisheries

The collection of live or just killed fishes by use of the crafts and gears is known as 'capture fisheries.' In India and other countries capture fisheries is carried out in fresh water bodies such as stream, lake, river and reservoirs. Presentat the mouth region of rivers about 50% of Indian population consumes or eat fish. In India capture fisheries is also important because it

contributes about 30% of total fish catch. Such captured fishes are preserved or processed and sold in the local markets in the rural and urban areas.

In India, inland fisheries are carried out in five major larger rivers on the large scale such as:

1. Ganga river system
2. Brahmaputra river system
3. Indus river system
4. East coast river system
5. West coast river system

In India about 3,000 large reservoirs are also used for capture fisheries. Recently in the fresh water bodies some exotic species of the fishes are also released which are having faster growth rate. The exotic species like Grass carps, Silver carps, Cyprinus species, Tilapia were used & reared.

For inland capture fisheries, various type of crafts are used such as rafts, dugout canoe, outrigger canoes and mechanized trawlers are used, while gears used are cast net, gill net, Rampani net, Trawl net are generally used for catching the fishes. The captured fishes are generally cleaned, ice preserved and sold in the market. Generally following fishes are captured in the fish water bodies.

Major carps: *Labeo rohita, Catla catla, Cirhinus mrigala, Grass carps, Silver carp etc.*

Cat fishes: *Clarius, saccobranchus, Rita rita, Wallago attu etc.*

Anguilla anguilla, Salmon fish, Milk fish, Cat fish, Tilapia

Marine Capture Fisheries

Marine fisheries mean where the species spend all or part of life cycle in marine water. Marine fisheries exist primarily in the oceans and particularly around coasts and continental shelves.

India has very long coastal line about 7,500 km long. There are about 1200 km fish catching center along the coastal line. Most of the southern part of India is surrounded by marine water. Generally, west coast is more productive than east coast of India. The three major oceans of the world are the Pacific, The Atlantic & Indian Ocean. There are more than 21,000 species of fish which most live in the Oceans.

Coastal Fisheries of India:

Catch composition of fisheries along the west coast shows regional variations. The abundance of species differs from area to area. Pomphret, shark, Cat fish, Ray fish, Oyster,

Prawn are captured along the entire west coast of India, while the molluscans such as Pearl oyster found in large number along east coast.

1) Gujarat: (11 coastal districts, 176 fishing coastal villages)

Among the states of the country, Gujarat has the longest coastline (1640 km). It ranks fourth among all states in fish production. The state has excellent estuarine potential.

Fisheries:

The Gujarat coast is well known for its Bombay duck and Pomphret fisheries. Prawns are also in abundance. The coastal line between Bombay abd Kathiwar has proved quite productive for Ghol, Koth, Doma, Rawas, Dara, Karkara and Eel fisheries. Kutch region has very rich resources of Clams, Cockles, Oysters, Chank, Seaweeds, Corals etc. The important species are *Penaeus merguiensis, Parapenaeopsis stylifera, Penaeus semisulcatus* etc.

2) Maharashtra:

Maharashtra ranks second among the maritime states in marine fish production, with 5 coastal districts, 720 km coastline and 153 landing centers.

Fisheries:

Bombay duck is one of the most abundant species in state. Fishes caught mostly by dol net. Cat fishes are another important group caught by gill net, trawl net, hook and line. The dominant species are *Techysurus thalassinus, T. dussumieri, T. sona* etc.

Pomphret is one of the more important groups in Maharashtra. Ribbon fishes, Elasmobranches, Mackerel, Eel, Carangids and Seer fish were some of the other important groups in fishery of the states.

3) Goa:

The state of Goa with a coastline of 153 km. Goa has 47 fishing villages.

Fisheries:

Oil sardine, other sardine, Cat fish, Mackerel and Prawns dominated the fisheries and together contributed about 52% of the total.

4) Karnataka:

The state has coastline of 270 km. there are two coastal districts Dakshina kannada and Uttara kannada with 147 fishing village.

Fisheries:

Pelagic group include Wolf herring, Oil sardine, Hilsa, shads, Cluepoids, Bombay duck, Half beaks, Full beaks, Flying fish, Ribbon fish, Mackerel, Mullets and Unicorn cods etc.

Demersal group include Elasmbranchs, Eel, Cat fishes, Lizard fishes, Croakers, Popmhret, Lobsters, Prawns, Crabs and Cephalopods.

Karnataka coast is rich in all these groups but the dominant among them are cat fishes, Prawns, elasmobranchs, Pomphret etc.

5) Kerala:

Kerala's potential yield of marine fish is estimated at 8 lac ton. There are 304 fisheries villages spread along the nine coastal districts.

Fisheries:

26% prawns come from Kerala. Penaeus dobsonii, Penaeus indicus and Para penaeopsis are main species included in prawn culture. Coilia, Setipinna, Stolephorus, Thrissina and Thyarra are important species of Kerala. Oil sardine, Mackerel, Perches, Croakers, Seer fishes, Tunna, Elasmobranchs and Pomphret etc. included in Kerala fishing.

6) Kokan:

The Kokan coast is famous for its shoals of Mackerel which continue to dominate the coast of Karnataka and Kerala.

7) Tamilnadu:

Tamilnadu has the unique distinction of facing three major seas the Arabia sea, Indian ocean and Bay of Bengal. Total coastline of 1,000 km Fisheries: Demersal varities of fish dominate over the pelagic ones in total landing. Major fisheries included Silver bellies, other sardines, Elasmobranchs, Ribbon fishes, Prawns, Crabs and Perches.

8) Pondicherry:

There are 26 fishing villages.

Fisheries:

Pelagic varieties formed 60% of the catches and the demersal 40%. Other Sardines, Carangids, Perches, Mackerel, silver bellies, Crabs, Prawns, flying fish and Elasmobranchs were main contributors to the catch.

9) Andhra Pradesh:

With coastline of 980 km there are 9 coastal districts in state with total of 453 fishing village.

Fisheries:

Prawns, Crabs, Lobsters etc. *Metapenaeus dobsonii, M. monoceros* and *Penaues indicus* were dominated species. Cehalopods, Cluepeoids, Sardine, Pomphret, Mackerel were also captured in the state.

10) Orissa:

Orissa has a coastline of 480 km. there are four districts.

Fisheries:

Croackers, Catfishes, Pomphrets, Sardine, Elasmobranchs, Hilsa and prawns formed the important fisheries of Orissa. A new development in the fishery of Orissa is the landings of oil sardines and mackerels. In the coastal areas of Orissa, abundance of demersal fishes likes catfish.

The crafts such as dugout canoes, outrigger canoes, rafts and mechanized boat such as trawlers and ships are also used for deep sea fishing. For the capture fisheriesdifferent types of gears are used such as cast net, gill net, rampani net and trawl net are generally used.

Inland Culture Fisheries

The breeding, rearing of the fishes, crustaceans and molluscans in the artificial condition which is much similar to their natural condition with sufficient amount of food and in the absence of predators so as to obtain maximum yield is known as 'culture fisheries'.

The culture fisheries provide constant or steady supply of useful aquatic animals to the market throughout the year. In culture practice young fishes are not captured, only full grown adult fishes are capture. Hence, maximum yield is obtained. Inland culture fisheries are carried out in fresh water bodies such as ponds, lakes, reservoirs. They are allowed for feeding, breeding, growing and then they are captured or harvested.

The main aim of fish culture is the maximum production of the fishes for the main food with minimum investment. The fish culture provides increase in number of rapidly growing fishes so that there is steady supply of fish food in market. The farmers can use waste land for fish production where water is stored throughout year.

Principle of Selection of Fishes:

Recently selective breeding and hybridization of fishes are also carried out for following qualities are selected;

1. Fast growth rate
2. It should have low bone to flesh ratio.
3. It should have small head, high body and thick back.
4. It should be hardy and resistant to disease.
5. It should be prolific and easy to breed in fresh water bodies.
6. It should be palatable with high nutritive value.

Ecological Condition:

In fish culture, some ecological conditions are required. In this requirement important part is water - depth, temperature, turbidity and light which constitute the more important to the

productivity. In chemical condition of water - gases, solids and nutrients dissolved in water and its pH constitute the more important for productivity.

In biological condition, water bodies consist of plant and animal communities. Towards the margin of water bodies, rooted aquatic plants such as Nymphoides, Potamogeton, Aponogeton, Trapa, Nymphea, Nelumbium, Scirpus, Chara and Nitella commonly occur.

Types of Fish Culture:

Fish culture contains following types, on the basis of economic and commercial consideration point of view.

1) Extensive fish culture: it is carried in large pond with little care. In extensive fish culture artificial food is not provided, so that there is no need to investment.

2) Intensive fish culture: It is carried in the smaller pond. In this fish culture fishes are provided with artificial food. Pond is improved by the use of fertilizers so as to produce more plankton which are used as food by young fishes. In this culture maximum fish production is obtained from smaller pond. The cost of investment is more but fish yield is much increased so that it gives more profit.

3) Semi intensive fish culture: It is carried out in the smaller or modern size pond. It gives moderate supply with less amount of artificial food or external food with low cost. It is intermediate between extensive and intensive fish culture.

4) Cage culture: Cages are prepared by metal or bamboo and they are supplied by wire or nylon net or mosquito net cloth from all the sites. In this culture, fishes are provided with artificial food.

5) Rice cum fish culture or paddy culture: Fishes are cultured in the rice field which are filled with water or in the plots of same size filled with fresh water so as to rear the fishes along with crop of rice.

On the basis of number of species to be culture, culture fisheries have following types:

1) Mono-culture: when single species of fish is cultured in the fresh water body, it is called 'mono-culture', fisheries.

2) Poly-culture: In this culture, more than 2 species of fishes are culture in the same pond or lake at the same time so as to obtain more yield of fishes.

For example, Labeo rohita, Catla catla and Mrigal are cultured in same pond.

3) Mono-sex culture: In this culture, either males or females are cultured, which give more yield. In this method following fishes are generally cultured- *Labeo rohita, Labeo bata, Labeo calbasu, Catla catla, Silver carps, Grass carps, Cyprinus carpio, Clarius, Anabas* etc

4) Hybridization culture: Recently hybridization technique is also used in the closely related species of fishes, due to hybridization and selective breeding of the fishes new varieties are mainly obtained.

For example: *Labeo rohita X Labeo bata, Labeo bata X Labeo calbasu, Labeo calbasu X Catla catla*

Marine Culture Fisheries
[Mariculture]

Introduction:

Marine culture or Mari-culture is carried out along the sea-shore in various fish landing centers. Recently it was observed that marine capture fisheries have reached at its maximum level of fish production. About 70% of total fish catch is from marine water. Capture fisheries is carried out thousands of years ago except in month of rainy season. Due to this there is decrease in the marine fish catch at the different areas of the fish landing centers.

The term mari-culture has come to mean organized culture of marine organisms of sea water. It includes rearing of marine forms in the marine environment itself.

Generally the habitat chosen for mari-culture is the edge of the ocean, its inshore bays, and inlets. This marine culture fishery under conditions there is much increase in the production of edible fishes, edible crustaceans and the molluscans.

I. Culture of the Fishes:

The fish culture mainly includes the culture of the Milk fish and Mullets or Mrigal cephalus.

a) Culture of Milk Fish:

It is deep sea fish, which enters into coastal water for breeding purpose. Milk fish can be successfully culture in estuarine water. The young stages are obtain and reared in the estuarine water.

b) Culture of Mullets:

Mullets are fresh water fish which migrated to estuaries. They are cultured in low saline water bodies. The fish seeds or fry stage are collected from coastal water after monsoon period and they are stocked in coastal lakes for rearing.

After complete growth they are captured.

II. Culture of Crustaceans:

In India, two species of marine Prawns namely *Penaeus indicus* and *Penaeus monodon* are cultured successfully. The *Penaeus monodon* is cultured only in the blackish water estuaries.

In this culture, larvae and juveniles (young stage) are allowed to enter in estuaries and they are trap. Such trapped young stages are allowed to grow or rear in the blackish water estuaries and after complete growth when adult is formed they are captured or harvest as per demand of market.

III. Culture of Molluscans:

It mainly includes culture of oysters like pearl and edible oysters. The pearl oysters are cultured by raft culture method. The fry stages or seeds are collected by artificial method. They are spread in cages or nets or ropes covered by mosquito net cloth. Such ropes are attached to floating rafts. After complete growth of pearl oysters, they are captured and used for Pearl oysters, they are captured & used for Pearl formation process and edible oysters are used as food. The culture of Mytilus is also carried out by raft or rope culture method. The larvae or seeds are collected and spread in mosquito net cloth. Such ropes are attached to rafts floating in estuarine water for rearing till adult. Mytilus are formed and they collected or harvested by taking rafts along sea shore.

BROAD OUTLINE OF FISHERY ACTIVITIES

I) Fishing:

Fishes, crustaceans and mollusks are aquatic animals which are mostly found in streams, rivers, ponds, lakes, reservoirs, estuaries and marine water of sea or ocean. In India total annual fish production is about 2 to 2.5 millions of tons of which marine fish production from 66 to 70% from Indian seas and Bay of Bengal, while remaining 30 to 34% of fish catch is from fresh water bodies. There are two methods of fishing i.e. old method and modern method.

The older methods of fish catching includes hand catching, hunting, poisoning, paralyzing, line fishing by hooks with bait etc.

Modern methods of capturing includes use of rafts, dugout canoe, out rigger canoe, trawlers etc. the capture of fishes are also carried out by use of various gears or nets such as Gill net, dol net, shore seine net, bag net, Purse net, Cast net and trawl net. Recently, electrical fishing method is also used. Electric currents of low voltage are used to trap fish.

II) Fish Processing:

If captured fishes and other animals are not quickly preserved, the fishes and animals get spoiled. The fish spoilage occurs by bacterial action, enzymatic action or by chemical action. Bacterial spoilage is also known as microbial spoilage. Fish processing is a special technique by which fish spoilage is prevented, so that captured fish is preserved for short duration and for

longer duration such as 4-6 months in good & fresh condition. In fish processing quality of flesh, taste, odour, firmness, vitamins and minerals contents are kept as that of fresh fish, hence they are sold in market.

Objectives of fish processing:

1. To prevent fish spoilage and maintain nutritive value of fish upto marketing.
2. To help or facilitate good transport and distribution of fishes from landing of fish to markets of fish.
3. To stabilize price level of fish throughout year.
4. To prepare various kinds of fish products according to the taste and demand of consumers.
5. To help in export of flesh of fish, crustaceans and mollusks to obtain foreign currency from canned, smoked and freeze forms of fishes.

Fish processing is carried out by two methods:

I) Short duration preservation W: hen preservation is required for short duration, the captured fishes are kept in crushed ice and transported to the market for their sale.

II) Long duration preservation :when the preservation is needed for a long period of time.

There are used different techniques for fish preservation:

I) Fish preservation for short duration:

a) Icing and chilling method: Firstly, captured fish is cleaned with marine water and then by fresh water so as to remove blood from tissue or flesh of fishes. After cleaning, temperature of fish body is quickly lowered by addition of layers of ice and fish alternatively in 1: 1 ratio one above another. At very low temperature bacterial growth is prevented and fish is preserved for 10 to 15 days. Fish can also be processed by chilled marine water at 0 oc, so that fish is preserved for 10-15 days.

b) Water salting/ wet salting: In this method cleaned fishes are processed in clean marine water or pure saline water for short duration i.e. for 10-15 days.

c) Dry salting: It is oldest method of fish preservation. By dry slating method, moisture content of flesh is removed by osmosis and prevents fish spoilage. Due to addition of pure salt, proteins of tissue get coagulated and make enzymes inactive; so as to prevent autolysis of fish flesh, salt can be applied in pure and dry form.

Firstly captured fishes are cleaned to remove bacteria, viruses and blood. If fishes are of small size pure salt is directly added. But if fishes are large in size they are cut, gutted i.e. viscera is removed and kept clean and open. Then fine, pure salt is applied to fish and in abdominal cavity of fish in sufficient amount, it depends upon season and size of body. The fishes are rolled

in salt or covered with salt. Pure sterilized salts are more effective and give better results, but sea salt is not suitable because it contain impurities of salts of Ca and Mg. They retard penetration of NaCl in flesh or body of fish and result in fish spoilage.

II) Fish preservation for long duration:

The fishes are preserved for long duration by methods such as freezing, drying, canning and smoking.

a) Freezing: In this method fish is frozen at -30 oc to -40oc in deep freezing and then stored in frozen storage rooms at -20 oc or below it. Due to freezing taste and flavor of fish is changed. In freezing method cleaned fishes are dipped in freshwater. Such frozen fish remains in good condition upto period of 4-6 months.

b) Drying: It is very old method of fish preservation. During drying method, content of fish is complete removed so as to prevent growth of bacteria thus fish spoilage is prevented. There are two types of drying: i) Sun drying & ii) artificial drying

i) Sun drying: In India about 35% of total marine catch is cleaned and sun dried such as Bombay duck, ribbon fish, Silver bellies, small prawns etc. Such cleaned fishes are simply spread on sand of beach or spread on coir mats.

ii) Artificial drying: In tropical coastal region effective sun-drying is not possible. In sun drying only outer part of body of fish dries while inner tissue remains moist so that get spoiled. Hence in tropical regions artificial dryers are generally used. In artificial dryer's temperature is maintained at 42-45oc for 48 to 60 hours such dried fishes remain in good condition for 4-6 months.

c) Canning: It is costly and complicated method of fish preservations. Fishes are cut into small pieces of suitable size. The hard body parts such as head, fins, scales are removed. Such pieces are washed and cleaned to remove blood from tissue. Then they are treated with pure salt water to remove blood from tissue and to give proper firmness and flavor. Then such tissues are cooked to remove excess moisture. The pieces are then packed in tin cans which are passed through steam chambers. The can is then sealed and sterilized at suitable temperature so as to kill bacteria which cause fish spoilage. Then final sterilization is done by heat.

d) Smoking: It includes salting, drying and smoking. The captured, cleaned fishes are treated with slat solution. The concentration of salt varies with the species. The salting removes moisture from fish body and prevents the growth of bacteria. The fishes are dried in smoking chamber so as to remove additional moisture. Wet dense smoke is prepared by

burning of hard wood and it is transferred or delivered through large pipe into smoking chambers. Smoking gives good flavor and color to the fish. Smoke has mild preservative action. Due to smoking fish is preserved for 4-5 months in good conditions.

III) Marketing:

The term marketing was earlier used to denote only buying and selling of fish at place of catch or in market. But with the advancement in various aspects of fishery and fish technology. Fish marketing includes all processes involved from catching of fish upto final consumption by consumer. It includes fish catching methods, fish processing, preparation of fish products and preservation of fish, according to demand and changes in fish farm.

Fish marketing channels: Domestic markets and distribution of fish are dominated by large number of intermediaries. All fish traded internally and for export pass through private channels. Fish distribution usually involves levels.

i) Primary market: Markets located in village, district headquarters or at some cross-roads are considered primary markets. They are usually near areas where fish are caught by fishermen and variety of fishes is available in market.

ii) Secondary markets: The retailers take the fish bought from the fishermen/primary markets/ landing points to the nearest Upzilla or river port markets by road, river or rail to sell to wholesalers. From these secondary markets the distribution of fish moves through different channels to urban markets/ higher secondary markets.

iii) Higher secondary markets: From secondary markets retailers bring fish to the higher secondary markets serving large areas of consumers/ terminal market. The higher secondary market may consist of one or more wholesales markets or centers where Vendors deals in fish. These markets are well connected by road, rivers and rail. Higher secondary markets have trading connection with several secondary markets. Markets in districts headquarters can be considered as higher. Higher secondary markets are connected to the several secondary markets for the supply of fish.

iv) City and terminal markets: Retailers buy fish from wholeselling centers of higher secondary and secondary markets. They supply fish directly to consumers either through fixed stalls or by vending from rickshaws. From the start of distribution channel for fish at secondary markets to city or terminal markets intermediaries operating on different levels perform marketing functions like cleaning, sorting, boxing, icing, re-packing and arranging transportation.

At each market level, wholesalers and retailers may be supplying fish to local consumers. The marketing channel for cultured fish starts with the fish farmer passes through number of intermediates and end with ultimate consumer.

Modern fish marketing: According to modern fish marketing the fishes are sold at distant places in city areas in different forms besides frozen, chilled conditions. The fishes are preserved by modern methods such as canning, smoking so as to obtain more money.

IMPORTANCE OF FISHERIES

Provide Food:

In India, humans are closely related to the fishing and fishes are mostly used as food. A very large number of fishes are captured or cultured now days and forms a major supplementary diet. Generally body of fish contains water, proteins, lipids, sugars, vitamins A & D, minerals and micronutrients. The fishes are used in fresh condition, preserved form, various by products are also used as food by man. Fish food is very tasty and helps in maintaining the nutrition level in humans.

Source of Income:

Central government and State government have taken much interest in development of fisheries. The capture and culture fisheries provide good job opportunities to poor coastal and rural people of India, so they can get more money at their native places. The state government have established fisheries departments at all district and culture fisheries is given while large number of fish seeds are sold at very low price to farmers and fisherman. Seeds of molluscans are also provided to fisherman due to most of fresh water bodies, estuarine water, river water and marine water of coastal areas are used for growing or rearing fishes. Crustaceans and molluscans which are used by man and fisheries development occurs rapidly in India to solve problems of food.

Provide Medicines:

Fish flesh and fish oil are rich in vitamins A & D and minerals which helps in medicines manufactured. These medicines are used in many medical treatments.

Agriculture and Fisheries:

From waste part of fish body make fish meal which is used in poultry farm. In poltry farm fish meal given as supplementary food to poultry bird. Fish manure is also prepared from the fish and used as fertilizers for cash crops.

2. TAXONOMY OF SHELL-FISH

Taxonomy:

It is branch of biology that practice of identifying different organisms, classifying them into categories and naming them. In aquatic environment fishes are broadly classified into Fin fish and shell fish. Shellfishes are aquatic invertebrates which are having a shell. Shellfish classify into Crustacea and Mollusca.

Sub-phylum Crustacea is included in Phylum Arthropoda.

General characters of Phylum Arthropoda:

1. They are solitary or colonial, most of they are free living.
2. Bilaterally symmetrical.
3. Body is covered by chitinous cuticle.
4. Body is divided into head, thorax and abdomen.
5. In some organism head & thorax fuse to form cephalothorax.
6. Body shows metameric segmentation.
7. Digestive system is complete and divided into forgut, mid gut & hind gut.
8. Circulatory system is open type.
9. Respiratory organs are gills, trachea, book lungs.
10. Excretion takes place by green glands or by malphigian tubules.

General characters of sub-phylum Crustacea:

1. These are mainly aquatic, fresh or marine water or live in moist place.
2. Body is covered by external chitinous exoskeleton.
3. They are triploblastic (organism shows 3 germinal layers i.e. outer ectoderm, inner endoderm and middle mesoderm).
4. They are coelomate animals (cavity is filled by coelomic fluid).
5. They are bilaterally symmetrical (Body of animal can be bisected by single median)
6. Body is divisible into three parts, namely head, thorax and abdomen. Head is generally fused with thorax to form cephalothorax.
7. Head bears a pair of eyes, pair of antennae.
8. Five pairs of jointed appendages are present which are modified for locomotion and capture of prey.
9. Abdomen is composed of 6 segments.
10. Digestive system is complete. Alimentary canal composed of forgut, midgut and hindgut.
11. Respiration occurs through general body surface or by gill.
12. Excretion occurs by a pair of green galnds.

13. Nervous system is ganglionated with dorsal nerve ring and double ventral nerve cord with paired segmental ganglia.

Class- Cephalocarida: i) commonly called horseshoe shrimps.
ii) Primitive crustaceans.
iii) Elongated body with large head.
iv) Telson present.
Example: Shrimp

Class- Branchiopoda: i) Small group of freshwater arthropoda
ii) Carapace present
iii) Gills present.
Example: water flea

Class- Malacostraca: i) Largest class of crustacean
ii) Usually marine, some are fresh water
iii) Body is divided into head, thorax & abdomen.
iv) Compound eyes are present.
v) Two pairs of antennae present.
Example: Lobster, crabs

Class- Maxillopoda: i) Usually small crustacean
ii) Abdomen highly reduced
iii) Body divided into cephalic, thoracic & abdominal segments.
iv) Telson present.
Example: copepods, barnacles

Class- Remipedia: i) Commonly called blind crustaceans.
ii) Body divided into head and trunk.
iii) Bear fangs with venom gland.
Example- Blind shrimp

Class- Ostracoda: i) Small crustaceans.
ii) They are the common zooplanktons of marine environment.
iii) Abdomen absent.
iv) Antennae present.
Example: Seed shrimp

General characters of sub-phylum Mollusca:

1. They are aquatic, mostly marine or some are terrestrial.
2. Molluscans are found in free living or sedentary forms.
3. They are triploblastic, unsegmented.
4. These are bilaterally symmetrical but few become asymmetrical due to torsion.
5. Body is soft generally shows four parts like head, foot, mantle & visceral mass.
6. Visceral mass is enclosed in thick, muscular fold of body wall called mantle.
7. Foot is ventral, thick, muscular and serves as locomotors organs.
8. The space between mantle & visceral mass is called mantle cavity. In this cavity, open the digestive, excretory and reproductive organ.
9. Outer surface of mantle produces calcareous shell.
10. Locomotion occurs by arms or foot.
11. Body show tube with a tube type of body plan i.e. digestive system is having two separate opening.
12. Digestive system is well developed, complete with anterior mouth & posterior anus.
13. Circulatory system is open type.
14. Nervous system is formed by 3 pairs of ganglia such as cerebral ganglia, pedal ganglia and visceral ganglia.
15. Excretion occurs by kidney.
16. Respiration by one or many gills or by lungs or by mantle.
17. Sexes are separate.

Class- Monoplacophora:
i) Body is oval and bilaterally symmetrical.
ii) Shell is made up of single piece.
iii) Foot is ventral.
iv) 5 or 6 pairs of gills are present.
Example: Neopilina

Class- Amphineura:
i) Body is oval or long, cylindrical and bilaterally symmetrical
ii) Mouth and anus terminal.
iii) Shell consisting of a row of 8 transverse plates on the dorsal surface.
iv) Nervous system is primitive with longitudinal pallial & pedal cords with transverse connectives.
v) All are marine. Example: Chiton

Class- Scaphopoda:	i) Burrowing and marine molluscs. ii) Body bilaterally symmetrical. iii) Body elongated with no distinct head and without eyes and gills. iv) Shell and mantle univalved. v) Foot small, conical & usually pointed for burrowing. Example- Dentalium
Class- Gastropoda:	i) Asymmetrical molluscs ii) Head distinct with one or two pairs of tentacles and eyes iii) Univalved shell, often spiral or conical or absent. iv) Marine, freshwater or terrestrial. Example: Pila
Class- Pelecypoda:	i) body bilaterally compressed ii) Shell bivalve. iii) Foot antero-ventral, usually wedge-shaped. iv) Marine and freshwater. Example- Mytilus
Class-Cephalopoda:	i) Body elongated, dorso-ventrally and bilaterally symmetrical ii) Shell external, internal, degenerate or absent. iii) Dioecious, development direct. iv) All marine and free swimming. Example: Sepia

3. TAXONOMY OF FIN-FISH

Fishes are aquatic, cold blooded, craniates with paired fins supported by dermal fin-rays & gills as main respiratory organs. Fin fishes are included in Phylum Chordata & sub-phylum vertebrata.

GENERAL OUTLINE OF CLASSIFICATION

General Characters of Chordata:

1. Presence of notochord
2. Gill slits present
3. Presence of hollow dorsal nerve cord

General Characters of Vertebrata:

1. Notochord replace by vertebral column.
2. Also have muscles and skeleton.
3. Endoskeleton is made up of cartilage or bones.
4. Well developed nervous system.
5. Have cranium, brain is set inside bony box.

General characters of super-class Pisces:

1. The fishes are cold blooded which are completely adapted for aquatic life.
2. The body is streamline or spindle shaped, laterally compressed or dorsoventrally flattened disc shaped.

3. Feeds on plankton, algae, mollusks & other aquatic organisms.
4. Endoskeleton may be bony or cartilagenous.
5. Exoskeleton is dermal scales. Skin is covered with scales.
6. Paired and median fins are usually present, supported by horny dermal fin rays for locomotion or swimming in water.
7. Mouth is terminal or ventral in position.
8. Alimentary canal is specialized with very short pharynx and definite stomach.
9. The gills are organ of respiration. They open outside by gill-slits which may or may not be covered by operculum. The gills may be 4 or 5 pairs in number.
10. Circulation is single & closed.
11. Heart is ventral in position, with two chambered i.e. auricle & ventricle.
12. Well developed brain with olfactory lobe.
13. Excretion by pair of elongated kidney.
14. Sexes are separated, oviparous or viviparous.

I) General Characters of class Chondrichthyes:

1. They are mostly marine animals.
2. Body is spindle shaped, laterally compressed or dorso-ventrally compressed.
3. Cartilagenous endoskeleton present.
4. Exoskeleton is formed by minute placoid scales.
5. Both median & paired fins are present supported by cartilaginous fin-rays.
6. Each lateral side consist of 5-7 gill-slits which are not covered by operculum.
7. Mouth present in ventral in position.
8. Heart contains two chamber- auricle and ventricle.
9. Excretion by kidney.
10. Sense organs are well developed such as olfactory sacs, pair of eyes, internal ear & lateral line system.
11. Sexes are separated.
12. Mostly viviparous.

    Example: Scoliodon, Sting Ray, Electric Ray etc.

General characters of sub-class Elasmobranchii:

1) Have no swim bladder. 2) Present pair of 5-7 gill clefts.
3) Small placoid scales are present. e.g. Shark

General characters of sub-class Holocephali:

1) Live close to bottom. 2) Scales are absent.
3) 4 gills with single gill opening. 4) Mouth is small, tail is long and thin.
5) Lateral line with groove. 6) Vertebrae are poorly developed.

e.g. Rat fish, Rabbit fish etc

II) General characters of class Osteichthyes:

1. Fresh water or marine water in habitat.
2. Body is spindle shaped adapted for swimming in water.
3. Exoskeleton is formed of cycloid or ctenoid scales.
4. Endoskeleton is bony; notochord is replaced by vertebral column.
5. Mouth is terminal in position.
6. Pair of nostrils are located on dorsal side of snout.
7. Both paired and unpaired fins are present, supported by fin-rays of bones.
8. Tail fin or caudal fin is formed by two equal lobes i.e. Dorsal & ventral lobe.
9. Sense organs are well developed.
10. Four pairs of gill-slits are present covered by operculum.
11. Heart present in ventral position with two chamber i.e. auricle and ventricle.
12. Air bladder or swim bladder is present.
13. Brain with very small olfactory lobes, cerebrum, cerebellum and optic lobes are well developed.
14. Excretion by kidney.
15. Sexes are separate. Fishes are mostly oviparous.
    e.g. Labeo, Catla, Mrigal, Flying fish, tetradon etc.

General characters of sub-class Actinopterygii:

1) They possess fin rays.

General characters of sub-class Sarcopterygii:

1) Fleshy lobed paired fins which are joined to body by single bone.

I) General characters of class Dipnoi:

Dipnoi (Di- two, pnoe- lung) is one of the group of bony fishes. They show similarities with both Telostomi and Amphibians. This class represented by only three living genera which found in different part of world.

1) Neoceratodus - Australia 2) Protopterus – Africa 3) Lepidosiren America

General characters of Dipnoi:

1. Paired (Pectoral and Pelvic) fins are lobate.
2. Thin cycloid scales embedded in connective tissue of the body.
3. Single dorsal fin present.
4. Diphycercal tail is present.
5. Dental plate large and fused to jaw bones.
6. Mouth present on ventral side of head.
7. Cloaca present.
8. Two nostrils present on ventral surface of the snout.
9. Spiracles are absent.
10. Operculum present.
11. Single bronchial opening found.

Characteristics of Neoceratodus:

1. Large fish of 10 kg in weight and length about 5 feet.
2. Non-gonoid scales present.
3. One lung is present and 5 branchial arches present.
4. It is found in slow moving or stagnant water.
5. Sluggish in nature and found at the bottom.
6. During summer water level is low and oxygen level is also low in that condition neoceratodus survive because of pulmonary respiration.
7. Carnivorous. Feeds on mollusks, crustaceans, worms and larvae.
8. Spawning period is September and October in morning hours.

Characteristics of Protopterus:

1. Large in size upto 6-7 feet in length.
2. Marshy places in habitat.
3. Paired fins are lobate and appear filamentous.
4. In swimming tail is principle organ of locomotion.
5. Body covered with small cycloid scales.
6. Five gill arches present but the anterior ones are devoid of gill filaments.
7. Lung is double.
8. The fish respires by gills as well as by lungs.

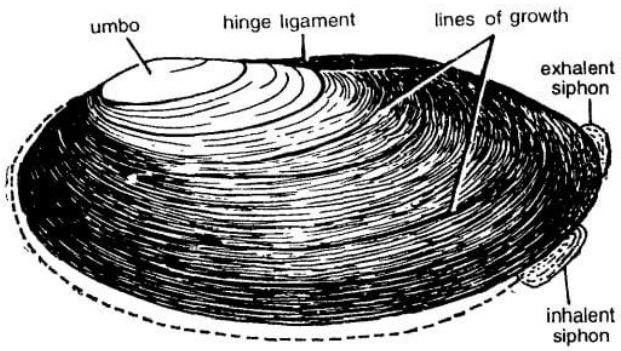
9. During summer, when marshes dry up, the fish undergoes aestivation or summer sleep till the next rainy season. During this period, the fish moves into the deeper mud and coils up in a 'cocoon' made up of special clay mixed with mucus secreted by the skin.
10. With the approach of the rainy season, the fish emerges from its cocoon and leads an active life.
11. Spawning takes place during rainy season..
12. Protopterus shows parental care, the fish prepares a nest which is a simple hole about a foot deep, full of water and surrounded by aquatic plants, the eggs are laid in the bottom of the nest and male guards the nest containing eggs and larvae.
13. Carnivorous in habit, they feed on frogs, worms, insects and crustaceans.

Characteristics of Lepidosiren:

1. This fish attains a length of 4 feet.
2. In this fish both Branchial and pulmonary respiration are found.
3. Paired fins are filamentous.
4. Lepidosiren shows hibernation period.
5. Fish feeds on only snail and sometimes they feed on plant material.
6. During summer, when the water nearly dries up, fish burrows into the mud and hibernates and depends on pulmonary respiration and stored fats for keeping alive.
7. In rainy season, fish emerges from the burrow & enters the breeding period. The eggs are laid in a nest which has the shape of a vertical tunnel about foot deep.

4. MORPHOLOGY

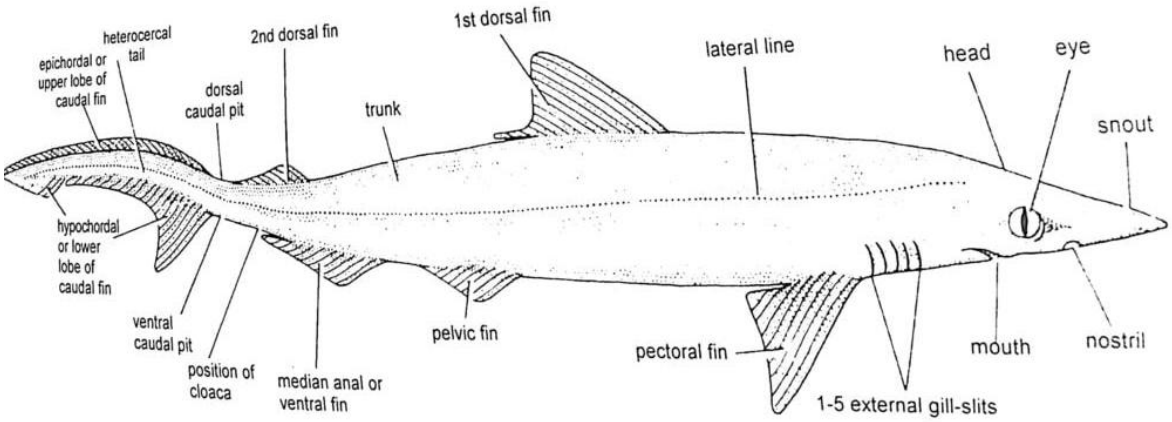
Morphology of Bivalve: Unio



1. Unio is commonly known as fresh water mussel.
2. **Habit & habitat:** Unio is found at bottom in ponds, lakes, streams and rivers buried in the sand or mud. They are carnivorous. Food consists of microscopic plants and animals.
3. **Size &shape:** Body is soft, unsegmented, bilaterally symmetrical and flattened from side to side, measuring about 5-10 cm in length and enclosed in a hard calcareous shell.
4. **Shell:** Shell is brownish in colour. The animal is completely surrounded by hard calcareous shell.
5. **Valves:** The shell consists of two separate, equal and lateral pieces are called valves, covering the right and left sides of the body, respectively. The shell of mussel made up of 2 valves so called bivalve.
6. **Hinge ligament:** The two valves of the shell are united together along the dorsal side in a straight hinge line. Hinge line is external, brown, tough, elastic and non-calcareous is also known as hinge ligament. It is made up of conchiolin.
7. **Umbo:** Umbo is situated near the anterior end of the dorsal side. It is whitish knob, swelling like structure. It is the first part of the shell. Umbo is thickest and oldest part of the shell.
8. **Lines of growth:** The outer surface of each shell valve presents a number of concentric lines around the umbo as center and running parallel to the free margin of the shell. These are the lines of the growth.
9. **Hinge teeth:** In Unio the inner surface of each valve possesses dorsally along the hinge line, small sharp ridges and teeth like projections separated by grooves. These are known as hinge teeth.
10. **Muscle scars:** Anterior and posterior adductor muscles are well developed and are responsible for the closing and opening of the valves.
11. **Foot:** Foot is large, muscular and wedge-shaped used for burrowing.

12. **Siphon:** Inhalent and exhalent siphons are present at the posterior end of the mantle.
13. **Gills:** Two bipctinate gills, one on each side of the visceral mass are present.
14. Sexes are separate but male and female shells are alike.
15. Development includes glochidium larva.

External Morphology of Scoliodon:



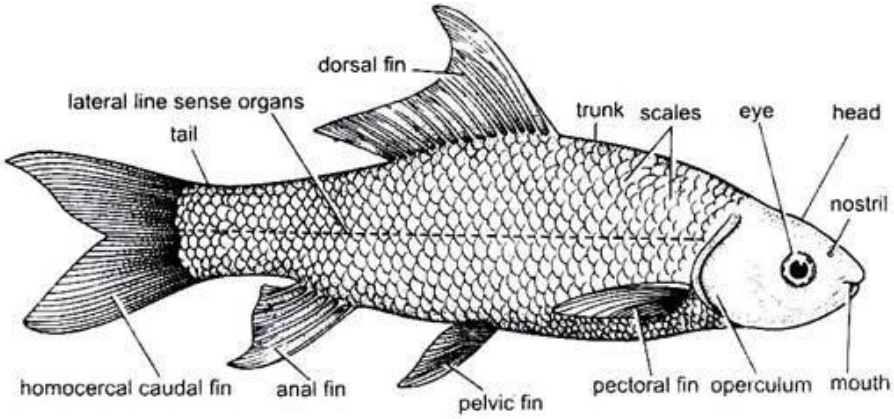
1. Scoliodon is commonly called dog fish or dogshark.
2. **Habit & habitat:** The natural home of Scoliodon is the sea, but some live in estuaries and even ascend the rivers. They are predacious and voracious feeders. They are active swimmer.
3. **Size & shape:** about 60 cm long. Scoliodon has an elongated, stream lined or spindle shaped body. Body is tapering at the anterior and posterior end. Body is regionated into head, trunk & tail.
4. **Colour:** Dorsal and lateral sides of body are pigmented dark grey or slightly grey, while the ventral side is white.
5. **Skin:** The skin of scoliodon is rough due to presence of large number of placoid scales which are embedded in the epidermis and dermis layers of skin.
    1. **Head:** Head is dorsoventrally compressed and flattened and prolonged anteriorly into thin blunt wedge shaped part called snout. The head region bears mouth, nares, pair of eyes, ampullary pores and 5 pairs of external gills.
    2. **Mouth:** The mouth is a wide cresentic opening located on the ventral side of head. It is bounded by upper and lower jaws. The skin is folded over jaws so as to form upper and lower lips. The both lips are immovable and contain one or two rows of oblique pointed backwardly directed teeth. The teeth help in catching of the prey and preventing escaping of prey instead of crushing food.

3. **Nares or external nostrils:** A pair of nares are located on ventral side of snout. The nares are obliquely opening divided into two by a flap of skin. The water enters in olfactory sac through one part of nare and water is given out through anterior part of external nostril.
4. **Eyes:** A pair of large circular eyes are situated at the lateral side of head region of body. Each eye has three eyelids, upper, lower and third eyelid is called as nictitating membrane. The upper and lower eyelids are immovable. The nictitating membrane is thin, transparent. The pupil of eye is narrow and vertical in Scoliodon.
5. **Gill slits:** On the lateral side of head region 5 pairs gill slits or external branchial opening are present. They narrow vertical aperture of gill pouches containing gills.They help in respiration.
6. **Ampullary pores:** The dorsal and ventral surface of snout region contain several groups of small openings. These pores lead into sense organ ampulla of Loranzini which detect temperate variations of water.
7. **Trunk:** It is middle largest part of body, extending from last gill slit to cloacal aperture. It is wide and thick part of body. It bears paired and unpaired fins and cloacal aperture.
8. **Fins:** fins are large, thin, flat outgrowth of body covered with skin and contains muscles and fin rays. The fins are two types- unpaired and paired fins.

   Unpaired fins- the middle and dorsal surface of body contain large first dorsal fin. It is triangular in shape while at the junction of trunk and tail small second dorsal fin is also present. On the ventral side in front of tail ventral or anal fin is also present.

   Paired fin: there are two pairs of paired fins on body, the pectoral and pelvic fins. The anterior large pectoral fins are located just behind 5th gill slits on the ventro-lateral side of body. A pair of posterior and ventral side of trunk region. They help in balancing the body. In male Scoliodon inner surface of pelvic fin bears long rod like copulatory organ, is called claspers. It has groove on its dorsal side; it helps in transfer of sperm.
9. **Cloaca:** The cloacal aperture is an elongated located in between two pelvic fins. It is chamber of digestive system and reproductive system.
10. **Lateral line:** on the lateral side of body there is a faint line from head to posterior end of tail called as lateral line sense organs.
11. **Tail:** It is the posterior most part of body which is located behind cloacal opening. It tapers posteriorly and bend upward at small angle. The tail is covered by caudal fin called as heterocercal caudal fin. It has dorsal epichordal lobe and ventral hypochordal lobe. At the base of caudal region on dorsal and ventral side caudal pits are present.

Morphology of Labeo:



1. Commonly known as carp and rohu in Hindi.
2. **Habit &habitat:** Labeo is abundantly found in ponds and rivers. Carps are vegetarian and bottom feeders. They can occasionally feed on animal diet.
3. **Size & shape:** Full grown Labeo measures about 90-100 cm in length and 20- 25 kg in weight. Labeo has elongated, laterally compressed spindle shaped body, tapering at anterior and posterior end.
4. **Colouration:** Colour of the body is bluish or brownish on back and silvery white below.
5. **Skin:** Body covered with large overlapping cycloid scales. Scales are of taxonomic importance.
6. Body is regionated into head, trunk and tail.
7. **Head:** Head is depressed and is produced into a short, obtuse and blunt snout. The head extends from tip of snout to posterior end of bony plate operculum. Scales are absent on head. Head bears mouth, a pair of nostrils, a pair of barbells, eyes and operculum.
8. **Mouth:** Mouth is subterminal fringe-lipped mouth bounded by fleshy upper and lower lips. Teeth are absent.
9. **External nares or nostrils:** These are a pair of small opening located dorso- ventrally on head region just infront of eyes. They lead into olfactory sac.
10. **Barbels:** A pair of short, filamentous barbels arises from upper lip.
11. **Eyes:** In Labeo a pair of large eyes is located on lateral side of head region. The eyelids are sbout but eyes covered with transperant skin. The eye have circular pupil.
12. **Operculum:** These are large bony flap located below and behind each eye and called as gill cover or operculum. Just below operculum lies space called gill chamber or branchial chamber. Branchial chamber containing four comb like complete gill. The gill performs function of respiration. The branchial chamber opens out by a large aperture called branchial

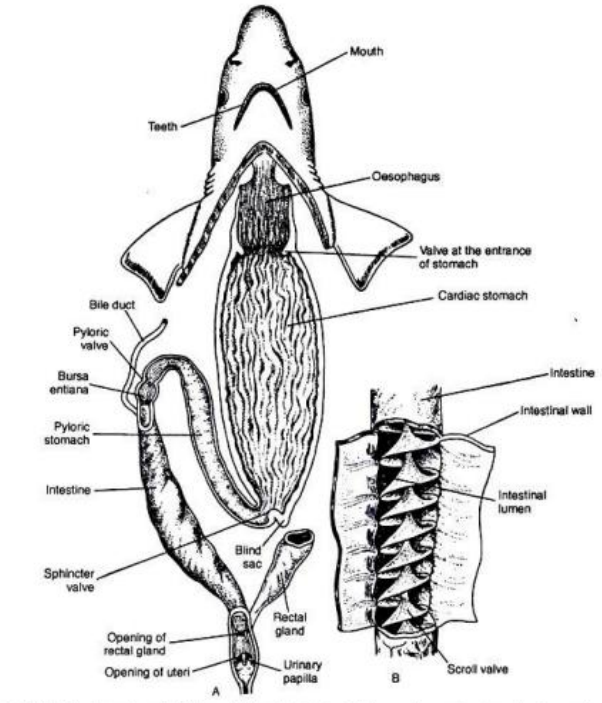
aperture.

13. **Trunk:** The trunk is middle large and broad part of body. It extends from posterior border of the operculum to the anus aperture. The trunk is thick, laterally compressed. The trunk region is covered by many large cycloid scales forming exoskeleton. Scales are flat, bony with rounded edges. Scales are of taxonomic value.
14. **Lateral line system:** Lateral line is distinct. Scales overlying the lateral line are perforated by tubes of the lateral line system.
15. **Fins:** The fins are outgrowth of body covered by skin, containing muscles and supported by bony fin rays. The trunk region contains unpaired and paired fins. The unpaired fin consist of single large dorsal fin and ventral or anal fin. Dorsal fin is present in mid dorsal position while ventral or anal fin located on ventral side of trunk. Paired fin consists of pair of anterior pectoral fin and pelvic fin. Pectoral fins are larger triangular located just behind operculum or on ventro-lateral margin. A pair of pelvic fins are small and located on ventral side of trunk region.
16. **Tail:** The tail forms about one third posterior part of body. It is laterally compressed. Tail is straight and covered by caudal fin. Homocercal caudal fin is present in Labeo.

ANATOMY OF FIN FISH: SCOLIODON

Scoliodon is commonly called as dogfish or Shark. It has widely distributed. The commonly available species in India seas is Scoliodon. Scoliodon is vertebrate animal which is having well developed body systems such as digestive, circulatory, excretory and reproductive systems.

Digestive System of Scoliodon



The digestive system of Scoliodon contains main 2 parts- Alimentary canal and digestive glands.

A) Alimentary Canal:

1. It is major part of digestive system.
2. It starts from mouth and ends with anus or cloaca.
3. It is longer than body and consists of mouth, buccal cavity, pharynx, oesophagus, stomach, intestine, rectum and cloaca

a) **Mouth:** Mouth is first part of digestive system from which digestive system start. It is a wide cresentric opening on the ventral side of the head. It is bounded by folds of upper and lower lips.

Function: Intake of food.

b) **Buccal Cavity:** Mouth opens into a spacious dorso-ventrally flattened mouth cavity; this cavity is known as buccal cavity. It is lined by mucous membrane. Teethes are present in buccal cavity and they are homodont, polyphyodont, lyodont type. On floor of the buccal cavity merely thick, flat, non-muscular, non-glandular tongue present. Salivary glands are

absent.

Function: Teeth mainly used to grasp the prey which is usually swallowed whole.

c) **Pharynx:** Buccal cavity opens into the Pharynx. Either lateral side of pharynxcontains an oval pit of spiracle and five pairs of gill slits. The mucous membrane of the pharynx bears numerous dermal denticles.

d) **Oesophagus:** The oesophagus is the short tube. Oesophagus contain thick muscular wall. The mucous membrane is raised into longitudinal folds called rugae. It is opened only during swallowing of food. Otherwise it remains closed to check the entry of water into the stomach.

e) **Stomach:** The stomach is a J-shape long tube. It has two parts. Its proximal part (Cardiac stomach) is longer, wider and distensible. The second distal part (Pyloric stomach) is shorter and narrower. The oesophagus opening into cardiac stomach. Cardiac stomach is guarded by an oesophageal valve formed. At the junction of cardiac and pyrolic stomach is present a sphincter valve and blind sac. At the end of pyrolic stomach there is a muscular bursa entiana which is guarded by pyrolic valve. Like pyrolic valve, similar valve occurs at the end of cardiac stomach and is termed as a cardiac valve or sphincter valve. The longitudinal folds of the pyrolic stomach ends into the bursa entiana which continues into the intestine.

f) **Intestine:** It is a wide, straight tube running backward into the abdominal cavity. The narrow anterior part of the intestine receives the bile duct dorsally and pancreatic duct ventrally and this region is called duodenum. The rest part of the intestine is called ileum. The ileum is lined with the mucous membrane which is folded and it form the scroll valve. One edge of thescroll valve is attached to the inner wall of the intestine and the edge isrolled up on itself longitudinally making an anticlockwise spiral of about 2 ½ turns. In a transverse section it looks like a watch spring.

It serves two main functions:

i) It increases the absorptive surface of the ileum.

ii) It slows down the passage of the food through the ileum to ensure proper absorption. The ileum narrows posteriroly and ends into the rectum.

g) **Rectum:** The rectum is the last part of the alimentary canal. It is a short, narrow, straight tube;leads behind into the cloaca by a passage called the anus. The tubular rectal (caecal) gland opens dorsally into the rectum. The rectal gland excretes from the blood excess salts taken with food.

h) **Cloaca:** Rectum as well as urinogenital duct is received in the cloaca. The cloaca is a short terminal chamber which opens out cloacal aperture. This aperture is situated ventrally at the base of the tube between two pelvic fins. Through this opening the faeces, urine and genital products are eliminated.

B) Digestive Glands:

Scoliodon has four digestive glands associated with the alimentary canal. These are liver, pancreas, gastric glands and intestinal glands.

a) **Liver:** The liver is an elongated yellowish gland, consists of two lobes, the right and the left. It lies ventral to the stomach extends backwards along the greater part of the abdominal cavity. A 'V' shaped thin walled gall bladder in which bile is collected, lies embedded in the right lobe of liver. A narrow bile duct, about 3 cm long, leaves the gall bladder and opens into the anterior end of the intestine near the commencement of scroll valve.

Function: Liver secrets bile, stores glycogen and fat.

b) Pancreas: Pancreas is elongated, whitish gland situated between the cardiac and pyloric stomach. The pancreatic duct opens into the ventral wall of the duodenum; opposite to the opening of the bile duct.

Function: Pancreas secrets pancreatic juice which is poured into the duodenum.

Rectal Gland: It is a small finger like body attached by its duct to the dorsal side of rectum into which it opens. It has a central cavity lined by cuboidal epithelial cells.

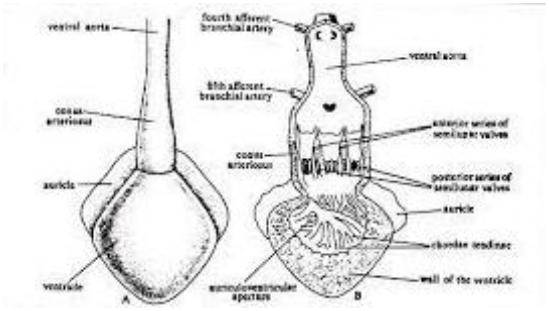
a) **Intestinal Glands:** Numerous, Microscopic intestinal glandslie in the wall of the intestine.

Function: They secrete the intestinal juice containing a ferment called erepsin.

Circulatory System of Scoliodon

The circulatory system of Scoliodon consists of the heart, arteries, veins andthe blood.

(A) Heart:



The heart of scoliodon is reddish brown. It is a muscular, conical in shape organ located in the middle line beneath the pharynx. It is enclosed in a delicate transparent, two layered sac

called the pericardium. A narrow space between the layers of pericardium is called pericardial cavity, containing a watery fluid called the pericardial fluid. This fluid protects the heart from shocks and provides free movement during contractions. Thus pericardial fluid and pericardial layers both protect the heart from the mechanical injury.

Structure:

The heart of Scoliodon receives non-aerated blood form all parts of the body and pumps it to the gills for oxygenation. The blood passes through the heart only once during its one complete circuit .The heart contains only impure or venous blood hence it is called venous or branchial heart. In case of Scoliodon the heart consists of two chambers and two accessory lobes: (i) sinus venousus,(ii)auricle or atrium,(iii)ventricle and (iv)conus arteriosus.

(i) **Sinus venosus:** The sinus venous is a thin walled, triangular chamber , lies on the dorsal side of the ventricle. Laterally two large vein the ducti cuvieri enter into the sinus venous which carry venous blood while two hepatic sinuses which open into it posteriorly. The sinus venous opens into the atrium or auricle by the sinu-auricular aperture.It is guarded by the sinu-auricular valves which prevent the backward flow of the blood from the auricle into the sinus venous.

(ii) **Auricle or Atrium:** It is large triangular and spongy chamber lying in front of the sinus venous and the posterious angles of it slightly projected laterally to the ventrical in its natural position. It opens into the ventricle by the auricular-ventricular aperture, guarded by bilabiate auriculo ventricular valve. The chordate tendineae attach the lips of the valve and enter into the inner surface of the ventricle. These fibro muscular strands keep the lips of the valve together to check the flow of blood back into the auricle.

(iii) **Ventricle:** It is a conical in outline and has very thick and highly muscular wall. The inner surface of the ventricle is produced into many muscular strands called chordate tendineae. The ventricle lies beneath the sinus venosus and the auricle. It tapers anteriorly to join the conus arteriosus.

(iv) **Conus arteriosus:** It is a stout muscular tube extending from the ventricle. It has thick and muscular wall is having two transverse rows of semi-lunar valves. Each row contains three valves, one dorsal and similar accessory or miniature valve on either side of the dorsal valve in each row. All the valves of the anterior row are larger than the posterior row. From the ends of all the valves fine tedious threads extend forwards as well as backwards. They are inserted on the wall of the conus arteriosus to keep the valves in position. The conus arteriosus runs forward in the form of a tube called ventral aorta.

The ventrical and conus arteriosus functions as the forwarding pump for the blood. As the sinus venosus and conus arteriosus are not considered as true chambers, the heart of shark is called two chambered heart.

Course of circulation:

The sinus venous receives the venous blood from the entire body through a pair of large veins,the ducti cuvieri and a pair of hepatic sinuses. Then the sinus venosus contracts and sends its blood into the auricle through the sinuauricular aperture. Now the auricle contracts and forces its blood into the ventricle through the auriculo- ventricular aperture. At this time, the sinus venosus relaxes and the back flow of blood into it from the auricle is prevented by the sinu-auricular valves. Fromventricle, the blood flows again forward into the conus arteriosus by contracting the muscular walls of the ventricle. The backflow of blood into the auricle is prevented by the auriculo-ventricular valve during contractions. From the ventricle the wave of contraction passes over the conus which propel the blood into the ventral aorta. When conus arteriosus contracts, the backward flow of blood into the ventricle from it is prohibited by the semilunar valves. Lastly the ventral aorta sends its blood into the gills for oxygenation, thus in all parts of the heart only venous blood circulates during the circulation. This is known as the single type of circulation. The rhythmic contraction and relaxation of different parts of the heart is called systole and diastole respectively.

Due to the presence of only deoxygenated blood in the heart, it is therefore, necessary that its walls should have a supply of oxygenated blood. It is provided by a pair of coronary arteries arising from the hypobranchial plexus.

(B) ARTERIES:

The arterial system of scoliodon mainly constitutes two types of blood vessels- the afferent and efferent branchial arteries. The afferent branchial arteries arise from the ventral aorta and carry impure blood to the gills. The efferrnt branchial arteries collect the pure blood from the gills and carry it to the dorsal aorta. For the sake of convienience the dorsal system may be divded into

i. Ventral aorta and afferent branchial arteries.
ii. Efferent branchial and epibranchial arteries.
iii. Arteries of head
iv. Arteries of dorsal aorta.
v. Hypobranchial plexus.

(i) **Ventral aorta and afferent branchial arteries:** The ventral aorta arises from the conus arteriosus and runs forward beneath the pharynx upto the hyoid arch. Here it bifurcates

into two short branches called innominate arteries. Each innominate artery again divides into two branches called first and second afferent branchial arteries.The first afferent branchial artery supplies branches to all gill-lamellae of the hyoideanarch. The second afferent branchial artery supplies branches to the anterior and posterior gill-lamellae of the first branchial arch. Behind the innominate arteries the ventral aorta gives out third fourth and fifth afferent branchial arteries. They supply the blood to the second ,third and fourth branchial arches respectively.

(ii) **Efferent branchial and epibranchial arteries:** The oxygenated blood from the capillaries of gill-lamellae is collected by nine blood vessels called efferent branchial arteries. Out of these the first eight arteries join in pairs to form four loops around the first four gill pouches. The ninth artery runs along the anterior surface of the fifth gill pouch. It collects the blood from the demibranch of the fifth gill pouch. The four loops are communicated with one another by the three short, longitudinal connectives. The fourth loop is connected to the ninth efferent branchial artery by fourth longitudinal connective. Each loop is continued into an epibranchial artery. The four pairs of epibranchial arteries of the two sides unite to form the median longitudinal dorsal aorta. The dorsal aorta runs backwards along the whole length of the body just below the vertebral column.

(iii) **Arteries of head:** Three arteries arises from the first efferent brancial artery of each side. These are an external carotid, afferent spiracular & hyoidean epibranchial. An external carotid artery gives two arteries, the mandibular and the submental. The mandibular supplies blood tolower jaw muscles. While the submental to the head. An afferent spiracular artery surrounds the spiracle and then goes to the brain. This artery is now named as the spiracular epibranchial artery. Just before entering the cranium the spiracularepibranchial artery gives off the great ophthalmic artery to the eye ball. Within the cranium it unites immediately with a branch of internal carotid and gives the cerebral artery. It supplies blood to brain. The cerebral artery which is a short vessel divides into an anterior and posterior cerebral arteries. An anterior cerebral artery supplies the olfactory sac. The posterior cerebral arteries form basilaries which run backwards all along the ventral side of the spinal cord as a spinal artery.

and inward. At the orbital level it receives a branch from dorsal aorta which is called the radix. Then it divides into a stapedial and an internal carotid. The stapedial artery runs forward and enters the orbit and gives two branches, the inferior orbital and the superior orbital. The inferior orbital supplies the eye muscles and the superficialtissues in the region above the auditory capsules. The superior orbital supplies the anterior boundary of the orbit. The superior

orbital artery then gives two arteries, the buccal artery and the maxilla-nasal artery. The buccal artery goes to the muscles of the lower jaw. The maxilla-nasal artery then gives two branches. One artery goes to the nasal aperture which is called the nasal artery while another artery supplies the rostrum, called as the rostral artery.

(iv) **Arteries of dorsal aorta:** The dorsal aorta runs backwards along the entire length of the body. Anteriorly it is formed by the union of four pairs of epibranchial arteries. In the trunk it lies below the vertebral column. It enters the tail as a caudal artery and continues within the haemal canals of branches to all the parts of the body. The anterior end of the dorsal aorta gives the buccal arteries which supplies the blood to the roof of buccal cavity. The radices also arise from the anterior end of the dorsal aorta and join the hyoideanepibranchial arteries. Close to the union of the fourth epibranchialarteries, the dorsal aorta gives off a pair of slender and small arteries called the subclavians.Each subclavian artery supplies the pectoral girdle and the pectoral fin of one side. The subclavian arteries, unite with epicoracoid arteries and then continues as the branchial arteries which supplies the pectoral girdle and the pectoral fin of one side. The subclavian arteries which supplies the pectoral fins. From the base of each fourth epibranchial artery, a large median artery arising which is called the coeliaco- mesenteric artery. It divides into two unequal branches,the smaller celiac and the larger anterior mesenteric. The celiac artery again gives off two branches, the anterior gastric -supplies the oesophagus, cardiac stomach and the dorsal wall while the hepatic supplies to the liver. The anterior mesenteric gives three branches:ventral intestinal and intra-intestinal supplying blood to the pancreas. Another median artery called lieno-gastric originate from a short distance, behind the coeliaco-mesenteric. It is also divisible into three arteries :the genital artery supplying the gonads, the posterior gastric artery supplying the pyloric stomach and spleen and dorso-intestinal supplying blood to the dorsal wall of the intestine. The dorsal aorta continues below and gives paired renal arteries arising from parietal arteries, supplying the blood to kidneys. It also gives a series of paired parietal arteries arising at intervals which supplies the body wall. Another small median artery arises from the dorsal aorta and supplies blood to the rectal gland which is called as the posterior mesenteric artery. The arteries are a pair of arteries from the dorsal aorta and goes into the pelvic fins for supplying the blood. Lastly, the dorsalaorta continues into the tail as a caudal artery.

(v) **Hypobranchial plexus:** This plexus occurs in the ventral wall of the pharynx. It controls four thin longitudinal vessels or arteries. These are a pair of median hypobranchial arteries and a pair of lateral hypobranchial arteries. Each lateral hypobranchial artery is connected externally with the efferent loops by a number of short fine vessels and internally each lateral hypobranchial artery is connected with the median hypobranchial artery of its side by fou

fine vessels. The two median hypobranchial arteries are interconnected by transverse vessels and by meeting posteriorly forms an unpaired artery. The latter gives off a pair of coronary arteries to the heart wall and pericardial artery to the pericardium. The pericardial artery gives off a common coracoids artery. The common coracoids artery then bifurcates into two arteries, the right and left coracoids arteries. These coracoids arteries join the subclavian arteries.

(C) Veins:

In scoliodon, the blood from the different parts of the body is returned to the heart by the veins The veins have thin walls and they form wide irregular spaces or sinuses during their course, instead of narrow, tubur muscular veins. The venous system can be divided into following five parts. They are (1) anterior cardinal system, (2) posterior cardial system,(3) hepatic portal system,(4) lateral abdominal system,(5) cutaneous system.

1. Anterior cardinal system

This system collects blood from the part of the body which lies anterior to the heart. It consists of a pair of large anterior cardinal sinuses and a pair of small inferior jugular sinuses.

(i) **Anterior cardinal sinuses:** Many small veins collect blood from the rostrum. These veins join to from the orbito-nasal or anterior facial vein. This vein passes backwards and expands into a small nasal or olfactory sinus. The nasal sinus leads posteriorly into the orbito-nasal sinus. The orbito-nasal sinus opens into a orbital sinus which is situated in the orbit. The right and left orbitar sinuses are interconnected by an interorbital vein. Two orbital sinuses empty into large anterior cardinal sinuses through narrow post orbital sinuses. Each cardinal sinus receives five dorsal nutrient sinuses from the dorsal region of the gills. The anterior cardinal sinuses run backwards and enter into the ductus cuvieri behind.

(ii) **Inferior jugular sinuses:** Two inferior jugular sinuses are located below the gill clefts. They receive blood from the floor of the buccal cavity and the pharynx. They also receive five ventral nutrient sinuses from the ventral region of the gills. The ductus cuvieri of each side opens into the sinus venosus through an opening guarded by semilunar valves to check the back flow of the blood.

2. Posterior Cardinal System

This system consists of a median caudal vein, renal portal veins and two large posterior cardinal sinuses. A median caudal vein collects blood from the tail. It bifurcates into right and left renal portal veins. The renal portal veins branch and capillaries in the kidneys and give off many afferent renal veins. They collect blood from the sinusoids of the kidneys. The renal veins

join to from the posterior cardinal sinuses. Each posterior cardinal sinus opens into the ductus cuvieri by an opening, opposite the opening of the anterior cardinal sinus.

In the posterior region of the kidneys numerous veins join to median inter- renal vein ,but towards anterior end two posterior sinuses are prominent separated by a median partition. Each posterior dinal sinus receives blood from the kidney by efferent renal veins and the dorsal body wall muscles by parietal veins. Blood from the veins collects in a pair of genital sinuses, which send it unto the posterior sinuses by genital veins it also receives an oesophageal vein from oesophogus.

3. Hepatic Portal System

This system carries blood from alimentary canal and the digestive to the liver. The hepatic portal system is made by seoarate veins which to form a large vein called hepatic portal vein. The hepatic portal vein is formed by the union of many veins namely, anterior gastric vein from the cardiac stomach, anteriorlieno-gastric vein from the anterior part of the pyloric stomach and spleen, pancreatic vein from the panereas,posteriorlienogastric vein from the pyloric stomach and spleen, ventral intestinal vein from the ventral wall of the intestine and intra-intestine and intra-intestinal vein from the scroll valve. The hepatic portal veins branch and capillaries in the liver. These capillaries unite to form two hepatic sinuses which opens into the sinus venosus by two separate openings near the median line. From the liver the blood is carried to the sinus venosus by these hepatic sinuses.

4. Lateral Abdominal System

This system consists of large lateral abdominal sinuses, running along the sides of the body. They bring the blood from the lateral body wall muscles and the paired fins. These two sinuses are joined posteriorly by a commissural vein. Near the hind end of each sinus is connected an iliac vein from the pelvic fin. Two subcalavian veins from the pectoral fins are also connected anteriorly with these sinuses. Anteriorly ,these sinuses discharge the blood into the ductus cuvierius or cuvierian sinus.

5. Cutaneous System

This system brings blood from the skin of the trunk and the tail region into ducti cuvieri. The system includes dorsal, ventral, left lateral and right lateral cutaneous veins. According to the position in the body, these veins collect blood from their respective regions.

The dorsal cutaneous vein runs beneath the skin along the mid-dorsal line and collects blood from the skin of the dorsal side. The ventral cutaneous vein runs along the mid-ventral line beneath the skin and collects blood from the skin of the ventral side. The left

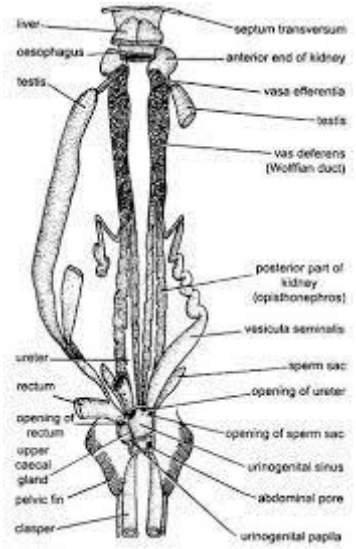
lateral and right lateral cutaneous veins run along the left and right side just beneath the lateral line canal and collect the blood from this region.

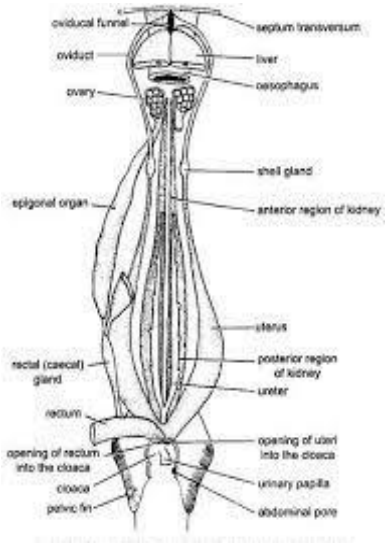
Thus the entire venous blood enters the sinus venosus through the ducticuvieri and the hepatic sinuses to begin its journey again.

(D) Blood:

The blood of scoliodon is reddish in color. It has a liquid component called plasma and cellular components such as R.B.Cs, W,B.Cs, blood platelets etc. The R.B.Cs are oval and nucleated. The leucocytes (W.B.Cs) are amoeboid cells similar with lymphocytes of other vertebrates.

Urinogenital System of Scoliodon





Male **Female**

In Scoliodon urinary or excretory system and reproductive or genital system are firmly related to each other and together called as urinogenital system. In Scoliodon sexes separate, sexual dimorphism is well marked by presence of pair of claspers in medial portion of pelvis fin.

A) Male Urinogential System:

Male Urinogential system of Scoliodon consists of organs of excretory system and organ of male reproductive system

a) The Excretory or Urinary System:

The excretory organs of male scoliodon consist of pair of kidney, a pair of urinary duct and a urinogenital sinus.

I) Kidneys:

a. In Scoliodon there is a pair of long, flattened ribbon like mesonephric kidneys
b. They extends from the cloaca to the oesophagus & lie on the side of the dorsal aorta.
c. Each kidney is differentiated into distinct anterior and posterior parts.
d. Anterior part is generally reduced and posterior part is developed.
e. Posterior part is excretory in function where as anterior part is reproductive in function.
f. It contains mass of coiled uriniferous tubules with peritoneal funnels, malphaign bodies and collecting tubules.
g. The collecting tubules of the anterior region are greatly reduced and non- excretory. This collecting tubules open into the Wolffian duct,While post region well developed.

Function: Filtration of waste products from blood and convented into urine.

II) Urinary Duct/ Ureter:

a. The collecting tubules of the posterior region of kidney leads into, thin-walled tube called the urinary duct or the ureter.
b. This common excretory duct arise from the ventral surface of each kidney run along its mid ventral line in post direction.
c. The urinary ducts are backwards and open behind into the urinogenital sinus.

Function: It carries urine from kidneys to urinogenital sinus.

III) Urinogenital Sinus:

a. It is the last part of excretory system of Scoliodon.
b. This is the common excretory duct which is large, somewhat triangular, median sac communicate with cloaca.
c. Both the ureters opens into this urinogenital sinus.
d. It is present in the median position in between pelvic fins just behind the urinogenital papilla.
e. Its opening of urinogenital sinus present at tip of pailla.

Function: Excretion of urine through urinogenital pailla.

b) The Reproductive or Genital System:

Male reproductive system of Scoliodon comprises a pair of very large, elongated testes,epididymis, vasa efferentia, vas deferens, a pair of Wolffian ducts, sperm sacs, a pair of siphons and a pair of claspers.

I) Testes:

a. There is pair of large creamish colored tubular glands called testes attached to the body wall by double fold membranous peritoneum called mesorchium.

b. Anteriorly it extending from the base of liver to the rectal gland.

c. Each testes composed of fine coiled tubules called seminiferous tubules.

d. Seminiferous tubules internally lined by germinal epithelium which produce spermatozoa.

Function: Production of Spermatozoa and sperms

II) Vasa effernetia:

a. From each testies there are given off several fine tubules called vasa efferentia.

b. These tubules run in the mesorchium to the anterior end of large Wolffian duct.

c. Spematozoa developed from the germ cells in the seminiferrous tubules of the testies/ sperms are carries to the vas deferens.

Function: It carries spermatozoa/ sperms to the vas deference.

III) Vas deference:

a. This is the third part of the reproductive system of the Scoliodon.

b. It is the anterior part of the Wollfian duct.

c. The vas deference is the coiled structure.

IV) Epididymis:

Vas deference forms a very large narrow and extremely coiled duct along the entire ventral surface of the anterior genital part of kidney called epididymis.

Function: It provides a nourishing fluid for growth & maturation of spermatozoa.

V) Seminal Vesicle:

a. In the renal part of the kidney the vas deference becomes much wider and much less convoluted called the seminal vesicle.

b. Seminal vesicle of both the sides open behind separately into the urinogenital sinus which in its turn opens into the cloaca on an elevated papilla.

Function: It stores sperms/ spermatozoa.

V) Sperms sacs:

a. Seminal vesicle gives off in front on either side an elongated club shaped blind sac, called sperm sac.

b. The sacs are blind in front but open into the urinogenital sinus just outside the opening of the seminal vesicle.

VI) Siphon:

a. On the ventral side of the body just beneath the skin there is a pair of elongated and muscular sacs, the Siphons.

b. They extend from the pectoral fins to the base of the clapsers.

c. They are closed in front but communicate behind with the groove of the claspers of its side.

d. It is believed that they are full of sea water and serve to force the sperms into the Female's genital tract along the groove of the claspers during copulation.

VII) Claspers:

a. The claspers are the stiff, erectile, rod like copulatory organs.

b. They extend backwards along the inner borders of the pelvic fins and supported by the cartilage.

c. Each clasper has a groove on its dorsal side which opens at both ends.

d. Its wide anterior opening is called the apopyle which communicates with the cloaca as well as the siphon. This opening receives the sperms from the cloaca.

e. The narrow posterior opening of the clasper is called the hypopyle which serves as an exit for the sperms into the cloaca of the female.

VIII) Female Urinogenital System:

The female urino-genital system constitutes the urinary or excretory system and the genital system. In the female, there is no direct connection between the kidneys and the genital organs.

I. Excretory system in female scoliodon:

It includes a pair of kidneys, a pair of Wolffian ducts and the genital system.

a) **Kidney-** Two short and flattened kidneys located between cloaca and ovaries on dorsal side. The anterior part of kidney is reduced and non-functional whereas posterior part is thick and functional. Uriniferous tubules of kidney open into the mesonephric or Wolfian duct.

b) **Wolfian duct:** In the female, the wolffian duct or Ureters are long, thin walled tubes, which are formed by the union of the collecting ducts of the mesonephric tubules. They unite posterior to open in to urinary sinus.

c) **Urinary sinus:** The urinary sinus is large median sac at the end of the body cavity. The urinary sinus open into the cloaca by an aperture seated on an elevation called the urinary papilla.

Excretion: In Scoliodon the end product of nitrogen metabolism is urea. A large quantity f urea is retained in the body, which is an adaptation to marine life. Urea retain by two ways:

i) Synthesis of urea in all tissues except brain and blood.

ii) Absorption of urea from the glomerular filtrate by the special urea absorbing segments of the uriniferous tubules of kidney.

The urine is thus hypotonic to sea water which consists of mainly water & salts. The high urea content makes the osmotic pressure higher than the sea water.

II) REPRODUCTIVE SYSTEM:

System consists of pair of ovaries, pair of oviduct, shell gland & a pair of uteri.

a) **Ovaries:** Ovaries are paired and situated on either side of the vertebral column behind the base of the liver. Each ovary is suspended by a double fold of peritoneum, called mesovarium. Both ovaries are connected with the anterior end of the rectal gland by long strands, the epigonal organs.

b) **Oviduct:** Oviduct is long tube. It is thick and muscular. Both these ducts originate from the septum transversum near the base of the liver in front of the ovaries. Both the anterior ends of the oviduct meet to form a longitudinal slit, called oviductal funnel. The fertilization of the mature eggs takes place in the part of the oviduct between the oviducal funnel and the shell gland.

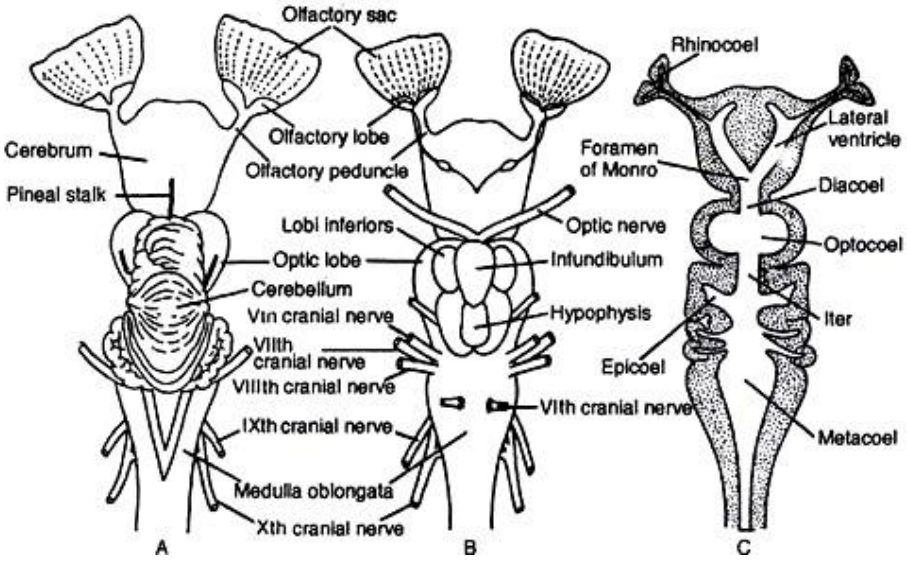
c) **Shell gland:** It is the enlarged part of the oviduct. It secretes albumen and shell around the egg.

d) **Uteri:** It is expanded part of oviduct in which embryo is developed. During breeding uteri become distended. Uteri unite posterior and form median chamber called vagina. It opens into the cloaca by a wide aperture. The mature ova, from the ovaries are at first shed into the abdominal cavity. From where they are forced into the oviducal funnel by the action of the body muscles.

Copulation: During copulation the claspers of the male are inserted into the cloaca of the female. The spermatic fluid is passed into the grooves of the claspers. Sea water is present in siphon forces into the grooves of the claspers. With this water the seminal fluid or spermatic fluid also forced into the cloaca of the female.

Fertilization: In Scoliodon, the fertilization is internal. The sperms swim up the oviduct and the fertilization of mature eggs takes place in the part of the oviduct, between the oviduct funnel and the shell gland. Mature eggs reach inthe shell glands from oviduct aperture.

Nervous System of Scoliodon



A: Dorsal View **B: Ventral View** **C: Longitunal View**

The nervous system of Scoliodon is broadly divisible into the central nervous system, the peripheral nervous system and the autonomic nervous system. The central nervous system consists of the brain and the spinal cord. The peripheral nervous system consists of cranial nerves and spinal nerves while the autonomic nervous system contains a paired series of irregularly arranged ganglia situated anteriorly in the dorsal wall of the posterior cardinal sinuses and posteriorly in the dorsal part of the kidney on each side of the mid dorsal line.

Brain:

The brain is enclosed in the cranial cavity of the skull. It is a soft and whitish organ divided into three parts: For brain, mid brain and hind brain.

a) **Fore brain-**

The forebrain or prosencephlon is very large. It includes olfactory lobes, cerebrum and diencephalon.

i) **Olfactory lobes:** From the antero-lateral sides of the cerebrum, a pair of stout olfactory tracts or peduncle extends forwards and outwards. Each olfactory peduncle ends in a bilobed mass called the olfactory bulb or olfactory lobe. The olfactory lobes are closely attached to the olfactory sacs of their own side.

From each olfactory lobe olfactory nerves are given off to the olfactory sacs.

Function: They are provided for the highly developed sense of smell.

The olfactory peduncles and lobes enclose narrow cavities called the olfactory ventricles or rhinocoels. The olfactory ventricles are continuous with the lateral ventricles of the cerebrum.

ii) **Cerebrum:** It is a large, rectangular mass with a smooth surface. The cerebrum forms the anterior part of the brain and it is undivided into the right and left cerebral hemisphere. It contains pair of cavities called lateral ventricles or paracoels, separated from each other by a median partition. The dorsal surface of cerebrum is quite smooth but on its mid-ventral surface there is a small aperture called the neuropore.

Function: The cerebrum is useful for sense of smell, it is seat of intelligence, controls voluntary actions.

iii) **Diencephalon:** The cerebrum is continued posteriorly into the diencephalon. The diencephalon is a narrow and very short part, completely hidden by the forward prolongation of the cerebellum. The roof of the diencephalon is membranous, thin and highly vascular which forms the anterior choroid plexus. The diencephalon encloses a laterally compressed cavity, the third ventricle or diacoel is continuous behind with the iter. The third ventricle extends into the base of the pineal stalk.

b) Mid brain:

It is mid brain or mesencephalon is the middle part of the brain. It consists of two optic lobes and cruracerebri.

i) **Optic lobes:** There are two large oval bodies on the dorsal side of the brain. They are completely covered dorsally by the cerebellum and ventrally by infundibulum outgrowths.

Function: The optic lobe has optic, olfactory, gustatory and acoustic- lateral sensory centers.

ii) **Crura cerebri:** These are thick bands of nerve fibers, running antero-posteriorly on the ventral side of the brain. They connect the fore brain with the hind brain. They are partially hidden by infundibulum and the other associated structures.

Function: It is used to transmit impulses.

c) Hind brain:

The hind brain or rhombencephalon is the posterior part of the brain. It consists of the cerebellum and the medulla oblongata.

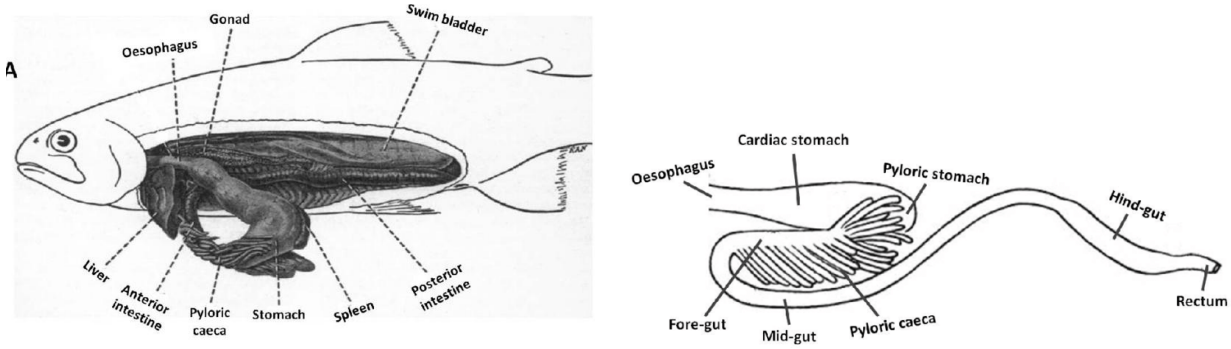
i) **Cerebellum:** It is well developed part extends forward up to the cerebrum and covers the part of medulla oblongata behind. The cerebellum is rhomboid in shape and its dorsal surface is thrown into numerous irregular folds.

Function: The cerebellum is the seat of regulation of balance and muscular control.

Medulla oblongata: It is the posterior most part of the brain. It is triangular in shape.

6. ANATOMY OF FIN FISH: LABEO

Digestive System of Labeo



Digestive system consists of the alimentary canal and digestive glands.

I) Alimentary canal:

The alimentary canal is divided into mouth, buccal cavity, pharynx, oesophagus, intestinal bulb, intestine and rectum with its external opening of anus.

Mouth- The mouth is bounded by soft upper and lower fleshy lips with four or five rows of sensory papillae. Mouth opens into buccal cavity.

Buccal cavity: The buccal cavity is a short dorso-ventrally compressed cavity.

The mucous membrane lining the buccal cavity contains minute papillae. The buccal cavity opens into dorso-ventrally flattened pharynx.

Pharynx: Pharynx is dorso-ventrally compressed and differentiated into a broad anterior respiratory part and narrow posterior masticatory part. The anterior portion is narrower and is perforated laterally by gill-slits. The posterior portion of the pharynx bears closely set pharyngeal 3 rows of homodont teeth on its ventrolateral walls and the ventral wall is highly folded transversly. The pharyngeal teeth help to crush solid foods. Pharynx leads posteriorly into oesophagus.

Oesophagus: Oesophagus is very short, narrow tube. Oesophageal mucous lining forms prominent longitudinal folds. In Labeo, pneumatic duct of air bladder opens into oesophagus. Oesophagus opens into intestinal bulb. In Labeo or in other Teleost stomach is absent.

Intestinal bulb: It's elongated, swollen, and thick walled in structure. The anterior part of intestine is swollen sac like. This sac is designated as intestinal swelling or intestinal bulb which stores food. Oesophagus opens into intestine by oesophageal valve and valve is helps to prevent regurgitation of food. The intestinal bulb has an anterior broader cardiac part into which open dorsally the pancreatic and bile duct and a posterior narrow pyloric part without

pyloric caeca. The mucous lining of cardiac part shows comb-like folds and that of pyloric part contains bold longitudinal folds. Gastric glands are absent in intestinal bulb. Intestinal bulb is followed by intestine.

Intestine: Intestine is longer in Labeo because of its herbivorous habit. Intestine is thin, narrow and extremely elongated tube. The intestine is more or less of uniform diameter and forms a number of coils. The mucous lining forms oblique transverse folds in its anterior region and distinct longitudinal folds in the posterior region. Pyloric caeca, intestinal villi and scroll valve are absent.

Rectum: Terminal part of intestine is rectum. Rectum which is follows nearly 1 meter long, slightly wider & thin walled. Rectum opens to the exterior by anus.

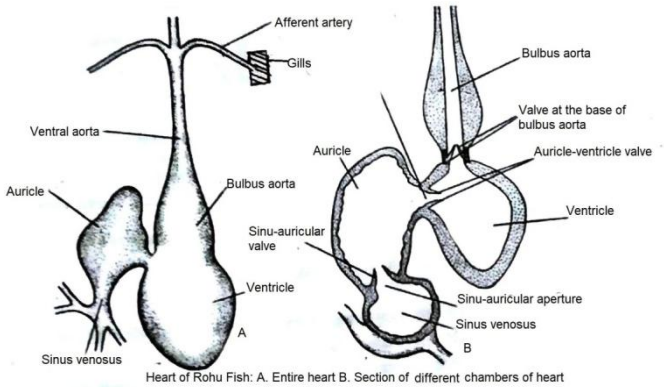
II) Digestive gland:

Liver and Pancreases are two types of digestive glands are present in Labeo.

Liver: It is a large and dark brown in colour. Liver divided into norrower right lobe and broader left lobe. The two lobes of the liver interconnected anteriorly by connecting median lobes. Gall bladder is thin walled elongated sac like structure. Lies dorsally between right lobe and intestinal bulb. A cystic duct arises from the anterior end of gall bladder, receives three hepatic ducts from the liver lobes and forms a bile duct which opens dorsally into the roof of cardiac part of intestinal bulb.

Pancreas: Pancreas is diffused, scattered form. It found in spleen and intestinal mesentry. A pancreatic duct which is enclosed in a common sheath with bile duct opens separately in the intestinal bulb.

Blood Vascular System of Labeo



Heart of Rohu Fish: A. Entire heart B. Section of different chambers of heart

The blood vascular system of labeo and physiology of blood circulation is somewhat similar to that of scoliodon. It is divided into anterial and venosus system.

Heart- The heart of labeo is located on ventral side of pharynx in the anterior part of coelom called as pericardium. The heart is a muscular tube bent on itself in shape of letters i.e curved like Scoliodon heart. The heart is two chambered composed of dorsal chamber called auricle and ventral ventricle. The heart of labeo also has two additional chambers such as sinus venosus and bulbus anteriosus. In Labeo conus arteriosus is absent.

Sinus venosus- It is the posterior most large spongy contractile receiving chamber. The sinus bears a pair of long lateral appendages on anterior side which is characteristic features of cyprinoid fish. The sinus venous receives impure blood from anterior part of body through two large veins called ductus cuveri. It also receives blood from posterior part of ductus cuveri. It also receives blood from posterior part of the body by two large hepatic veins . The sinus venous opens into auricle through sinu-auricular opening guared by a pair of membranous valves.

Atrium/Auricle- It is large slightly thick walled chamber present on dorsal side of ventricle .The auricle opens into ventricle through auriculo-ventricular opening guarded by vales.

Ventricles- The ventricle is large prominent thick walled muscular ventral chamber. The inner surface of ventricle is spongy due to muscular ridges which increases surface area of ventricle. The auricle and ventricle both are contractile in nature. The ventricle continues anteriorly into thick walled bulb like bulbus anteriosus. It continues anteriorly into ventral aorta .The opening between ventricle and bulbus is also guarded by valves to prevent back flow of blood into ventricle of heart of labeo. The heart of labeo contain only impure or venous blood hence known as venous heart.

The sinus venous receives impure blood collected from body .The sinus venous control and forces this blood into auricle. Then auricle contracts and force this blood into ventricle. After auricular contraction ventricle straction ventricle starts contracting. The ventricular wall is thick, muscular. Hence ventricular contraction is strong. It forces blood to bulbus arteriosus which then contract and forces blood into ventral aorta.

The valves present between openings of various chambers of heart allows the blood to flow only in forward direction and prevents back flow of blood.

The ventral aorta carries venous blood to gills for purification or aeriation the blood absorbs O2 and become pure. It is collected by anterior set of vessels which opens into dorsal aorta. The dorsal aorta distributes pure blood to various parts of body of labeo. Thus oxygenated (pure) blood collected from gill is never carried to heart. As heart contains only venous blood it is called as venous heart. The heart forces blood to gills or branchiae hence also called as branchial heart.

In one complete circuit from any organ back to the same organ blood passes only once through heart hence it is called as single circulation heart or single circuit heart.

Function- The function of heart of labeo is to receive only venous blood from body, pump it forward to gill for oxygenation. The sinus venous and auricle are only receiving chambers.

Urinogenital System of Labeo

A) Excretory System of Labeo

Excretory organs are a pair of kidneys, a pair of ureters, urinary bladder and urinary opening.

1) **Kidney:** In Labeo a pair of kidneys are located all along the length of body cavity. The kidneys are much elongated,brownish coloured structures. They are located on either side of vertebral column. The kidneys are mesonephric i.e. middle and posterior part of kidneys are only functional. Each kidney is further divided into 2 distinct regions.

a) Anterior globular part or head of kidney- It is non renal or non functional part of kidney.

b) Posterior broader part or trunk kidney- The middle part of kidney is broader. It is made up of large number of uriniferos tubules, composed of bowman's capsule, proximal & distal convoluted tubules & collecting tubules.

Function: Separation of metabolic wastes from blood so as to form urine. The posterior part of kidney is narrow and separate.

2) **Ureter:** From each kidney posetriorly origin acts a duct called as Ureter. It carries urine from kidney to urinary bladder.

3) **Urinary bladder:** The two ureters are fused with each other and opens into a thin walled elongated sac known as urinary bladder.

Function: Stores urine temporarily.

4) **Urinary opening:** From Urinary bladder arises common duct which opens to exterior by separate opening called as Urinary opening. It is located just behind anus.

B) REPRODUCTIVE SYSTEM OF LABEO

In Labeo sexes are separated i.e. dioecious animal. In Labeo fertilization is external. The male and female Labeo release their gametes in fresh water bodies

i.e. female Labeo is oviparous in nature.

Male Reproductive System:

Male reproductive system consists of Testis, sperm duct and genital opening.

1) **Testis:** In Labeo a pair of testis are elongated paired structures, freely suspended in the body

cavity by means of a peritoueal fold called mesorchium.

The testes are composed of large number of seminiferous tubules containing spermatogonial cells which during spermatogenesis produce sperms.

Function: Testis produce sperms.

2) **Sperm duct:** The peritoneal covering posteriorly continuous behind as a duct called sperm duct. It collects sperms from seminiferous tubules of testis through smaller duct. The two sperm duct unites to form common sperm duct.

Function: It carries sperms from testis.

3) **Genital opening:** Two sperm duct unite posteriorly and opens into exterior as a male genital opening located just behind urinary opening. The sperms are released free in the fresh water which fertilizes ova released by female Labeo.

Female reproductive system:

Female reproductive system consists of pair of ovaries, oviduct and female genital opening.

1) **Ovary:** A pair of ovaries are elongated, globular and located on either side of kidneys and suspended in body cavity by fold of peritoneum called mesovarium. Each ovary is composed of large number of ovarian follicles in different stages of development.

Function: It produce large number of ova.

2) **Oviduct:** The mesovarian of each ovary continuous behind as oviducts.Two oviducts unites to form common oviduct.

Function: It carries ova from ovary.

3) **Genital opening:** Two oviducts runs posteriorly & fuse together before opening to exterior as female genital opening through which eggs are released in water.

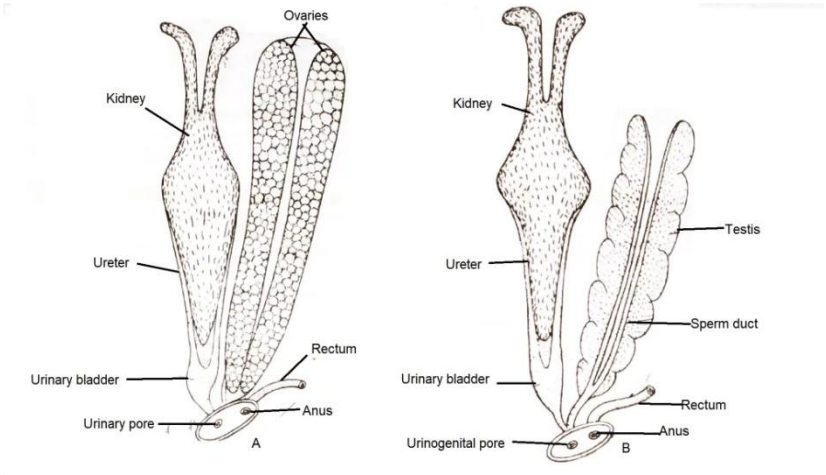
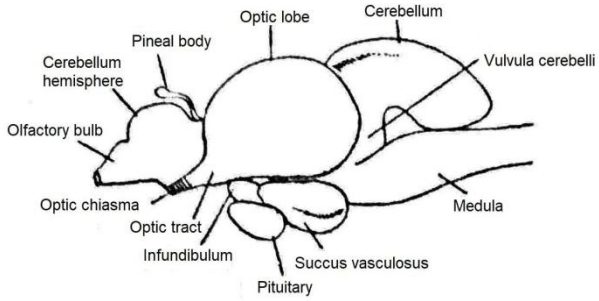


Fig. Urinogenital system of *Labeo rohita*: A. Female B. Male

Nervous System of Labeo



The brain of Labeo is enclosed in hard cranium. The brain is protected by a single membrane called M.contirm primitive. The brain of Labeo is composed of 3 main parts:

1) Fore brain or Prosencephaplon- composed of olfactory bulb, cerebrum and diencephalon.
2) Mid brain or Mesencephalon: consisting of very large optic lobe.
3) Hind brain or Rhombencephalon: consisting of cerebellum and medulla oblongata and spinal cord.

1) **Fore brain:** It is the anterior most part of brain. It includes olfactory bulb, cerebrum and diencephalon. In Labeo olfactory lobes are absent.

Olfactory bulb- The olfactory tracts are long and tubular which enlarges below olfactory organ so as to form olfactory bulbs.

Function: It is responsible for sense of smell which is well developed.

Cerebrum- In Labeo two cerebral hemisphere are more or less spherical in shape and well developed. The two cerebral hemispheres may be united sometimes. Function: the cerebrum is concerned all voluntary action such as, parental care, sexual behavior and locomotion etc.

Diencephalon: In Labeo the diencephalon is very much reduced and indicated by presence of pineal apparatus. It is composed of pineal stalk and pineal body at its tip. The roof of diencephalon is extremely thin and membraneous which is highly vascular and called as anterior choroid plexus. The floor of diencephalon gives off hollow outgrowth on ventral side called as infundibulum. The large hypophysis or pituitary body is located at the tip of infundibulum. On the lateral side of infundibulum lies two lobi inferior. The hypophysis is surrounded by glandular sac called as saccusvasculosus. In front of infundibulum lies optic chiasma formed by crossing of optic chiasma.

Function: It is endocrine in function.

2) **Mid brain:** It includes largest part of brain, the optic lobes. The optic lobes on their ventral side gives out stout optic nerves which crosses each other so as to form optic chiasma

present in front of infundibulum.

Function: optic lobes control sense of vision in Labeo.

3) **Hind brain:** It is composed of anterior small metencephalon which gives off dorsally tip like outgrowth called cerebellum and posterior thick walled mylencephalon or medulla oblongata.

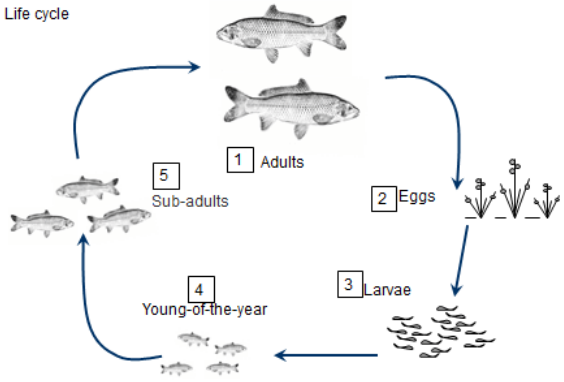
Cerebellum- It is large in size and well developed. It covers medulla oblongata posteriorly and posterior part of optic lobes. Cerebellum is spherical in shape. Function: it controls body equilibrium.

Medulla oblongata- It is relatively short and forms posterior part of brain in Labeo. The medulla oblongata is tapering.

Function: Controls involuntary activities like heartbeat, respiration etc.

Spinal cord: Medulla oblongata posteriorly continued into spinal cord.

Study of Life Cycle of Labeo



Labeo is a fast growing Indian major carp of fresh water. Labeo is common Indian major carp. It is fresh water bony fish. Labeo is extensively used in aquaculture. Sexes are separate. Male attains maturity in year and female attains maturity in 2 years. Labeo breeds in flooded river during monsoon period. Female lays about 2 million eggs at a time. Life cycle involves egg, spawn, fry and fingerling and adult stages.

Egg of Labeo:

1) Eggs are nonfloating. Nonadhesive type.
2) Eggs are round in shape and reddish in colour.
3) Size of eggs are 4 to 5 mm in diameter.
4) Eggs contains nucleus and yolk globules.
5) The incubation period is about 14-18 hours when water temperature ranges from 26oc to 31oc

Fertilized egg:

1) The fertilized eggs are adhesive, sticky, demersal & brownish-yellow in color.
2) The average diameter of the egg is approximately 0.8 mm.
3) Slightly swelling is observed immediately after the fertilized eggs.
4) The fertilized eggs has a spot on one pole and were readily recognizable through naked eye.

Hatchling of Labeo:

1) Newly hatched larvae are slender, straight and transparent, gradually tapering towards the tail.
2) Larvae silver in colour and the yolk sac attached to the body.
3) The heart of larvae are functional in between head & the anterior margins of the yolk.

Fry stage of Labeo:

1) Eggs developed into number of undivided fry.
2) Size ranges from 14-25 mm.
3) A pair of whitish or light grayish maxillary barbells present.
4) Fringed lips.
5) A dark diffused transverse band present at the caudal peduncle.
6) Fry stage Labeo feeds on zooplanktons.

Fingerling stage of Labeo:

1) Early fingerlings of Labeo are 30 to 100 mm in length.
2) Dark band at the caudal peduncle persists.
3) Reddish tinge present in the dorsal, pelvic, anal and caudal fins.
4) Lips fringed.
5) Both the lobes of the caudal fin have reddish tinge with dirty grey color along the margins.
6) Maxillary barbells are prominent. A pair of small rostral barbells also appears.

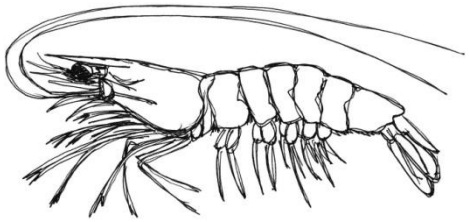
Adult stage:

1) Spindle shaped, elongated body with moderately rounded abdomen.
2) Head prominent with blunt snout, mouth is sub-terminal.
3) The color of the body is bluish or grayish on the dorsal side. The lateral sides are silvery in appearance.
4) Cycloid scales with orange to reddish center.
5) Caudal fin is deeply forked.
6) Lips are thick and fringed with a distinct inner fold above and below and a pair of short and thin barbels.
7) It breeds during monsoon period.
8) Attain weight of 1 kg in one year. It grows up to 1 m.

7. ECONOMIC IMPORTANCE OF THE FOLLOWING

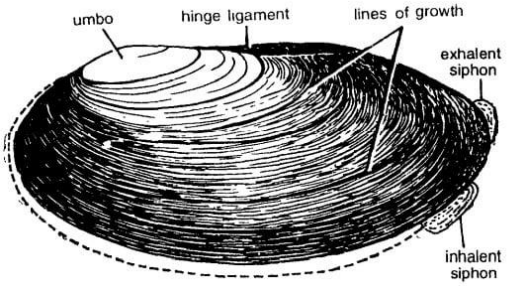
Some fishes are consumed by man in fresh condition or frozen condition or canned form. Some fishes are used by man as ornaments, decorative articles and medicines. Some fishes are used for the preparation of lime, poultry food, fertilizers, fish etc. Some fish organs are used for human activities such as bathing and cleaning.

Prawn:



1) The prawns are mainly used as food in fresh, frozen, smoked, sundried and canned condition.
2) The flesh of prawn is sweet & tasty.
3) Flesh contain large amount of glycogen and low fat content and rich source of vitamins A, D and free amino acids.
4) The prawns have great demand in foreign countries for it's sweet and tasty pleasant taste. Hence they gives good foreign currency to India.
5) The useless organs such as head, thorax, tail, appendages and tail of prawn are used in lime industries.
6) The sundried prawn parts such as head, thorax, tail, appendages, chitinous body is used in prawn meal and manure which is used as fertilizers for cash crops.
7) The whole materials of prawns such as chitinous shell is dried and powdered to form prawn meal which is used as valuable poultry feed.
8) The prawn fishery provides good employment to the coastal people.

Unio:

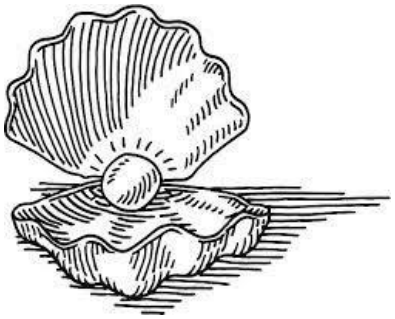


1) It is delicious and nutritious as food.
2) Bivalve are very good food for many aquatic animals.
3) Bivalve contain muscles which are used as food. The shells are used to prepare buttons, ornamental work and knife handles etc.
4) Largest shells of giant clams are used in babies cradles.

Pearl oyster:

1) Pearl oyster produces precious pearls which have great ornamental value.
2) Pearl oysters are used as food.The flesh of oyster is delicious and nutritious. Flesh contain large amount of proteins, minerals and vitamins.

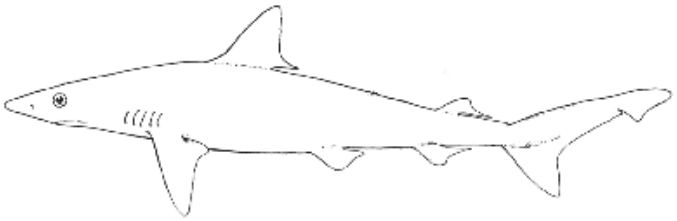
3) Crustacean genus of oyster are called edible oysters because its flesh is tasty, delicious and nutritious hence mostly consumes as food by rich people.



4) The shells of pearl oysters are used for preparation of button and other decorative articles because of their inner shining surface which is made up of nacreous layer.
5) The shells of oysters are composed of CaCO3, hence used in lime industries.
6) The shells of pearl oysters are also used in preparation of poultry feeds.
7) Pearl oysters are used in study of morphology of molluscan animals.

Scoliodon:

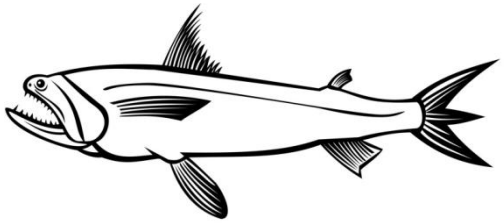
1) The Scoliodon are mainly used as food in fresh condition, salted and sundries condition.
2) Liver oil is obtained from the liver of scoliodon, which is a rich source of vitamins A & D. it is used as in medicine to protect & cure for rickett disease in childrens. The oil is also applied on wounds and burns for curative purpose.



3) The dries and tanned skin of sharks is rough due to roughness it is used for polishing furniture and for preparation of handle covers of vehicles.
4) The dried skin of sharks is commonly called shagreen. It is used for preparation of leathery articles such as shoes, bags, sword handle etc.
5) The muscles of Scoliodon are used in preparation of fish meal. It is an excellent food for poultry bird and cattles.
6) The spoiled and dried fishes are used for preparation of fish manure. It is used as fertilizer for crops such as tea, coffee, tobacco.
7) Wastes of fish such as skin, fins and skeleton is used for preparation of fish glue. Fish glue is an adhesive for preparation of paper boxes, book binding, leather, wood and in glass industries.

Bombay duck (Harpodon):

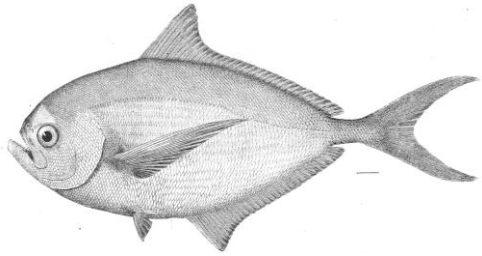
1) Bombay duck is used as food in fresh condition in coastal areas.
2) Sundried, salted form of Bombay duck is called Bombil. About 20% of Bombay



duck used as fresh condition while 80% fishes are salted, dried and sold in market.

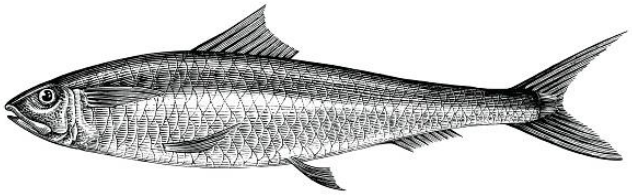
3) Useless and spoiled fishes are mainly used in preparation of fish manure, which is used as fertilizers for cash crops like tea, coffee, tobacco etc.

Pomphret:



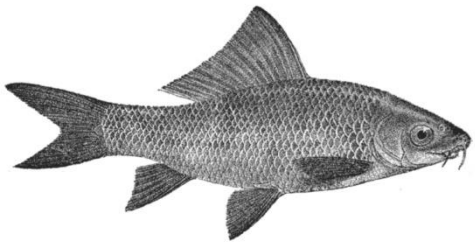
1) Pomphret has very soft flesh and minimum number of bones hence this fish is highly priced delicious fish. It is used in fresh or ice preserved form.
2) Pomphrets are mostly exported to foreign countries in smoked , ice preserves and canned form, hence they gives good foreign currency to India.
3) The skin, fins and bones of fishes are used for preparation of fish glue which is used as an adhesive for book binding and preparation of paper boxes.

Sardine:



1) Sardine is a marine fish which is commonly called oil Sardine because from sardine body oil is mainly extracted.
2) The fish body oil is used for preparation of Laundry soaps and insecticidal soaps.
3) It is also used for preparation of paints and varnishes, printing inks etc.
4) The fish body oil is also used for preparation of candles, cosmetics and lubricants.
5) In leather industries body oil is used for tanning of skin.
6) Lesser sardines are tasty and delicious hence mostly used as food.
7) After extraction of body oil, tissues of sardines are used for preparation of fish meal.
8) The spoiled fishes are used in preparation of fish manure which is used as fertilizer for cash crops.

Labeo:

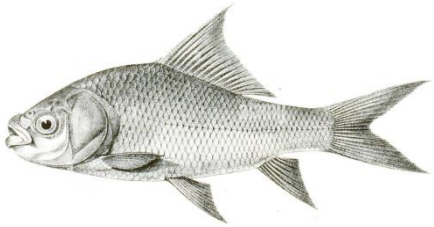


1) Labeo is mainly used as food. It is consumes in fresh or ice preserved form.
2) The flesh of Labeo is tasty and very delicious hence its has high market value.
3) If fishes are captured in large numbers and if these are spoiled, they are used for preparation of fish manure, which is used as fertilizer for cash crops.
4) The waste material of fishes such as connective tissues of the skin, fins and bones are used

for preparation of fish glue. It is used as an adhesive for paper, wood, leather and glass industry.

5) Labeo fish meal is also added in poultry supplementary feed to increase protein content in food.
6) Air baldder of Labeo is used in preparation of isinglass which is used for purification or clarification of beer & wine. It is also used for preparation of plasters and cement.
7) In various fishery colleges it is used in type study.

Catla:



1) The flesh of Catla is tasty and delicious. Catla is mainly used as food in fresh form or in ice preserves for.
2) Isinglass is prepared for the purification wine and beer industries.
3) Excess catched fish are used for preparation of fish manure, which is used as fertilizer for cash crops.
4) The Waste part of fishes such as skin, fins and bones are used for preparation of fish glue. It is used as an adhesive for paper, wood, leather and glass industry.
5) Excess fishes are used for preparation of fish meal.

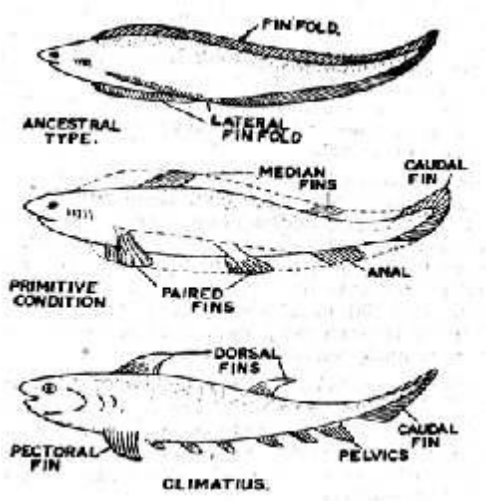
8. STUDY OF THE FOLLOWING GENERAL TOPICS

Study of Fins

Evolution of paired and unpaired fins in fishes

Fins are the chief organs of locomotion in fishes and are of two kinds, median or unpaired, and paired fins. The median fins include a dorsal on the back, an anal on the ventral side behind the vent and a caudal at the end of the tail. Paired fins are pectorals and pelvic corresponding to the fore and hind limbs of the terrestrial vertebrates. Both the median and paired fins are supported by skeletal rods called the radials and dermal fin rays.

Fin fold theory: This theory was put forward almost simultaneously by Balfour and Thacher and later supported by Mivart.



According to the fin fold theory, the ancestral vertebrate had a pair of lateral continuous fin folds extending from behind the gills upto the end of the tail. These folds were separae in the proximal part but fused in the caudal region behind the anus, forming a ventral fin-fold. Besides these, there was a dorsal median fold. The paired metapleural folds of amphioxus and the continuous fin folds of the skates are put forward as an evidence for this assumption.

As the continuous folds were an obstruction in swimming and prevented the undulating movements of the body, certain portions of these folds became enlarged while the intermediate portions disappeared. As a result, there was now left, a pair of fins near the gill arches (pectoral), a pair of fins near the anus (pelvic), a median dorsal fin and caudal fin.

During development, paired fins first appear as longitudinal folds of the body wall. Thacher and Balfour believed that the pectoral and pelvic folds were differentiated from an original continuous fold. This supposed primary continuity from the pectoral to the pelvic region may not be an essential part of the theory, and it is possible that the paired as well as the median fins were discontinuous from the very beginning.

The theory receives further support from a number of facts from embryology and paleontology:

1) The mode of development and early structures of the paired and median fins of fishes are identical.
2) In the Elasmobranch embryos and in the extinct shark Cladoselache, the paired fins are in the

form of longitudinal folds of the body wall and have parallel arrangements of their fin rays.

3) In Climatius, there was a series of smaller spines and finlets between the pectoral & pelvic fins. This suggests that they were originally joined by a continuous fold.

Median fins: The median fins of all the fishes develop as a result of differentiation in a continuous embryonic fin-fold. During development, a continuous fold of tissue is first formed running dorsally along the back upto the tip of the tail and is then continued as a ventral fold upto the cloaca. This fold is then strengthened by a series of cartilaginous rods and this condition is seen in lampreys and represents a primitive condition of the median fin. In higher fishes, separate dorsal, caudal and anal fins are formed by the concentration of the radials in certain areas and degeneration of the fold in the intervening spaces, between the fins. The ontogeny of the median fins in teleosts shows that they are basically segmental structures as regards their nervous, muscular and skeletal elements and concentration is an important process during their development.

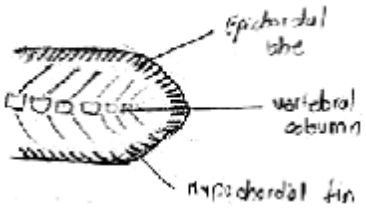
Dorsal fin: The dorsal fin is located on the mid-dorsal side of the body. It often comprises two parts, the first dorsal and second dorsal fin. In some fishes second dorsal fin lacks.

Ventral fin: The ventral fin is located close behind the vent and also called as the anal fin.

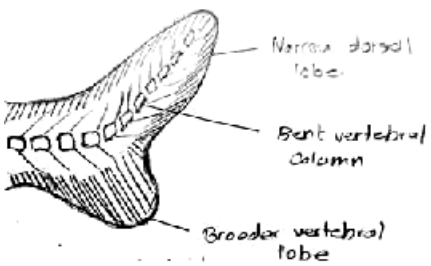
The dorsal and anal fin are provided with a fleshy lobe at the base consisting of fin muscles surrounding the basals and the radials.

Caudal fin: the caudal fin differs from the dorsal and anal fins in the nature of its supporting skeleton and is of three main types:

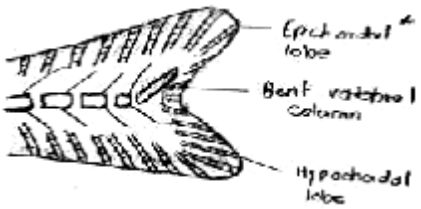
1) **Protocercal:** first tail is probably the most primitive. Here the hind end of notochord or the vertebral column is straight and divides the caudal fin into two equal lobes, the dorsal epichordal and the ventral hypochordal lobe. The term diphycercal is also used for secondarily symmetrical tails, as in Dipnoi, but the term protocercal is preferred for all types of symmetrical tails. It is found in amphioxus and cyclostomoes. In all the fishes the caudal fin passes through the protocercal stage during development.



2) **Heterocercal:** unequal tail is characteristics of chondrichthyes and some primitive bony fishes. Here, the hind end of the notochord is bent upwards and continues almost upto the tip of the caudal fin. The ventral hypochordal lobe is much larger than the dorsal epichordal , so that the caudal fin is asymmetrical both externally and internally.



3) **Homocercal:** equal tail is characteristics of most higher bony fishes. It is symmetrical externally consisting of equal sized epi and hypo-chordal lobes. But internally the tail is asymmetrical and the hinder end of vertebral column is turned upward and greatly shortened.



The end of the vertebral column does not reach the posterior limit of the fin. Actually epichordal lobe is much smaller than in the heterocercal tail, as almost the entire caudal fin of the homocercal type is derived from the lower lobe, and upper lobe contributes only a few small, unbranched rays to the upper margin of the fin. Majority of the lepidotrichia of te caudal fin articulate with the hypurals.

The homocercal tail is derived from the heterocercal type and intermediate types are found in many bony fishes. This transition is seen in many fossil bony fishes & in living primitive teleostomes like Amia, lepidosteus & Polypterus.

Paired fins:

Paired fins are called pectoral and pelvic. Paired appendages were not present in the ancestral vertebrates and were development during the course of early fish evolution.

a. Pectoral fin: Pectoral fins are present in almost every fish. They are found behind the gill cavity and are prominent. In primitive fishes, the pectoral fins are found lower on body, nearer the ventral side. In some fishes , these fins look like wings for flying fish and pad for resting on the bottom in some catfish. Other fish have developed specialization in their fins for certain habits like protection, tactile organs, taste and crawling.
b. Pelvic fin: the pelvic fins are generally smaller than the pectorals, and more restricted function. The pelvic fins are located behind the pectorals. Pelvic fins function in stabilizing and braking, they are little use for locomotion. Some have spines and rays on them. Other fish have modified pelvic fins in the form of a sucker, or use them as an appendage to create friction between themselves and the substrate to help them stay in place.

Swim Bladder:

Swim bladder or the gas bladder is more or less a sac-like structure lying between the alimentary canal and kidneys and contains a mixture of carbon dioxide, oxygen and nitrogen. It is a characteristic organ of Osteichthyes (bony fishes). However, it is found in all Osteichthyes (bony fishes) except a few bottom dwellers (Lophius, Pleuronectes, etc.). It is vestigial in Latimeria, the only living crossopterygian. Air- bladder shows a number of structural modifications in various groups of bony fishes.

Location:the air-bladder arises as an outgrowth from the oesophageal region of the alimentary canal. the air-bladder lies below the kidneys between the gonads and above the gut. The connection with the oesophagus may be retained throughout life or may be lost in the adult. It shows a great diversity in mode of development, structure and function in different fishes. It lies ventral to alimentary canal in Polypterus, laterally in Dipnoi and dorsally or dorsoventrally in teleosts.

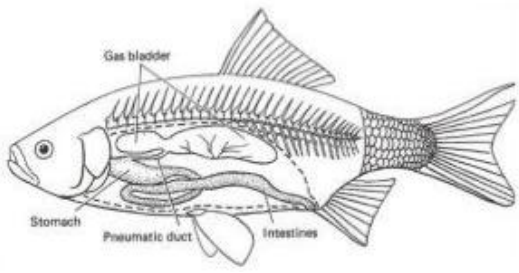
Basic Structure of Air- Bladder:

The air-bladder in fishes varies greatly in structure, shape and size. It is essentially a tough sac-like structure with an overlying capillary network. Beneath the capillary system there is a connective tissue layer called tunica externa. Below this layer lies the tunica interna consisting primarily of smooth muscle fibres and epithelial gas-gland.

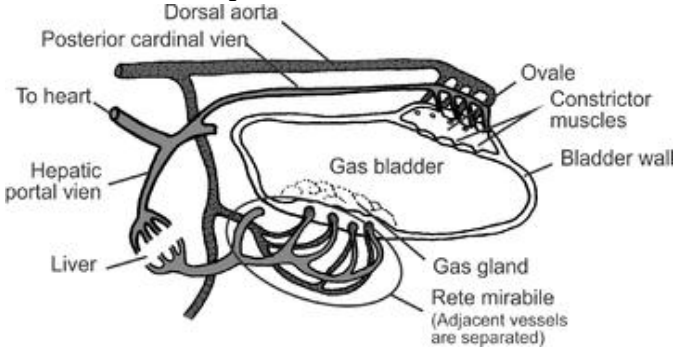
Types of Air-Bladder:

Depending on the presence of the duct (ductus pneumaticus) between the air- bladder and the oesophagus, the air-bladder in fishes can be divided into two broad categories- physostomus and physoclistous types. Depending on the conditions of air-bladder, the teleosts are classified by older taxonomists into two groups- Physostomi and Physoclisti. A transitional condition is observed in eels.

1) **Physostomous swim bladder:** the swim bladder develops from the oesophagus. When the ductus pneumaticus is present between the swim bladder and the oesophagus, the swim baldder is called physostomous type. The pneumatic duct, allowing the fish to fill up the swim baldder by 'gulping' air. Excess gas can be removed in a similar manner.



2) **Physoclistous swim bladder:** in this condition the ductus pneumaticus is either closed or absent. This type of swim baldder is observes in spiny rayed fishes. In the physoclistous fishes, the capillary are covered with a thick glandular folded epithelium and is called the 'red gland'. Among the Physostomi, the eels (*Anguilla anguilla*) shows a close resemblance to the condition found in physoclisti.



Gases in the air-bladder come from blood secreted by the red gland. The posterior chamber is thin-walled and forms the oval gland which permits reabsorption of gases by the blood. Secretion and resorption are under the control of autonomic nervous system.

The air-bladder receives its blood from branches of the coeliaco-mesenteric artery or directly from the posterior branches of dorsal aorta. The venous blood is then drained into a vessel that joins the hepatic portal system, while in some species the air-bladder vein joins the posterior cardinal vein. The air-bladder also shows differences in its degree of vascularity in various teleosts and in the formation of 'red bodies' or 'red glands'.

In some species (Clupeidae and Salmonidae), the capillaries are uniformly distributed all over the surface of the air-bladder & do not form a 'retia mirabilia', while in other Physostomes as the carps (Cyprinus, Labeo, Tor tor) the blood vessels are arranged in a fan-like manner and are concentrated at one or more points on the inner surface of the air-bladder, forming red masses of various shapes, called the 'red bodies'.

These are essentially 'retia mirabilia' consisting of numerous arterial and venous capillaries, running parallel to one another and carrying blood to and from the gas gland. These constitute a 'wonder net' of capillaries which do not communicate until they reach the postcardinal vein epithelium of the air-bladder. In the physostomous fishes, this structure is more primitive, being covered with a simple flat epithelium and is called the 'red body'.

Functions of Air-Bladder:

1. Hydrostatic Organ:

The air-bladder serves as an important hydrostatic organ in fishes and helps to keep the weight of the body equal to the volume of the water the fish displaces. It also serves to equilibrate the body in relation to the surrounding medium by increasing or decreasing the volume of gas content. Secretion of more gases means lower specific gravity so that the fish rises in water. Resorption of gases means increased specific gravity and the fish sinks.

Thus, the fish is able to rise or sink and maintain its equilibrium or position in water without any muscular effort. In the physostomous fishes the expulsion of the gas from the air-bladder is caused by the pneumatic duct, but in the physoclistous fishes where the pneumatic duct is absent the superfluous gas is removed by diffusion.

2. Respiration:

The original function of the air-bladder was probably respiratory. The respiratory function of the air-bladder is quite significant. A cellular lung-like air-bladder is present in the teleostomes such as Polypterus, Amia and Lepidosteus in which it is primarily respiratory in function. In Dipnoi, the air-bladder resembles closely with an amphibian lung.

In certain teleosts as Megalops, Chirocentrus, Gymnarchus, Erythrinus, Umbra and some cyprinoids, the air-bladder works like a lung. These fishes live in swamps or pools where the carbon dioxide tension is high & that of oxygen is low.

These teleosts come to the surface, swallow air and pass it back to the air-bladder which is highly vascular. It appears that the lung-like function has been reacquired in these teleosts as a special adaptation for living in foul water.

Air-bladder can also be used for storing oxygen to be used in emergency. This has been demonstrated both in physoclistous and physostomous fishes as Perca fluviatilis. Tinea tinea, Opsanus tau, Cyprinous carpio, Carassius sauratus, etc. Although it has been shown that in many species the amount of oxygen stored in the bladder would enable the fish to survive for a few minutes only, the air- bladder may be more important in deep water fishes where the amount of oxygen stored is much higher.

Studies have shown that in fishes living nearer the surface the gas in air-bladder is much like the air, while in those living at greater depths, oxygen forms a major component, extending up to 75% in some species.

3. Sound Production:

The air-bladder plays an important role in sound production. Some fishes are able to produce sounds with the gases inside air-bladder by the use of special muscles attached to the air-bladder. But the actual mechanism is not understood. Many fishes as Doras, Platystoma, Malapterurus, Trigla can produce grunting or hissing or drumming sound.

The circulation of air inside the air-bladder causes the vibrations of the incomplete septa, which in turn, produce sound. The sound may also be produced by compression of extrinsic and intrinsic musculature of air-bladder.

Polypterus, Protopterus and Lepidosiren can produce sound by compression and forceful expulsion of gases in the air-bladder. In Cynoseion male, the compression of the air-bladder is achieved by contraction of specialised muscles, musculussonorificus. The sound production serves to startle the enemies or to attract mates.

4. Auditory Function:

Air-bladder serves to transmit sound waves to the ear especially in the Ostariophysi, more efficiently than in the species in which a connection with the ear is missing. In Cypriniformes, a series of small bones, the Weberian ossicles, connect the air-bladder and perilymph cavity containing internal ear. Low frequency vibrations of the contained gas, induced by noises in water, are transmitted by the ossicles to the membranous labyrinth. Thus, these fishes can hear.

5. Sensory Function:

When the fish is subjected to pressure changes by moving into different depths of water, compression of the wall of the air-bladder which functions as a pressure receptor like a manometer, barometer or a hydrophone. It has been suggested that the air-bladder ac mg as a sense organ enables a fish to maintain a steady depth.

If the fish moves above or below a certain depth at which it is in equilibrium, changes in the tension in the bladder wall lead to compensatory swimming movements and the fish returns to the original level. However, there is not much evidence in support of this hypothesis.

In Cypriniformes (Ostariophysi), the connection of the air-bladder (gas bladder) with the membranous labyrinth through the Weberian ossicles, increases the sensitivity of the fish to volume changes in the air-bladder and the fish is able to control the escape of gas via the pneumatic duct.

Migration in Fishes

Generally migration is seasonal movements of animals from one region to another region. Fishes are also migrating from one water body to another water body. Fishes restrict their movements within water body and do not go out of their home ranges. This movement take place in vertical direction as from the deeper to surface of water or it may be in a horizontal direction either upstream or downstream. Thompson (1980) has defined a true migration as seasonal movement that implies return to the starting point.

Migratory species: several species of fish show interesting migrations of mature adults for spawning & feeding. They breed in one area but grow & feed in another area.

Cod (*Gadus morhua*), Herrings (*Cleupea harengus*), Salmon, Tunnas (*Thunnus thynnus*), Eel (*Anguilla anguilla*), Hilsa (*Hilsa hilisha*), Lampreys (*Petromyzon marinus*)

Fish can make migratory movements by several methods:

a) Drifting: fishes are carried passively be water currents, this called drift.
b) Random: Locomotory movements that are random in direction lead to uniform distribution or to an aggregation.
c) Oriented: fishes swim in a particular direction.

Types of migration:

There are four main types of migration.

1) Alimental migration: fishes are migrating in search of food.
2) Gametic migration: fishes are migrate for reproduction.
3) Climatic migration: fish is migrate to secure more suitable climatic conditions.
4) Osmoregulatory migration: fishes migrate to maintain osmotic pressure.

Patterns of migration:

Three different patterns are formed and it differs between species as well as within a species.

1) **Potamodromous:** Fishes are migrate from one fresh water body to another fresh water body. E.g. the carps and the trout travel long distances in large rivers in search of food and in search of spawning ground.
2) **Oceanodromous:** fishes are travels from one part of marine water to another part of marine water. E.g. Herring, Mackerel, tunna etc.
3) Diadromous: fish migrate between fresh water to marine water or marine water to fresh water. There are three types of migration.
   a) **Anadromous:** some species of fishes are spend major part of their lives in the sea but migrate to fresh water during breeding period for spawning. E.g.

   Salmon, Hilsaetc
   b) **Catadromous:** some species of fishes are spending major part of their lives in the fresh but migrate to marine water during breeding period for spawning.
   E.g. Eel
   c) **Amphidromous:** in this type fish migrate from fresh water to marine water or vice versa, is not for the purpose of breeding , but occurs regularly at some other definite stage of the life cycle.

Catadromous migration:

The long distance migration of fresh water fishes to marine water of ocean for spawning or reproduction is called as catadromous migration. It is observed in Anguilla fish. The fresh water eel spends its most of life time (about 10-14 years) in fresh water streams and rivers which acts as feeding ground. In Anguilla fish migratory movements are observed in adult as well as elver stage. The gonads are developed in male after 8 to 10 years while in female after 10 to 14 years. The scientist observed that during winter season groups of large sized sexually matured eel fishes migrates from fresh water rivers downwards to reach marine water of ocean which acts as their spawning ground.

Italian scientists studied life cycle of European eel fish. It consists of following 4 stages:

1) Pelagic stage or leptocephali 2) Elver or glass stage
3) Yellow stage 4) Silver or adult stage

The adult males and females starts downward migration through river water. They reach to estuary in winter season. Then they enter in Atlantic Ocean. They cross Atlantic Ocean, crossing distance of about 3000 miles & reach to Sargasso Sea.

Spawning: after reaching to Sargasso Sea eggs are laid by female eel fish at depth of about 900 feet. They are fertilized by sperms released by male fishes. Parents die after spawning. These fertilized eggs are floating for some time and are hatched at depth of 100 to 150 feet and young ones are formed.

1) Pelagic Stage:

i) The fertilized eggs hatch into young one called as leptocephali.
ii) Leptocephali is transparent, flattened and leaf in shape body.
iii) They move by drifting along with the depth of 100 to 150 feet.
iv) At the end of one year they attain length of 25 mm.
v) They are having long needle like teeth for feeding. It is called as zero leptocephali.
vi) Fins are absent upto one year and hence they float passively along with current of water.
vii) They feed with well-developed mouth having long needle like teeth.
viii) After 6 months a continuous fin fold is developed around the posterior part of the body and about 50 mm length is developed. It is known as one-year group leptocephali.
ix) They migrate in groups and by the second summer season they reach mid Atlantic Ocean.
x) One group leptocephali attain length of about 75 mm and known as two group leptocephali. At this stage fins are poorly developed.
xi) Two group leptocephali reach at west coast of Europe.

2) Elver stage:

i) When these two group leptocephali reach at west coast of Europe, they stop feeding and undergo metamorphosis which extends for 1 year.
ii) The long needle like teeth have disappeared and new teeth are formed.
iii) The upper and lower lips become pointed.
iv) The pectoral fins become well developed, caudal fin also get enlarged and spherical in shape.
v) The body of elver stage becomes cylindrical and much elongated which measures about 10 cm in length.
vi) After feeding in coastal water energy is stored.
vii) At this stage age is 2-3 years.
viii) Elver stage then start upward migration from estuarine water into fresh water of river.

3) Yellow stage:

i) Yellow stage reach in stream water.
ii) After feeding and development they acquire 150 cm length.
iii) They live for 10 to 14 years.
iv) The colour of body becomes yellow hence this stage is called yellow stage.

4) Silver stage:

i) The yellow eel stage due to heavy feeding for 10-14 years in fresh water body stores fat

below skin in the form of Adipose tissue.

ii) Then they stop feeding, the digestive system degenerate.

iii) Eyes becomes 4 times larger.

iv) Gonads become mature.

v) The pectoral fins become more pointed and darker in colour.

vi) thus after attaining sexual maturity colour of body becomes bright silvery hence called as silver eel stage.

These silver eel during winter season starts downward migration through streams, rivers and reach to estuaries and again to marine water.

Anadromous migration:

The migration of adult fishes from marine water to fresh water streams for the purpose of breeding or spawning is known as Anadromous migration.

The anadromous migration mainly studied in Atlantic salmon or Pacific salmon.

The life cycle of Salmon consists of following stages:

1) Alevin stage 2) Parr stage 3) Young or smoll stage 4) Adult fish

Sexually mature salmon starts migration in groups from marine water of ocean. They reach to estuary and then migrates through river water. The upward journey of salmon occurs in groups but when one group of salmon reaches at mouth of the streams they are segregated in pairs of male and female.

Spawning: Generally spawning takes place during November and December.After entering in stream female salmon prepare nest for egg lying. The nest is prepared from leaves of aquatic plants, smaller stones and sand particles. After resting for 1 to 2 days in spring water spawning takes place. Large number of eggs are laid by female salmon in nest. These eggs are fertilized by sperms. The fertilized eggs require incubation of two weeks and egg hatches into larval stage called Alevin stage.

1) Alevin stage:

i) The newly hatched larva of salmon is called Alevin stage.

ii) In alevin stage have a yolk sac on its ventral side.

iii) Digestive system is poorly developed, hence alevin stage use reserved food in yolk sac.

iv) Alevin stage remains for about 2 months.

2) Parr stage:

i) The alevin stage after 2 months absorbs yolk completely and parr stage of life start.

ii) In these stage digestive system is well developed.

iii) This parr stage acquires fish like body form.

iv) The paired and unpaired fins are well developed.

v) On lateral side of the body 5-6 black coloured pigmented areas appear called parr marks areas.
vi) Parr stage is lasts for one to one and half years.
vii) The parr stage feeds in stream water for about one to one and half years. Due to feeding fat is deposited below the skin in the form of adipose tissue.

3) Young or smolt stage:

i) The parr stage stop feeding and acquires silvery colour, this called young or smolt stage.
ii) The large number of young stage starts downward migration in groups in month of Julu or August. They migrate from streams to river and to sea and finally enters in Atlantic Ocean.
iii) In ocean young or smolt stage feeds and after complete growth adults are formed in 5 to 6 years.

4) Adult Stage:

i) The weight of mature Salmon becomes about 10 to 15 kg.
ii) Before migration Salmon stops feeding, digestive system gets degenerated.
iii) The gonads become well developed.
iv) The skin becomes thick and spongy.
v) Silver colour of body is replaced by dull reddish brown colour.
vi) The body of male become spotted with red orange and black spots.
vii) After attaining sexual maturity these group of Salmon again starts upward migration from ocean.

Locomotion in fishes

Fishes are variously adapted for locomotion in water. The body spindle shaped, thicker in front then behind and is perfectly streamlined for movement through water. Body is covered with layer of mucus which reduces drag on it. Typically, the shape of the body fusiform but variations occurs when the fish becomes adapted to specialized mode of life. Some species have laterally compressed body as in Cluepidae, others possess dorso-ventrally depressed body as t and many cat fishes. While he skates, rays and many cat fishes, while some are elongated and eel like. Fishes swim in water mainly by three methods:

1) By movements of the fins
2) By body movements brought about by alternate expansion & contraction of the myomeres
3) Movements caused by the action of jets of water expelled from the gill openings during the process of respiration.

1) By movements of the fins:

Locomotion, only by means of fin movements, takes place when slow progress is desired, but for rapid swimming, body movement is most important. During such active swimming, the paired fins serve for balancing the body so that the fish remains in position, and does not float

with belly upwards. The dorsal and anal fins form dorsal and ventral keel which can be lowered or raised according to needs and give stability to the body.

The tail and the caudal fin are the chief organs of locomotion in fishes. During swimming, the tail is lashes from side to side by alternate contraction and relaxation of the muscles on the opposite sides of the vertebral column. During such movements, the tail is first bent to one side. This called the no- effective or backstrokes. By a stroke in the reverse direction, the tail is extended & straightened. This is the forward or effective stroke. By a rapid succession of these stokes to right and left sides alternately, the fish forces its way through the water.

Besides the body muscles, fins are also important organs of locomotion in fishes. Many fishes are capable of moving slow forwards by means of wave like movements of the fin itself. The caudal fin is moved mainly by the muscles of the tail. The dorsal and the anal fins may be used as organs of propulsion. Some fish like Globe fish, Procupine, Sea horse swim mainly by the propelling action of their dorsal and anal fins. Of the paired fins, the pelvics serve mainly for stabilizing the body, but the pectorals are often used for slow locomotion.the pectoral fin may also be used for steering.

2) By body movements brought about by alternate expansion and contraction of the myomeres:

Locomotory movement in fishes is the result of coordinated action of muscles of the body and those of the fins. In other words, the axial myotomal muscles and the appendicular muscles are directly involved in locomotion in fishes. The muscles of the fish body are differentiated into segmental myomeres by connective tissue septa (myocommata).

The myomeres of teleosts are generally successive segments fitting one into another in a tight complex manner. The orientation of individual muscle fibres is accordingly altered to varying directions. Fish possessing a larger number of myomeres have more flexible body (viz.; eels having 56-120 myomeres) than others.

Repeated contraction and relaxation of the myomeres on the opposite sides, generates undulatory waves originating in the cephalic (head) region and going down to the caudal (tail) region. This causes'thrust' causing forward propulsion of the body during swimming in water. Median fin movement during swimming for propulsion or steering is brought about by paired muscles attached to the base of the fin rays.

Muscle Innervation:

Two contrasting types of myotomal muscles are found in teleosts, the white and the red muscles.

White muscles: White muscles form the bulk of the body musculature & are light (white) coloured & constitute about 80-90% of the total myotomal muscles. These are comparable to the

striated muscles of other vertebrates, exhibiting lesser number of mitochondria, lack myoglobin. Less active fishes as the carps and cods contain large proportion of white muscles whereas active fishes like herrings and mackerels possess large proportion of dark muscles.

Red muscles: Red muscles are brown or red in colour due to the presence of myoglobin. Red muscles have narrower cells as compared to white muscles. Fin muscles are mostly red muscles. These exhibit large number of mitochondria. These constitute 5-10% of total muscle mass and require sufficient oxygen during active swimming. For this, these are equipped with better vascularization in the form of rete mirabile. Also lipase activity is greater in red muscles.

Types of Locomotion in Fishes:

Locomotion in fishes has been classified into three types:

(1) Anguilliform or eel like

(2) Ostraciform or trunk-fish like

(3) Carangiform or jack-like

Anguilliform: In an elongated type of fish such as the eel, the locomotion is of anguilliform type.. It is brought about by sequential, alternate contraction of the myotomes on each side of the body. Contraction of first few myomere on one side, so that the anterior part of the body is thrown into a curve, which passes backwards in a series of waves by alternate contraction and relaxation of the muscle segments, on each side of the body. The movement is of serpentine nature and the fish looks-like a crawling snake.

Ostraciform: Found in trunk fishes. In this case, the head and body is enclosed in a hard and rigid bony case and the tail with fan-like caudal fin projects behind. In such fishes, undulating movements of the body are not possible and the dorsal and the anal fins form the chief propelling agents for slow movements. A rapid movement takes place by lashing movements of the tail.

Carangiform: Carangifrom is the most common type of locomotion. In this type, the first action of first few myomeres of the anterior ends of the body on one side only, so that the head is bent sharply to one side. This is followed by alternate contraction and relaxation of the successive myomeres, first on one side of the body and then of the other, from head towards the tail and the curve of the body passes backwards. The fish thus shows undulating movements and its body during swimming is thrown into a 'S' shaped curve.

LUNG FISHES

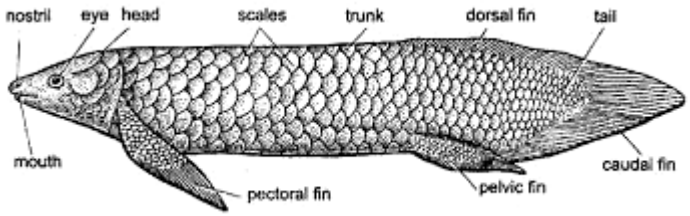
Dipnoi (Lung fish): Dipnoi (Di- two, pnoe- lung) is one of the group of bony fishes. They show similarities with both Telostomi and Amphibians. This class represented by only three living genera which found in different part of world.

1) Neoceratodus - Australia 2) Protopterus - Africa 3) Lepidosiren America

General characters of Dipnoi:

1) Paired (Pectoral and Pelvic) fins are lobate.
2) Thin cycloid scales embedded in connective tissue of the body.
3) Single dorsal fin present.
4) diphycercal tail is present.
5) dental plate large and fused to jaw bones.
6) mouth present on ventral side of head.
7) Cloaca present.
8) Two nostrils present on ventral surface of the snout.
9) Spiracles are absent.
10) Operculum present.
11) Single branchial opening found.

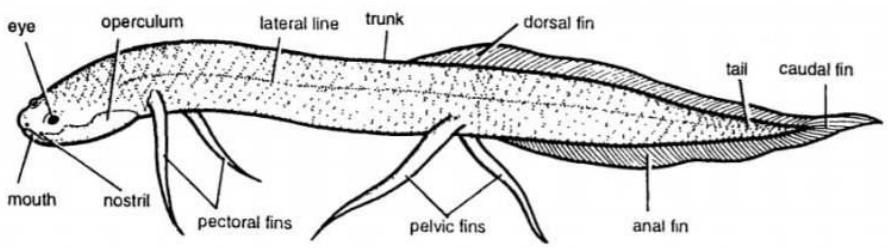
Characteristics of Neoceratodus:



1) Large fish of 10 kg in weight and length about 5 feet.
2) Non-ganoid scales present.
3) One lung is present and 5 branchial arches present.
4) It found in slow moving or stagnant water.
5) Sluggish in nature and found at the bottom.
6) During summer water level is low and oxygen level is also low in that condition neoceratodus survive because of pulmonary respiration.
7) Carnivorous. Feeds on mollusks, crustaceans, worms and larvae.
8) Spawning period is September and October in morning hours.

Characteristics of Protopterus:

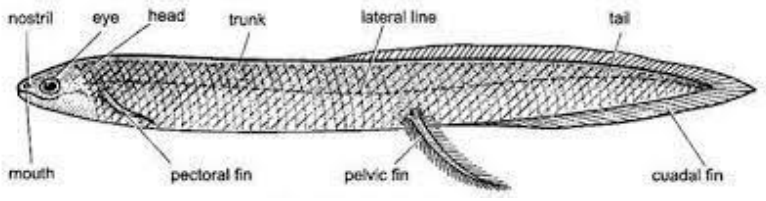
1) Large in size upto 6-7 feet in length.
2) Marshy places in habitat.
3) Paired fins are lobate and appear filamentous.



4) In swimming tail is principle organ of locomotion.
5) Body covered with small cycloid scales.
6) Five gill arches present but the anterior ones are devoid of gill filaments.
7) Lung is double.
8) The fish respires by gills as well as by lungs.
9) During summer, when marshes dry up, the fish undergoes aestivation or summer sleep till the next rainy season. During this period, the fish moves into the deeper mud and coils up in a 'cocoon' made up of special clay mixed with mucus secretes by the skin.
10) With the approach of the rainy season, the fish emerges from its cocoon and leads an active life.
11) Spawning takes place during rainy season..
12) Protopterus shows parental care, the fish prepares a nest which is a simple hole about a foot deep, full of water and surrounded by aquatic plants, the eggs are laid in the bottom of the nest and male guards the nest containing eggs and larvae.
13) Carnivorous in habit, they feed on frogs, worms, insects and crustaceans.

Characteristics of Lepidosiren:

1) This fish attains a length of 4 feet.
2) In the fish both Branchial and pulmonary respiration are found.
3) Paired fins are filamentous.
4) Lepidosiren shows hibernation period.
5) Fish feeds on only snail and sometimes they feed on plant material.



6) During summer, when the water nearly dries up, fish burrows into the mud and hibernates and depends on pulmonary respiration and stored fats for keeping alive.
7) In rainy season, fish emerges from the burrow and enters the breeding period. The eggs are laid in a nest which has the shape of a vertical tunnel about foot deep.

Affinities of Dipnoi:

Dipnoi show similarity with Teleostomi and Amphibians.

Affinities with teleostomi:

1) In Dipnoi and teleostomi paired fins are lobate.

2) Powerful palatine teeth are present.
3) Presence of layer of cosmine covering the scales.
4) In both classes nostrils are present on ventral side.
5) Paired inferior jugular veins.
6) In both classes swim bladder present but in Dipnoi it modified into lungs.
7) Scroll valve present in the intestine.
8) Tail is diphycercal.

Affinities with Amphibians:

1) Both capable of living in marshy places and respiration occurs by gills & lungs.
2) Larva of Protopterus and Lepidosiren posses external gills and can be compared with the tadpole of frog.
3) In Amphibia and dipnoi circulatory system is similar.
4) A pulmonary artery and pulmonary vein present.
5) Two external nostrils present and opens into buccal cavity.
6) Jaw suspension isautostylic.
7) Structure of cerebral hemispheres and a small cerebellum is similar in both.

Hill Stream Fishes

A number of fishes have migrated from sluggish waters of the lower streams to colonize in the torrential waters of the upper streams. These migrations were chiefly in search of food and the shelter from the predators. Upon reaching the new habitat, these fishes adapted themselves through a number of structural modifications and called the hill stream fishes. Fishes living in the hill streams show several important modifications.

The important fishes of the hill streams belong to several geneara of two families:

1) Family Cyprinidae: Garra, Balitora, Bhavania, Psilorhynchus, Parasilorhynchus, schizothorax, Barilius, Nemacheilus, Barbus(Tor), Crossocheilus
2) Family Siluridae: Glyptosternum, Glyptothorax, Pseudoecheneis, Laguvia, Erethistes

Environmental Conditions of the Hill Stream:

1. Strength of Water Currents:

The water moves predominantly in one direction on the hills, causing both, the lesser stability of bottom materials as well as the erosion. Although the role of flow of water varies in different seasons, it is in general, much higher than in rivers and streams of the plain. Fishes living in hill streams have, therefore, to develop adhesive organs to avoid being swept away with the water currents.

2. Light Intensity:

The sun rays in hill streams penetrate deep into the water because it is shallow and very clear Fishes, therefore, have to adopt either to withstand the intense light or to shelter themselves under the rocks or stones. The small sized fishes can hide themselves below rocks and stones.

3. Dissolved O_2:

The water is well aerated with plenty of oxygen due to rapid rate of flow of water. Abundance of O_2 is, therefore, a favorable condition to fishes inhabiting the torrential streams.

4. Availability of Food:

Sufficient amount of food is available in the hill streams but is in the form of algae covering stones and rocks, as any other type of vegetation cannot grow due to rapid flow of water.

Adaptive Modification in Hill Stream Fishes:

1. Shape:

Hill stream fishes usually have greatly flattened head and body in contrast to cylindrical bodies of fishes found in tanks and lakes. In highly specialized species of Balitora, Glyptosternum, Glyptothorax and Pseudoechensis, the body becomes leaf like.

The dorsal surface of hill stream fishes is mostly arched while the ventral surface flattened. The head of hill stream fishes is generally small and semi-circular.

2. Size:

Hill streams fishes are generally small in size. Their small size permits them to hide under the rocks and stones during the intense sunlight and prevents them from being crushed between the rolling stones in flood.

3. Scales and Bony Armour:

The scales and bony armour in hill stream fishes are poorly developed. It is because that they remain free from the danger of predators.

4. Mouth:

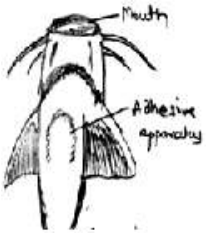
The mouth of hill stream fishes is crescentic or semi-circular in shape. The jaws are strong.

5. Lips:

The lips in most of the hill stream fishes are modified to form suckers of diverse types. They are used for scooping mud as well as for clinging on stones.

6. Barbels:

Barbels in the hill stream fishes are specialized, greatly reduced being short and stumpy.



7. Eyes:

The eyes in the hill stream fishes are generally small in size and are pushed towards the upper surface of the head where they lie close to each other.

8. Fins:

The fins in the hill stream fishes are used as organs of locomotion as well as for attachment.

9. Paired Fins:

Both the pectoral and pelvic fins are set low on the body to provide greater friction against the rocks and stones.

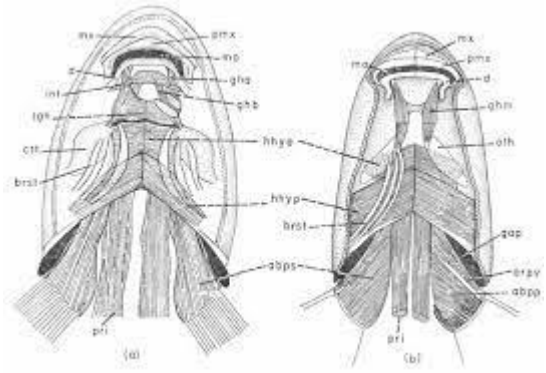
10. Breathing Apparatus:

As the ventral surface is used for adhesion to rocks and stones, the gill slits lie on the sides & the gill chamber specialized for retaining water for a longer time.

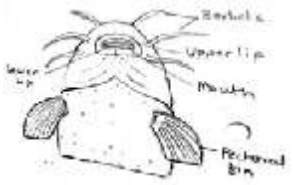
11. Air Bladder:

The air bladder used chiefly as a hydrostatic organ in most fishes is much reduced or degenerate in hill stream fishes, because the buoyancy would be a disadvantage in swift currents. The bladder if present is enclosed in a thin bony capsule.

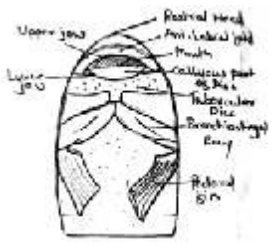
12. Adhesive organ:



i. In Mullya, the adhesive organ looks like a disc on the Postero-ventral side of the mouth opening. The disc consists of a central callous part and free tuberculated lateral and posterior borders. The anterior labial fold of the fish is fringed and tuberculated. The whole structure helps the fish in adhesion to rocks and stones. The adhesive disc of Mullya works on the suction principle.



ii. In Nemacheilus mouth aperture is surrounded by thick horny lips which function as a sucker. The base of the pectoral fins is thickened & cushion like.



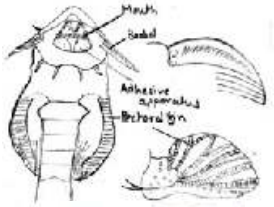
iii. In Schizothorax, the jaws are covered by a hard callous plate, the skin is thickened and tuberculate. The anterior labial fold may also be fringed.

iv. In the genus Erethistes are included a number of small fishes

having smooth and flattened under surface, but in E. elongate, well developed striations are present on the chest and belly.

v. In the genus Laguvia, striations are present on the chest only & the belly is smooth.

vi. In Glyptosternum, the chest is devoid of adhesive apparatus, but the skin on the under surface of the pectoral spines is striated, and each ridge is supported by ashort pointed cartilaginous ray given out from the outer margin of the first pectoral and pelvic rays.



vii. Glyptothorax and Pseudoecheneis possess a highly specialized adhesive organ. In Glyptothorax a well-defined adhesive apparatus, inverted 'U' and 'V' shaped, is formed by the folds of skin between the bases of the pectoral fins. The folds alternating with grooves run antero-posteriorly, and the adhesive apparatus is oval in shape wider in the middle but narrow at the two ends. The anterior and posterior labia folds are tuberculate. The maxillary barbels are thick and fleshy at the base and show tubercles or striations.

Parental Care in fishes:

Parental care can be defined as an association between the parent and offspring's, so as to increase the chances of the survival of the young ones, and in fishes it includes all the post spawning care of the offspring's by the parents.

Many species do not care for their eggs and leave the spawning grounds soon after fertilization. But some species have evolved various method to ensure proper development the eggs which may be protected by one or the sexes. These include selection of a suitable site, nest building and various other methods of protection of the larvae.

Species which do not exhibit any device for the safety of the ova, generally produce a very large of eggs to increase the chances of survival of atleast a few of them. Eggs of many species possess various mechanisms for attachment to stones, pebbles or aquatic vegetation, so that they are prevented from being washed away with the current of water.

I) Nest building: Some fishes prepare crude nests for egg laying.

i) Males of Cichlids, prepare a shallow basin like nest, and all stones and pebbles are carefully removes from its bottom. The eggs are laid in the nest and the male after fertilizing them, keeps guard over them till the young ones are hatched. A few species however, leave the nests unprotected.

ii) In the family Salmonidae species exhibit the most primitive type of parental care. The

female makes a furrow in the gravely bottom of a running stream for the eggs, which are then covered by a layer of fine gravel.

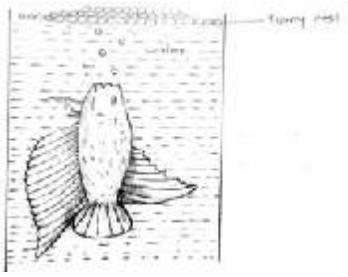
iii) Aarius australis, living in the rivers of Queensland deposits its eggs in circular excavations in sandy bed of the river, and covers them with a layer of larger stones. But in species, the parents do not take any further interest in the young ones.

iv) By American Cyprinids elaborate nests are prepared from heaps of stones and is known as chubs.

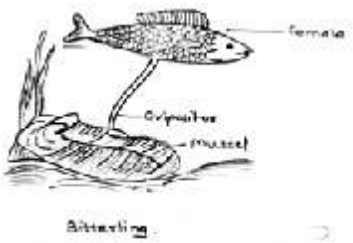
v) The African lung fish Protopterus, prepares a simple nest in the form of a deep hole in swampy places along the river banks. The male prepares the nest, and after spawning keeps guard over it, occasionally aerating the water by his slow body movements.

vi) The male three spined stickle back, prepares an elaborate nest before starting the courtship. He selects a suitable place among the aquatic plants, where water flow is regular but slow. He then collects plant material which is pressed into the clear area of the nest. A sticky substance is produced by the kidneys of the male and serves to join the plant pieces together. When sufficient amount of plant materials has been collected, the male burrows through its center, thus making a small tunnel, through which he brings a ripe female for egg lying. After the eggs have been fertilized, the female leaves the eggs, while the male keeps guard over it.

vii) Gourami, familiar to aquarium lovers, makes a nest of foam a very unusual type indeed. The male makes bubbles of air by blowing and then glues them by mucus from his mouth. The bubbles adhere together to form a dome shaped floating mass, after an elaborate courtship, the female extrudes her eggs, which are immediately fertilized by the attendant male. He catches the eggs in his mouth, swims upwards, gives a coating of mucus and sticks them to the underside of the foaming nest. At each extrusion,3 to 7 eggs are collected and process is repeated till about 150 to 200 eggs are massed together. The male takes guardianship of the nest as well as the female till the larvae hatch out and are old enough to leave the nest.



II) Other methods of egg protection: Many species have developed other methods of protecting the eggs without actual nest building.



i) European Bitterling rhodeus: takes extra care for the protection of eggs. When the female is ready to spawn, the

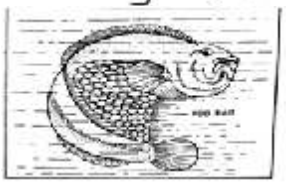
oviduct extends out to form along tube acting as an ovipositor which is used to deposite the eggs within the valves of a fresh water mussel. The male fertilizes the eggs as they are laid. After hatching, the fry leaves the host and thus remain well protected from the enemies.

ii) The male of Pomato schsistusminutus, selects a suitable shell which is turns over so that the concave surfaces downwards. He then clears the sand from below the shell with his tail, so as to form a small chamber opening to the exterior by a small tunnel-like structure. The whole structure is then covered with sand and mud and eggs are laid by the female in the chamber.

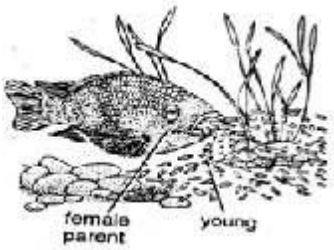
iii) In cichlids, the female carries the eggs in her oral cavity. After hatchling the young fry do not leave the shelter for some times, and swim about in water very near the mouth, so that they can return to it in case of danger.

iv) The cat fish Arius, the male carries the eggs and young ones in his mouth and does not take food during this period.

v) The Butter fish Pholis, rolls the eggs into a rounded ball, and then one of the parents remains on guard by coiling round it.



vi) In Hippocampus the eggs are transferred by the female into the special brood pouch of the male who carries them till the time of hatching.



vii) Tilapia is also called a mouth brooder because the young ones enter into enter into the oral cavity of the female at the time of danger.

INLAND FISHERIES

FRESHWATER HABITAT

Introduction:

Water is essential for plants, animals and microorganism's life (It occupies 71% of the earth's surface). On the earth only 3% water is freshwater. About 77.2% fresh water is in the form of ice, 22.4% is in the form of ground water and 0.36% water is in the lakes, ponds, streams and rivers

Types of freshwater habitat:

The fresh water habitat is divided into two types. They are lentic habitat and lotic habitat

a) Lentic habitat: It is the standing water system. It includes ponds, lakes, swamps and reservoirs.

b) Lotic habitat: It is the running water system. It include springs, streams & river.

Characteristics of freshwater habitat:

The freshwater habitat has following characteristics

1) Salinity: Freshwater has low salinity as compared to sea water. The salinity of freshwater is 1.8% . The important salts present in freshwater are -Ammonium, calcium, carbonates, iron, magnesium, manganese, nitrogen, Nitrates, Potassium, Phosphorus, Sodium, sulphur, Silicon and Zinc.
2) Osmosis- Freshwater is hypotonic because of low salinity. The body fluids contain salts, hence freshwater organisms are hypertonic.
3) pH -The pH of freshwater it varies from 1.2 to 7.2.
4) Water current -

a) In standing water system, water current is caused by the action of wind.

b) In running water system, the rate of flow depends on the slope and amount of water

5) Transparency - In freshwater transparency is affected by suspended materials like clay, slit and water plants.
6) Oxygen -The running water system contains oxygen in higher concentration, as compared to standing water system
7) Carbon dioxide- CO_2 present in water. All aquatic plants and phytoplankton are depend on CO_2 for photosynthesis.
8) Pressure: In fresh water habitat pressure is much less.
9) Density: Fresh water has less density as compared to marine water.
10) Temperature: The temperature variation is high in fresh water habitat. In a pond of 3 meter

depth, there is a variation of 5 ?c between day and night. However in deep lakes the variation is less 2.8 ?c.

11) Light- The euphotic zone is a lighted zone (it extends to a depth of 0 to 80 meters). In the disphotic zone light is highly modified (it extends from 80 to 200 meters). Aphotic zone is without light (it extends beyond 200 meters).

Classification and Characters of Ponds:

Ponds are small and open fresh water body. It is different from river because of standing water and ponds also different from lake because ponds have small area.

Characteristic of ponds-

1) Ponds are small, shallow standing water bodies.
2) Plants can grow on most of the bottom.
3) Most ponds are less than 8-10 feet deep.
4) It may be either natural pond or manmade pond.
5) They are connected with sea through streams.
6) Wave action is slight.
7) Light penetrates to the bottom.
8) The temperature of pond changes as per atmosphere.
9) Zonation- Based on the depth of the water and availability of light three different zones are recognized in pond.

They are: a) Littoral zones b) Limnetic zones c) Profoundal zone.

a) Littoral zone: It is the shallow water edge of the pond with plenty of light and rooted vegetation.
b) Limnetic zone: It is the open water zone. In the zone light penetrates up to the bottom of the pond. In this zone planktons, nektons and neuston exist.
c) Profoundal zone: it is the deep water zone where they cannot penetrate (profoundal zone is usually absent in pond).

Classification of ponds:

Ponds are classified into two types. This classification is based on seasonal duration. They are temporary ponds and permanent ponds.

1. Temporary ponds: In ponds water exists in certain seasons only, these ponds are known as temporary ponds. At the other times, they remain dry. Temporary ponds are further classified into three subtypes.

I. Vernal ponds: Only spring season water exists in these ponds.
II. Vernal autumnal ponds: Water exists in these ponds during spring and autumn and they dry

up in summer.

III. Aestival ponds: Water persists in these ponds throughout the season but it freezes.

2. Permanent ponds: In these ponds water persists throughout the year.

Characteristics and Classification of Lakes:

A lake is a large body of standing water.

Characteristics of lake:

1. A lake is standing large freshwater body.
2. Lakes are variable in size. Lake Superior (U.S.A) is the largest lake in the world which measures about 31000 sq. miles.
3. Depth: Lakes are variable in depth. Lake Baikal in southern Siberia has a maximum depth of 1706 meters.
4. It has no connection with sea.
5. It has stable environmental factors.

Thermal Stratification: The lake water exhibits a temperature gradient from surface to bottom. Different strata of water have different temperature. This is called thermal stratification.

a. **Summer Stratification:** During summer three strata with variable temperature are noticed. They are upper elimination, middle thermocline & lower hypolimnion.

i. Epilimnion: Is the warm surface water. Here the temperature fluctuates with the atmospheric temperature water currents are produced due to wave action. It has plenty of vegetation. The temperature ranges from to21oC to 22o C.

ii. Thermocline: The middle layer is called thermocline. The water temperature ranges from 21oC to 7oC.

iii. Hypolimnion: The lower layer is hypolimnion. The water temperature ranges from 7oC to 5oC. The water is cool, or deficient, stagnant & devoid of plants.

b. Winter Stratification: During winter only two layers can be noticed. The surface layer becomes ice. The temperature ranges from 0o C to -2o C.

6. **Penetration of Light:** Based on penetration of light the water column of a deep lake is divided into three zones:

i) The euphotic zone is a upper zone and lightened zone and it extends to a depth of 0 to 80 meters.

ii) The disphotic zone is middle zone and light is highly modified and it extends from 80 to 100 meters.

iii) Aphotic zone is lower zone & without light and it extends beyond 200 meters.

7. **Zonation of Lakes:** Lake contain three zone:

   1) Littoral zone 2) Limnetic zone 3) Profundal zone

1) Littoral Zone: It is the marginal shallow water zone occupied by vegetation.
2) Limnetic zone: It includes the open water zone, Rich in flora and fauna. Light is penetrated in the zone.
3) Profundal Zone: It is the deep water zone where there is no light.

Classifications of lakes:

The very first generally accepted system of classification of lakes was given by F. A. Forel on the basis of thermal characteristics. He classified three types of lakes as Polar, tropical and temperate lakes.

a. Polar Lakes: Subsurface temperature never above 4^0C.
b. Temperature Lakes: Surface temperature varies above and below 4^0C.
c. Tropical Lakes: Temperature always above 4^0C.

S.Yoshimura classified lakes in 5 types on the basis of thermal characteristics-

a. Tropical Lakes: Surface temperature 20^0C to 30^0C. Small thermal gradient at any depth.
b. Sub-tropical Lakes: Surface temperature never below 4^0C. Large annual variations; thermal gradient large; circulation period winter.
c. Temperature Lakes; Surface temperature above 4 oC in summer and below 4oc in winter. Seasonal variation and thermal gradient large; circulation period in spring and autumn.
d. Sub-polar Lakes: Surface temperature above 4 oC only for short duration during summer; thermal gradient small; circulation periods in early summer and early autumn.
e. Polar Lakes: Surface temperature below 4oc almost with ice; circulation periods only the summer.

B. G. E. Hutchinson recognized 5 categories of lakes

a. Amictic- No mixing of bottom & top water. Lakes are protected by ice cover.
   Ex. Antarctic lakes and high mountain Aeolian lakes
b. Monomictic: The lake waters mix once a year subdivided into cold monomictic and warm monomictic.
   Cold monomictic: Water temperature never more than 4oc at any depth with a circulation in summer.
   Warm Monomictim: Always warmer than 4oc, stratify in summer & mix in water.
c. Dimictic: Lakes stratify twice a year with mixing twice a year. Ex. Northern temperate lakes
d. Oligomictic: Water temperature above 4 ?c with rare mixing.
e. Polymictic: They Stratify and mix more or less everyday.

On the basis of availability of nutrients and productivity, lakes are often classified into 3 catogories.

a. Eutrophic Lakes:

1. Usually located in flat country valleys and plains.
2. Types of Basin- Much humus and mud
3. The lake is broad and shallow. Hypolimnion smaller than epilimnion. Warmer, slide sloping.
4. Water color is yellowish green to yellowish brown.
5. Rich in Nitrogen & phosphorus. Rich in calcium. High dissolved organic matter.
6. Oxygen is rich; hypolimnion is devoid of oxygen.
7. Vast littoral and sublittoral zones; grater primary productivity. Plankton abundant. Organic debris rich.

b. Oligotrophic Lakes:

1. Location: Alpine or rocky location.
2. Type of basin- Rocky shores and bottom.
3. Very deep; profundal zone extensive but littoral and sublittoral zones narrow. Hypolimnion larger than epilimnion.
4. Water color is blue to green.
5. Nitrogen and phosphate status is poor. Organic matter poor.
6. Oxygen high in hypolimnion.
7. Little vegetation; Plankton production low.
8. Ex. High mountain lakes

c. Dystrophic Lakes:

1. Found at highly polluted locations.
2. Types of basin; Peat basin.
3. Deep to shallow.
4. Yellow to brown water lakes.
5. Very rich in nitrogen; very rich in humus; rich in organic matter. Oxygen is poor.
6. Hypolimnion is completely devoid of oxygen.
7. Bottom water contains H2S and Methane.
8. They are poor in flora and fauna. Fauna includes insects larvae and deep water animals. Ex. Lower Bhopal Lake of India.

Characteristics and Classification of Rivers:

Characteristics of Rivers:

1. Rivers are lotic habitats or running water system.
2. Rivers are wide range in size.
3. Water is always in motion or flow that is Laminar flow or Turbulent flow. In laminar flow water particles move parallel to one another. In turbulent flow water particles move irregular.
4. Oxygen is abundant in running water system.

Zonation of river:

i) Rapid or Riffle zone: This zone is characterized by the shallow water and irregular substrate of rocks

ii) Flowing water zone: the water is deep but there is flow of water.

iii) Pool zone: This is a river, pond where the water current is very slow.

Classification of River:

a) Rivers classify in two groups by their nature-

i) Bedrock River: Some small rivers flow directly on bedrock.

ii) Alluvial River: Some large rivers flow on sediment substrate and can continue to transport.

b) On the basis of water Surface River classify in two types-

i) Effluent river: In this type water surface of river is above the local ground surface.

ii) Influent river: In this type water surface or river is below the local ground surface.

c) Depend on the water flow rivers are classify into two types-

i) Perennial river: flow of water all time.

ii) Ephemeral river: flow of water only short time.

Characteristics and Classification of Reservoirs

In reservoir water is stored for supplying a community, irrigating land and generating power. The stream or river flow is obstructed by constructing dam.

Characteristics of Reservoirs:

1) It is multipurpose body of freshwater standing water.
2) Reservoirs vary in size.
3) Transparency of water is generally high in most of the reservoirs.
4) Temperature is different in different situations.

Classification of Reservoirs:

On the basis of size of reservoirs classify into three group.

i) Small reservoirs: small reservoirs occupy upto 1000 hector area.

ii) Medium reservoirs: covered 1000 to 5000 hector area.

iii) Large reservoirs: to cover over above 5000 hector.

FRESHWATER ECOSYSTEM

An ecosystem is community of living and non- living things that works together. The term ecosystem is most preferred, where 'eco' implies the environment and 'system' implies an interacting or interdependent complex. Ecosystem is a community of living things and non-living things.

Structure of ecosystem:

Ecosystem has 2 major components- 1) Abiotic & 2) Biotic

1) Abiotic components (non-living things)- it includes

a) Inorganic substance - Chlorophyll
b) Inorganic chemicals - P,N,S,H etc.
c) Organic materials - Protein, carbohydrates, lipid etc.

2) Biotic component (Living things):

This is indeed the trophic structure of any ecosystem; where living organisms are distinguish on the basis of their nutritional relationships. From these ecosystems has two component, Autotropic component & heterotrophic component.

a) Autotrophic component: In which fixation of light energy, use of simple inorganic substances and build up of complex substances predominate. Members of the autotrophic component are knows as producers. E.g. aquatic green plants, photosynthetic bacteria etc
b) Heterotrophic component: In which utilization, rearrangement and decomposition of complex materials predominate. Organisms of the heterotrophic component as-

i) Macroconsumer- includes herbivores, carnivores or omnivores. Herbivorous are also known as primary consumers and carnivores include primary carnivores and secondary carnivores.
ii) Microconsumer- Also known as decomposer, include bacteria, fungi etc. they break down complex compounds of dead living protoplasm.

In environment many types of ecosystem are maintain like forest ecosystem, Desert ecosystem, Grassland ecosystem, fresh water ecosystem etc. Pond ecosystem, Lake Ecosystem, Stream ecosystem, River ecosystem and Reservoir ecosystem are including in freshwater ecosystem.

POND ECOSYSTEM

Pond is good example of a fresh water ecosystem. A pond indeed exhibits a self sufficient, self regulating system. It is lentic freshwater ecosystem because it contains shallow, standing water.

A pond ecosystem contains biotic and abiotic component.

i) Abiotic component:

The chief substances are heat, light, pH value of water and basic inorganic and organic compounds such as water itself, CO2, O2, Calcium, Nitrogen, Phosphate, amino acid etc.

ii) Biotic components:

The biotic factors of the pond ecosystem are plants and animals. They are producers, consumers and decomposers.

a) Producers: the producers synthesize the food from abiotic substances. They carry about photosynthesis. 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. The producers of pond includes phytoplankton like diatoms, blue green algae (Oscillatoria), Green algae, green flagellates (Volvox, euglena), Rooted plants, submerged plants & floating plants.

b) Consumers: they are heterotrophy which depends for their nutrition on organic food manufactured by producers, green plants. Most of consumers are herbivores, a few insects and some large fish are carnivores feeding on herbivores. The consumers in pond are distinguishes as-

Primary consumers (Herbivores): herbivores feeding directly on plants and producers. For example, Zooplankton, insects, snail.

Secondary consumers (Primary carnivores): are carnivores which feed on primary consumers. These are chiefly insects, fish, frogs and beetles.

Tertiary consumers: secondary consumers are eaten by tertiary consumers. Are also carnivores and includes some large fish as game fish that feed on smaller fish. Fro example large fish, snake etc.

c) Decomposers: the reducers or decomposers are organisms that break up the dead bodies of other organisms and their waste products.

They are also known as micro-consumers. They play important role in return of mineral elements again to the medium of pond. They include microbes like bacteria, fungi.

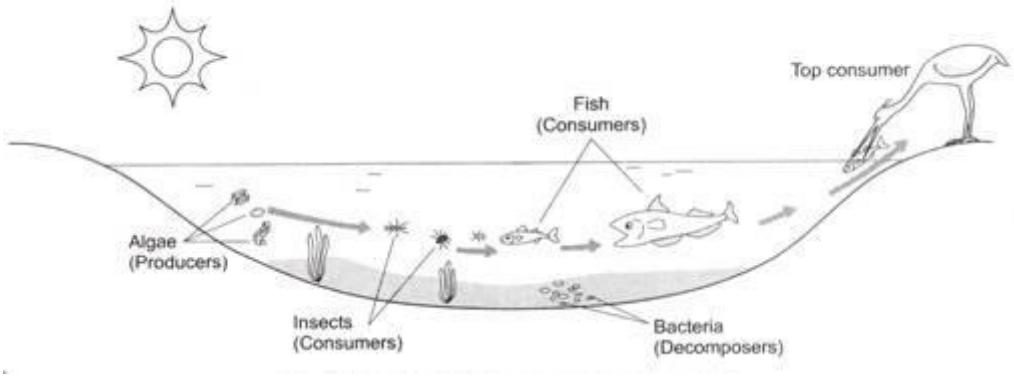
The enzymes digest the dead organisms and the debris into smaller bits or molecules. These molecules are observed by reducers.

Food chain in pond ecosystem:

The organisms of the ecosystem need energy in the form of food. The transfer of food energy from the producers, through a series of organisms (Herbivores to carnivores & carnivores to decomposers) with repeated eating and being eaten is known as food chain.

The ultimate source of this energy is the sun. producers like aquatic green plants trap solar energy and convert it into the chemical energy of food. When the primary consumers eat the producers, a part of this energy is passed on to it.

The primary consumers are eaten by a secondary consumer and the secondary consumer may be eaten by a tertiary consumer and so on. In this way energy gets transferred from one consumer to the next higher level of consumer. And this series of organisms through which food energy flows in an ecosystem is called a food chain.



Food chain in Freshwater ecosystem

In fresh water aquatic ecosystem like pond, the organisms in the food chain include algae, small animals, insects and their larvae, small fish, big fish and fish eating birds or animals.
A food chain in pond ecosystem starts with producers like phytoplankton, algae and some plants.

In which the energy, as stored in food matter manufactured by green plants is then utilized by the plant eaters- the herbivores such as zooplankton & insects.

Zooplankton and insects in turn are eaten by the carnivores like small fish. These in turn may be eaten still by other carnivores like large fish. Large fish eaten by mammals or top consumers.

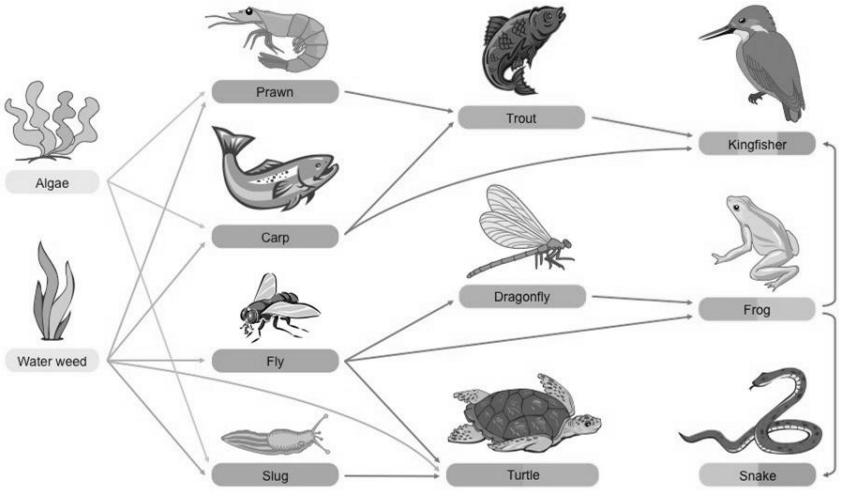
Food web in pond ecosystem:

Most food chains are interconnected, so it is also called as interlocking pattern of organisms. A food web is the natural interconnection of food chain and generally a graphical representation of what-eat-what in an ecological community. Food web showing all possible

relationships. Food web is important ecological concept. Normally food webs of a number of food chains meshed together. The complexity of any food web depends upon the diversity of organisms in the system. It would be accordingly depending upon two main points-

i) Length of the food chain

ii) Alternatives at different points of consumers in chain



Primary Productivity:

Primary productivity refers to rate of generation of biomass in an ecosystem. Primary production is the synthesis of organic compounds from atmospheric or aqueous CO2. It principally occurs through the process of photosynthesis, which uses light as its sources of energy. Almost all life on earth is directly or indirectly reliant on primary on primary production. The organisms responsible for primary production are known as primary producers or autotrophs, in freshwater ecosystem, algae, bacteria and some green, rooted, floating plants are producers and these producers are responsible for primary production in freshwater ecosystem. Primary production is differing in different kinds of ecosystem.

Large sized trees with dense population does not necessary mean that the forests would be more efficient in terms of primary production than apond, where the producers are smaller forms of plants mainly the phytoplankton.

Plants convert light energy into chemicals energy in the form of sugar by photosynthesis. So defined as the primary productivity is the amount of biomass produced through photosynthesis per unit area and time by producers.

Or

The amount of organic material produced during a given period of time per unit area is called primary production.

Primary production is distinguished as either gross primary productivity or net primary productivity.

Gross primary production: Gross primary production is the amount of chemical energy as biomass that primary producers create in a given length of time.

We know that plants convert light energy into chemical energy in the form of sugar by photosynthesis. The total amount of sugar and other organic material produced in plants per unit area per unit time is called gross primary production. The total energy fixed by plants in a community through photosynthesis is referred to as gross productivity.

Net primary production: during photosynthesis respiration is also going on side by side. During respiration some amount of energy is oxidized i.e. subtracting respiration from gross primary production gives net primary production.

Net primary productivity = Gross primary production - Respiration

Or

Pn = Pg - R where, Pn: net primary production

Pg: Gross primary production R: Respiration

Primary productivity usually expressed in units of energy- joules/m2 day. Or in units of organic dry material kg/m2 year.

INLAND CAPTURE FISHERIES

India is blessed with vast inland water resources in the form of rivers, estuaries, natural and manmade lakes, brackish water impoundments and mangrove wetland. For convenience the inland fisheries have been considered in the following sections-

Riverine capture fisheries:

The total length of river in India is about 29000 km. all these rivers, their tributaries, canals and irrigation channels have an area of roughly 13000 km. Riverine fisheries of India comprises of five major river system.

a) Ganga river system
b) Brahmaputra river system
c) Indus river system
d) East coast river system
e) West coast river system

a) Ganga river system:

i) Length: about 8047 km (Largest river system in the world)
ii) Origin: Gangotri in the Himalayas at a height of about 3129 km above the sea level.
iii) State of India: Ganga passes U.P, Bihar, Some part of Rajasthan & west Bengal.
iv) Tributaries: it had a number of tributaries and Yamuna river is one of the major tributaries of this system. Other tributaries are Ram Ganga, Gomati, Ghaghara, Gandak, Kosi, Chambal, Betwa and ken.
v) Catchment area: Total catchment area is about 9.71 lakh sq.km.
vi) Annual rainfall: 25-77 inches.
vii) Physico-chemical parameters: Temperature is 16.5oc to 31.5oc and pH is 7.4 to 8.3.
viii) Planktons: Phytoplanktons are generally poor during the monsoon. Phytoplanktons found in Ganga river system are Amphora, Cymbella, Navicula, Chlorella, Denticula, Spirogyra, Nostoc, Oscillatoriaetc. And zooplanktons are Rattulas, Rotaria, Filuia, Monostyla, Polyarthra etc.
ix) Fisheries of Ganga river system: The ganga river system supports a large number of commercially important fish species including major carps (*Labeo rohita, Labeo calbasu, Catla catla* & *Cirrhinus mrigala*), Minor carps (*Labeo fimbriatus, Labeo bata*), catfishes (*Wallago attu, Mystus oar, Clarius batrachus, Heteropneustes fossilis*), Cluipeids, Murrels (*Channa marulius*), Mullets, freshwater eel and prawns.
x) Gears: Gears used in Ganga river system are dragnet, cast nets and bag net.

b) Bramhaputra river system:

i) Length: about 2900 km

ii) Origin: Great glacier mass near Mansarover lake in the Himalaya.

iii) State of India: Tibet, Arunachal Pradesh, Assam, Bangladesh and Gaolundu.

iv) Tributaries: Principal tributaries of Bramhaputra on the north side include the Jiodhal, Subansiri, Ranganadi, Dihrong, Burai, Jaibharti, Dhansiri, Phulamari, Ail, Manes, Sankosh and Gangadhar.

v) Catchment area: Total catchment area is about 2 lakh sq.km.

vi) Annual rainfall: 40 to 83 inches.

vii) Physico-chemical parameters: pH is 6.95 to 8.

viii) Planktons: Phytoplanktons found in Brahmaputra river system are Spirogyra, Nostoc, Oscillatoria, Ulothrix, Gomphonema, Zygnemaetc. And zooplanktons are Brachionus, cyclops, Bosmina, Daphnia, Nauplius etc.

ix) Fisheries of Bhramputra river system: The Brahmaputra river system supports a large number of commercially important fish species including *Wallago attu, Labeo rohita, Hilsa. Tor tor, Labeo gonius, Mystus menoda, Rita rita, Channa species, Heteropneustes fossilis, Notopterus notopterus, Cirrhinus mrigala, C. reba, Labneo calbasu*, Catla and Prawns. Catfishes predominated the catches.

x) Gears: Gears used Gill net, drag net, bag net, cast net, dip net, trap net and long line.

c) Indus river system:

This system is represented by small portion in India.

i) Tributaries: The important rivers are Beas, Sutlej, Chenab, Jhelum, Ravi and Indus.

ii) State of India: The network covers the states of Himanchal Pradesh, Punjab and Harayana.

iii) Fisheries of Indus river system: this system is of growing importance, because of having several species of carps like Catla, Rohu and catfishes like *Wallago attu*. The fish fauna is richer than the Bramhaputra river system. In upper reaches of Beas and Sutlej are found the exotic rainbow & brown trouts.

iv) Gears: Gears used Gill net, drag net, bag net, cast net, dip net, trap net and long line.

d) East coast river system:

This system constituted by four principal rivers viz. Mahanadi, Godavari, Krishna and Cauveri, drains the entire peninsular region, east of Western Ghats in the west and southern parts of central India including Chota Nagpur region. Of the four rivers, Mahanadi, the principal river

of Orissa supports a rich fishery of major carps and other fishes as in Ganga river system. The remaining three rivers harbor a large number of indigenous species. These are poor in the fishery of major carps and hence these have been transplanted from the north to enrich the system.

Godavari:

i) Length: about 1465 km
ii) Origin: Doolali hills near the Nashik in north western ghat.
iii) State of India: Maharashtra, A.P., M.P.
iv) Tributaries: Manjira, Wainganaga, Painganga, Wardha, Purna, Amner, Sabari.
v) Physico-chemical parameters: pH is 7.2 - 8.3, Temperature 27.5 to 36.4oc
vi) Catchment area: Total catchment area is about 3,15,980 sq.km
vii) Fisheries of Godavari river: *Wallago attu, Labeo rohita, Hilsa. Mystus seenghala, Cirrhinus mrigala, Pangasius pangasius, Bagarius, Labeo calbasu*, *Catla* and Prawns.
viii) Gears: Gears used Gill net, seines, cast net etc.

Krishna:

i) Length: about 1401 km
ii) Origin: In Western Ghats region, South of Poona
iii) State of India: Maharashtra, A.P., Karnataka
iv) Tributaries: Bhima and Tungbhadra
v) Physico-chemical parameters: pH is 7.2 - 8.3, Temperature 27.5 to 36.4oc
vi) Catchment area: Total catchment area is about 2,33,229 sq.km
vii) Fisheries of Krishnariver: The Krishna river system supports a large number of commercially important fish species including *Wallago attu, Labeo rohita, Hilsa. Mystus seenghala, Cirrhinus mrigala, Pangasius pangasius, Bagarius, Labeo calbasu, Catla* and Prawns.
viii) Gears: Gears used Gill net, seines, cast net etc.

Cauveri:

i) Length: about 800 km
ii) Origin: Brhmagiri hills on Western ghat an elevation of 1340 m.
iii) State of India: Karnataka, Tamilnadu
iv) Tributaries: Bhavani, Noyil and Amarawati
v) Physico-chemical parameters: pH is 7.6 - 8.5, Temperature 26 to 30.9oc
vi) Catchment area: Total catchment area is about 4,70000 sq.km
vii) Fisheries of Cauveririver: *Acrossocheilus hexagonolepis, Tor putitora, Barbus carnaticus, B. dubius, Labeo ariza, Cirhinnus cirrhosa, Mystus aor, Mystus seenghala,*

Wallago attu, Pangasius pangasius, Labeo rohita, Cirrhinus mrigala, Notopterus notopterus, Silonia silondia, etc.

viii) Gears: Gears used gill net, seines, cast net etc.

e) West coast river system:

The west coast system comprises the river Narmada and Tapti, both of which flow in westernly direction of the country.

Narmada:

i) Length: about 1280km

ii) Origin: Amarkantak hills of M.P.

iii) State of India: M.P., Gujarat

iv) Tributaries: 16 in M.P. and 2 in Gujarat

v) Catchment area: Total catchment area is about 1,00,565 sq.km

vi) Fisheries of Narmada river: Carp group- *Tor tor, Labeo fimbriatus, Labeo calbasu, Labeo bata, Labeo gonius, Cirhinnus reba, Cirhinnus mrigala, Catla catla.* Cat fish group- *Rita pavimentata, Mystus seenghala, M. aor, M. cavasius, Wallago attu*.

vii) Gears: Cast net, gill net and long line.

Tapti:

i) Length: about 720km

ii) Origin: In mount Vindhya of Satpura range, at an elevation of 670-1000 meters above the sea level.

iii) Catchment area: Total catchment area is about 48,000 sq.km

iv) Fisheries of Narmada river: Carp group- *Tor tor, Labeo fimbriatus, Labeo calbasu, Labeo bata, Labeo gonius, Cirhinnus reba, Cirhinnus mrigala, Catla catla*. Cat fish group- *Rita pavimentata, Mystus seenghala, M. aor, M. cavasius, Wallago attu, Mastacembalus armatus*.

v) Gears: Cast net, gill net and long line.

RESERVOIR CAPTURE FISHERIES

Reservoir is a large multipurpose standing water body created by the efforts of human beings. Reservoir is formed by constructing soil or massonary wall in the flow of river or stream.

1) Ganga river:

Reservoir- Rihand, Matatila, Gandhisagar, Kangsabati, Mayurakshi.

Fishes- *Labeo calbasu, Labeo bata, Labeo gonius, Cirhinnus reba, Cirhinnus mrigala, Catla catla, Mystus seenghala, M. aor, M. cavasius, Wallago attu, Pangasius panasius, Ompak bimaculatus, Rita rita, Puntius sarana*.

2) Mahanadi river- Reservoir- Hirakud

Fishes- *Labeo calbasu, Labeo bata, Labeo gonius, Cirhinnus reba, Cirhinnus mrigala, Catla catla, Mystus seenghala, M. aor, M. cavasius, Wallago attu, Pangasius panasius, Ompak bimaculatus, Rita rita, Puntius sarana*.

3) Krishna river-

Reservoir-Tungbhadra, Nagarjunasagar, Nijamsagar

Fishes- *Labeo fimbriatus, Labeo calbasu, Labeo bata, Labeo boga, P. saran, Tor khudree, Osteobrama, M.aor, Ompak bimaculatus, Bagarius bagarius*.

4) Kaveri river-

Reservoir- Krishnarajsagar, Bhavanisagar, Mettur dam, Poondi

Fishes- *L. porcellus, L. potail, L. rohita, Labeo fimbriatus, Labeo calbasu, P. saran, Tor khudree, Bagarius bagarius, M. punctatus, Cirhinnus reba, Catla catla, P. pangasisus, T. mussullah.*

5) Narmada river- Reservoir- Sardar sarover

Fishes- *Labeo fimbriatus, Labeo calbasu, Labeo bata, Labeo gonius, T. mussullah, Bagarius bagarius, Mystus seenghala, Tor to*r.

Among the major carps, the *Labeo rohita* is incapable of adjusting to reservoir, but a hybrid Catla and rohu has been found to be thriving well in the reservoir.

Various weed fishes and carp minnows such as *Ambassis nama, A. raga, Osteobrama catio Gadusia chapra* are well suited for reservoir fisheries.

The reservoirs Ganga should be stocked regularly by the carp fingerlings.

LACUSTRINE CAPTURE FISHERIES

A lake is a large body of standing water which does not have connection with sea.

Characteristics of lake:

Thermal stratification- the lake water exhibits a temperature gradient from surface to bottom. During summer 3 strata with variable temperature are noticed. They are upper epilimnion (22oc to 21^0C), middle thermocline (21^0C to 7^0C) and lower hypolimnion (7^0C to 5^0C). During winter

only two layers can be noticed. The surface layer becomes ice. The temperature ranges from 0^0C to -2^0C. below the ice layer uniform water temperature is 4^0C.

Size: lakes are variable in size.

Depth: lakes are variable in depth. Lake Baikal in south Siberia has a maximum depth of 1706 meters.

Important lakes in India:

1) Logtak lake is located in Manipur. It is weed checked lake. The annual production is about 262 tones.
   Fish fauna: *Wallgo attu, Osteobrama, Puntius, Channa, Clarius* and *anabas* etc.
2) Kodaikanal lake: it is 26 hector in extent with average depth of 2 m. productivity of the lake is over 5.3 kg per hectare per year.
   Fish fauna: Trouts, Exotic carp.
3) Ooty lake: it is situated in Nilgiri at an altitude of 2500 m. it has an area of 34 hectare average with depth of 3 m. The fish yield is 75 kg/hectare/year.
4) Yercaud lake: it is a horse shoe shaped lake with an area of 8 hectare, average depth 2 m. the annual fish production is over 5.3 kg/ha/year.

Fresh water lake fish fauna:

i) Cat fishes- Clarius batrachus, wallago attu, Saccobranchus.
ii) Mullet
iii) Feather backs
iv) Perches
v) Carps- Catla catla, L. rohita, L.fimbricats, L. calbasu, Cirrihina mrigala, C. reba.
vi) Live fishes- C. puntatus, C. striatus
vii) Exotic carps- Cyprinu scarpio.

Brackish water lakes:

The great Chilka lake is an example of brackish water lake. It is one of the largest brackish water lagoon with water spread of about 906 sq.km in summer and 1165 sq. km during monsoon season. The total length of lake is about 65 km and 16 km width.

The fishery of Chilka lake is very rich. Chilka lake supporting 152 species of fishes and 21 species of prawn. The water is rich in phytoplankton and zooplankton.

Important fish species include *Mugil cephalus, M. microlepis, Polynemus, Lates calcarifer, Mystus gulio, Hilsa hilisha*.

Crafts: Raft, dugout canoe, plank built boats.

Gears: cast net, hook and line, gill net, drag net, trap net.

FISHING CRAFTS AND GEARS

Fishing craft:

Fishing means catching or trapping of fishes from various water resources like ponds, rivers, estuaries and oceans.

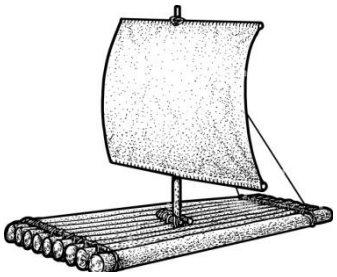
Fishing craft: Craft is a device used to operate gears or nets in big rivers, lakes, reservoirs, sea etc. it is also used for transport of fishes and fuel. Fishing crafts includes raft, catamaran canoes, machwa and trawler. Generally, crafts are categorized into two main types:

Inland fishing crafts and marine fishing crafts.

a) Inland fishing crafts: these are commonly used in the rivers, ponds, lakes and reservoirs. E.g. Raft, Canoes, Machwa etc.

b) Marine fishing crafts: The crafts are commonly used in seas. E.g. Catamaran, Canoes, Boats, Trawler etc.

1) **Raft:**



i) This is the simplest and most primitive type of craft used for fishing in inland waters.

ii) Raft is a rigid, floating platform made up of buoyant materials like logs, planks, barrel etc. fastened together by rope.

Types of Crafts:

a) Raft of banana stem are used in west Bengal. The banana stems are arranged parallel to each other and tied together by rope.

b) Rafts of logs: it is made up of dry logs of wood. The logs are arranged parallel to each other and tied by rope.

c) Rafts of inflated buffalo skin: Inflated buffalo skins are tied together to form raft.

d) Chatty: is also known as earthern pot raft. Chatty is commonly used in Patna, Gaya and Hazaribagh. it is usually constructed of 9 earthern pots, arranged in rows of three. Connected bamboos are latches on either side of the mouth of these pots. They also support a light platform of bamboo. The mouth of each pot is covered by sal leaves. Single pots are also used in some region, where a person sits on the pot and keeps the legs on two sides of pot.

e) Coracle: it is used in Cauvery and the Tungabhadra rivers of South India. It is a shallow cylindrical frame of woven canes. It is about 1.5, in diameter at the periphery cow hide is tied and firmly stretched on the sides of this raft. Similar device used in West Bengal is known as 'Gamla'.

f) Rafts prepared from bamboo are used in Bihar.

g) Rafts of Plantain: Plantain is a banana like herbivorous plant used in the construction of raft.

h) Inflated tyre tube: are also used as a raft in Ganga and Yamuna river.

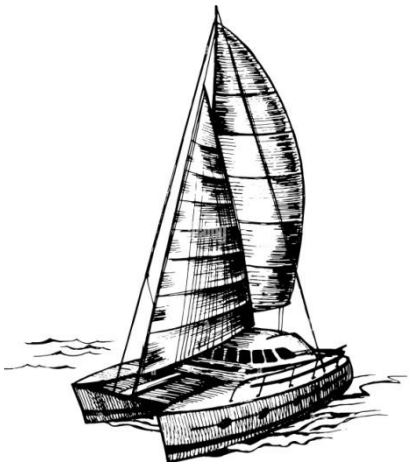
i) Rafts of dry cucurbit are used in Narmada.

Operation: Rafts are operated in slow water. It is operated by 2-4 fishermen by oars. It can be used for transport of net and fish.

Merits: it is easy to construct and operate. It is cheap because constructed by using local materials.

Demerit: strong water currents can overturn the raft, so not fit for using in sea.

2) Catamaran:



i) It is a primitive and the most important fishing craft of east coast.

ii) This is a keel less craft formed by tieing the several logs together.

iii) The logs are canoe like curved. Posterior end of the craft is cone shaped and projects above the water and used for operating the rudder. There is a shallow depression in the center at the middle to carry men, gear and fish.

iv) In general catamaran is 4-7 feet in length, 07 to 1.4 meter in width.

v) The life of catamaran is of 10 years.

Types of Catamaran:

a) Raft catamaran: it is made up of 4-5 logs and used in quilon region of Kerala.

b) Boat catamaran: it is made up of 3 logs and boat shaped, used in Madapam, Mukkar, Tuticorin.

c) Coromadal type: it is made up of 3-5 logs used in Chennai.

d) Orrisa type: Boat shaped, made up of 5 logs pegged with wood.

e) Andhra type: made up of heavy wood. It is 5-7 meter in length.

Operation: al the catamarans are paddled by oars. Some times the sails are used. It is used in the operation of drift nets, gill nets, boat seines and lines.

Merits: It is cheap and made from locally available materials. Cleaning and repairing is easy.

Demerits: it required maintenance from time to time.

3) Canoes:

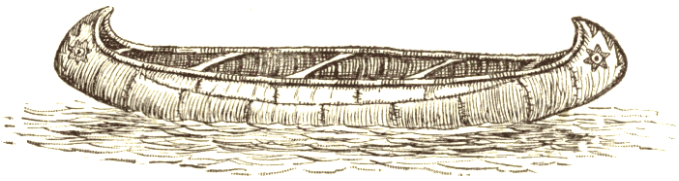
The canoes are boat shaped crafts. According to size, location and design canoes are of three types:

a) Dugout canoe:

i) It is prepared from a single large log of cheeni or aini wood.

ii) The log is trimmed from the outer side to give a boat like shape.

iii) The upper and middle part of log is scoped out to form a shallow, depression.



iv) The keel is thicker than the sides for balancing the boat.

v) These are popular on the Kerala and Kokan coasts.

vi) Such canoes are called Donga in Bengal and Ektha in Bihar.

vii) Small dugouts are used in the operation of gill net, seine net and drift net.

viii) 10-12 meter long of malbar region are used for operating variety of nets.

b) Plank built canoes:

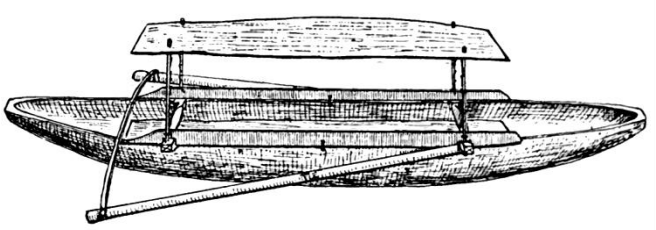
i) These are dugout further enlarged with plankton the sides.

ii) These are used in Kerala, North Mumbai for operating variety of nets.

c) Outrigger canoes:

i) The outrigger is a framework extended out from the side of a dugout canoe, which gives stability to the boat.

ii) The outrigger is locally called as 'Uldandi'.



4) It consists of two curved bamboo poles and a log of wood. The poles are fitted to dugout on one side and to the wooden log on the other side. These boats are called Rampani boats as these are used during Rampani operation Machwa:

i) It is a sea fishing strongly built, highly evolved type of fishing craft used along the Suarashtra coast.

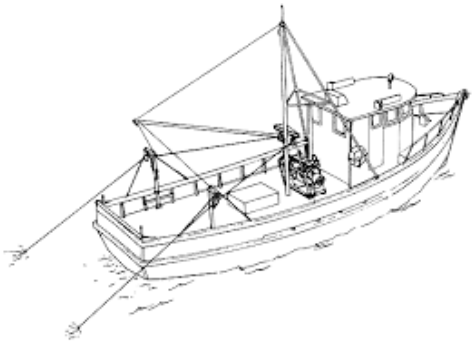
ii) It is a plank built boat. In between two planks glue soaked cotton is packed to make the boat waterproof.

iii) It has a broad hull, pointed bow and straight keel.

iv) Machwa has a large capacity and much compartments.Storage room for nets and other instruments. Fish room for storage of fishes and engine room.

Operation: These are used for deep fishing and operated by 2 to 10 fisherman. There are holes on the sides for extending oars. In open sea these are pushed by sail. They are also provided with Engines.

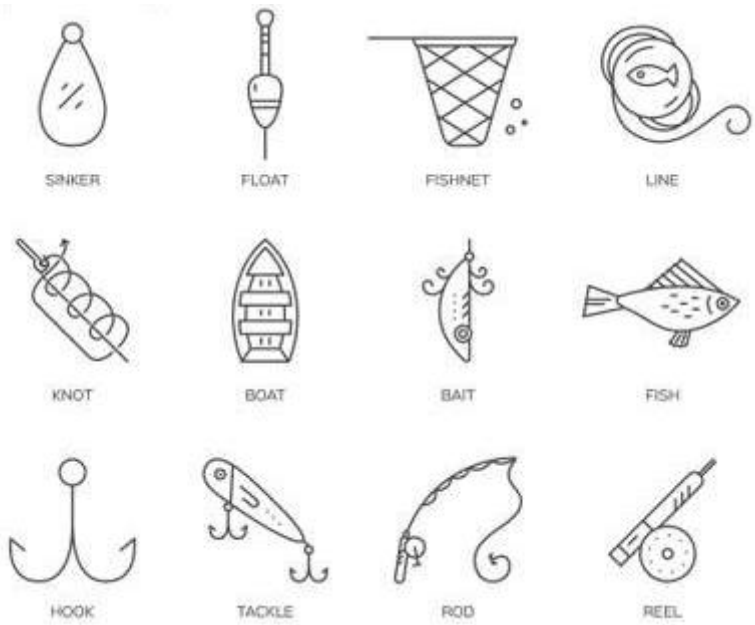
5) **Trawler:**



i) The vessel that pulls a trawl net through the water is called trawler.
ii) Trawlers are suitable for deep fishing.
iii) Trawlers vary in size from open boats to huge ships.
iv) Trawlers have adequate towing power and mechanical hauling system.
v) In many trawlers propeller nozzles are fitted to give them more towing power.
vi) There are different kinds of trawlers and known by different such as otter trawlers, side trawlers, stern trawlers, shrimp trawlers, beam trawlers etc.

Fishing Gear:

The device used to catch, trap or hook the fish is called fishing gear. Fishing gear includes hooks and lines, nets and traps.



Hooks and lines:

Fishing with the help of hooks and lines is the ancient method. It is the fishing gear of poor fisherman who cannot purchase costly nets. Hooks and lines are usually used in sport fishing and recreation. There are two methods of line fishing:

1) Pole and Line method 2) Long line method

1) **Pole and line method:** The pelagic fishes are captures by pole and line method. The pole and line gear consists of a rod or pole, line & hook.

i) Pole- Earlier cane sticks were used. Recently fiber glass and steel rods are in use. The steel rods are stronger and can withstand greater amount of pressure required for casting heavy baits. The fiber glass rods are even stronger and better than steel rods due to their non-rusting property. In India Ringal cane rods are very popular because they possess all the good qualities of rod and are also cheap. The length of the rod varies from 3-4 m. there is ring at top of rod. Body rings are also fitted at short intervals along the length of the rod. The line passes through the body ring and top ring. A "reel is fitted on the rod near the butt. It is large enough to wind nearly 140 m of the line.

ii) Line: The thread used for tying the hooked bait is called line. it may be made of silk, braided line, flex or nylon. The fisherman prefers nylon lines because it requires less maintenance.

iii) Hooks: it is made of a rust proof metal. The hook has the parts like the eye, shank, bend and barbs or spear. The hooks used in commercial fishing are divided into two groups, baited hooks and unbaited hooks. Hooks of various verities, standard sizes and qualities are available with the fishing tackle dealers.

iv) Bait: It is kind of lure fixed on the hook for attracting to fish. The baits are of three kinds, live bait, paste bait and artificial bait.

Live bait: it is a natural organism fastened to the hook. Commonly small sized fishes, worms, insects, crustaceans, mollusks, frogs are used as like bait.

Paste bait: Herbivorous fishes are lured by paste baits.

Artificial bait: plastic or wooden artificial fishes & flies are used as artificial bait.

Operation: Pole and line fishing is normally done by an individual fisherman. He cast his line in the water. The fish attracted by the bait snaps on the hook. The fisherman heaves on his back and flings the fish out of water. The fish is then disengagd from the hook.

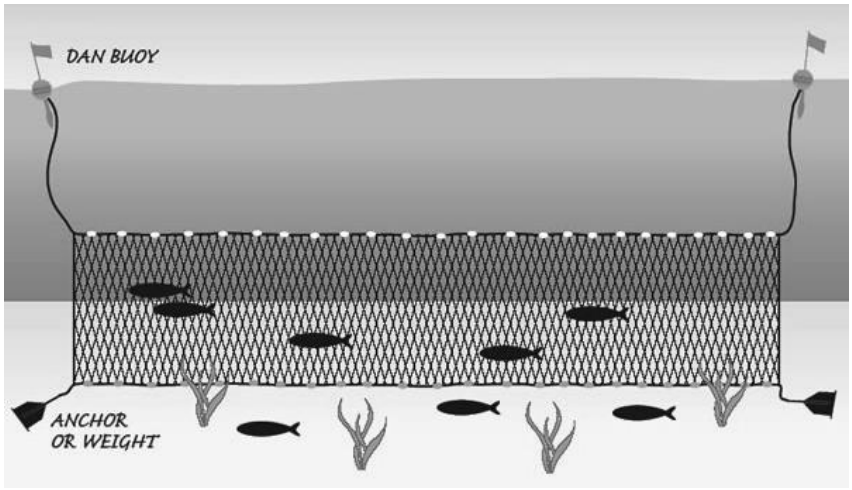
2) **Long line method:** Long line is mainly used in Cuba, France, Japan, South Africa & Taiwan. Long line is more than 1000 m long. It consists of main line and many short ganaglines. The ganglines are attached on the main line at interval of 2-6 feet. The ganglines are two types is permanently spliced and clipped ganglines. The ganglines baited with baits like worms, bread, flesh, shelled animals.

There are two types long line: 1) Floating long line 2) Bottom long line

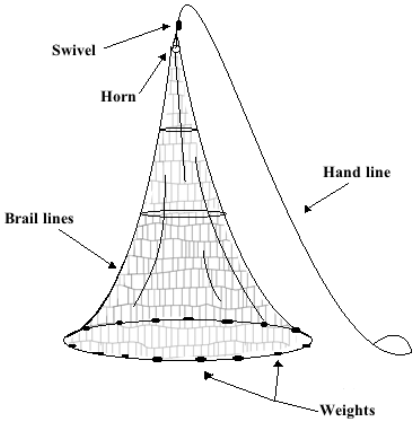
Floating long line: is maintained at desired depth with the help of floats. The longline is rigged with the floats & sinkers. The surface buoys carry marker flags.

Bottom long line: it lies nearer or on the bottom of the sea and is maintained in such position by a pair of anchors, one at each end. The place of line is indicated by the marker flag.

Operation: long line is set over the stern of the craft. While setting long line first a buoyant with marker and very long rope is released in the water. The other end of main line is tied to the buoyant with marker. After some time long line may be hauled either from the stern over the side rail of the vessel. A hauler is used to retrieve the long line. Then hooked fishes are unhooked from the permanently spliced ganglines.



Cast Net:

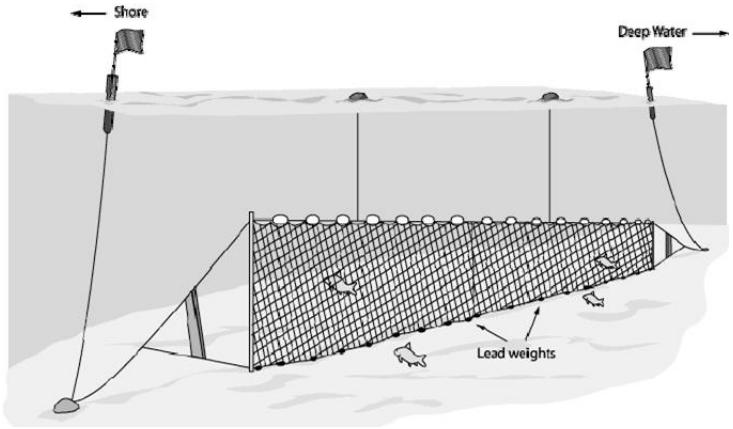


1) It is an active fishing gear. It is also called as ghagaria jal or throw net or circular net.
2) It is commonly used in rivers and ponds having sandy and muddy bottom.
3) This is cone or umbrella in shaped, forming a circle when cast off. The radius of net is about 2.5 m to 3 m.
4) Net is made up of cotton or nylon twines.
5) The mesh size ranges from 1 to 2 cm.
6) Foot rope is at circumference of the net. Foot rope is folded on the inner side upto 6 to 7 meshes and tied to the net and circular pocket is formed along the circumference of net.
7) Sinkers are attached to the foot rope at a distance 15 to 20 cm. intervals. Each sinker is cylindrical.
8) Hand rope is 5-8 mm thick and 7-15 m in length.
9) The weight of the net is 4.5 to 7.0 kg.

Operation: it is operated by a single fisherman. The free end of hand rope is tied to the forefinger of the left hand. The net is swung over the head by right hand and dropped in the shallow water

to cover the fishes by net. The net slowly sinks downward and when touches to the bottom, hand rope is pulls and trapped fishes are collected.

Gill Net:



1) It is a passive fishing gear.
2) The net is set in the way of migrating fish. When fish tries to swim through a net wall, the meshes form a noose round its head and fish is caught by gill.
3) It drifts vertically with the help of floats and sinkers hence also called drift net.
4) It is a wall like net, made up of 16-25 pieces. Each piece is 3 to 5m. Long and 2- 3 m height.
5) The mesh size is 5-6 cm.
6) The net is prepared from synthetic transparent fibers. Various dyes are used to make it invisible.
7) On the basis of setting of gill nets are of 3 types.

i) Floating gill net- the net is set at the surface or at a desired depth in the mid water by proper adjustment of floats and sinkers.

ii) Anchored gill net: the net is set in column waters of large lakes and in coastal regions by using anchors. The net is fixed with anchors.

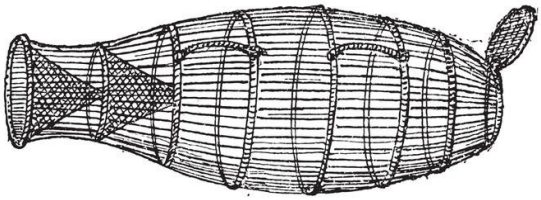
iii) Trammel gill net: The net has 3 walls. The walls are connected together above the float line and below the lead line. A small mesh size webbing is usually hung between the two tightly netted walls of large mesh webbing.

Operation: Gill nets are generally left overnight and then hauled. When a fish tries to swim through the net by its head, the head enters through the mesh but the body cannot pass through. When the fish tries to withdraw its head, the fish is entangles as the twines slip under the gill cover. The net is hauled the next morning and the gilled fishes are collected.

Traps:

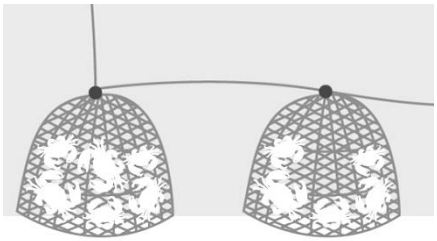
A) Inland fishing trap :

These are passive gears. Following three inland water traps are used.

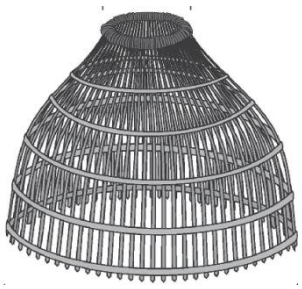


1) Basket trap: It consists of two dome shaped hemispherical baskets. Each provided with an opening at the narrow end. The opening is guarded by flexible recurved bamboo strips. The strips are facing towards the inner side.

Operation: Suitable bait is kept in the basket and the trap is lowered in the water for sometimes. Fishes trapped inside are collected.



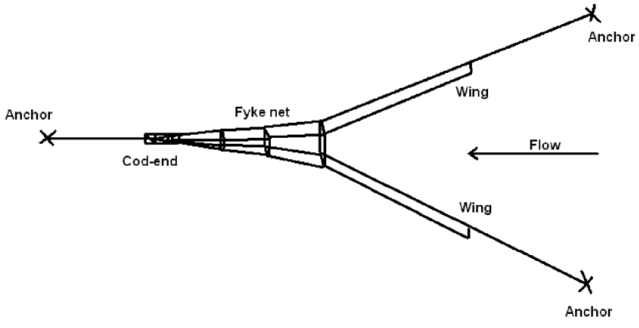
2) Pot trap: It is the fishing gear of poor people. A wide mouthed earthen pot or vessel is used as a trap. Suitable bait is placed inside the pot. The mouth of the pot is closed with a thick cloth. The cloth having few holes for the entry of fishes. The fishes tempted by the food enter the trap. These are then collected by hand.



3) Konch trap: It is commonly used in shallow muddy water during summer season. It is a conical basket prepared from bamboo pieces. It is about 1 m in height. The basket has a small circular opening at the top. The trap is dropped in water and the wide mouth is pressed in the mud. The trapped fishes are collected by hand.

B) Marine fishing trap nets:

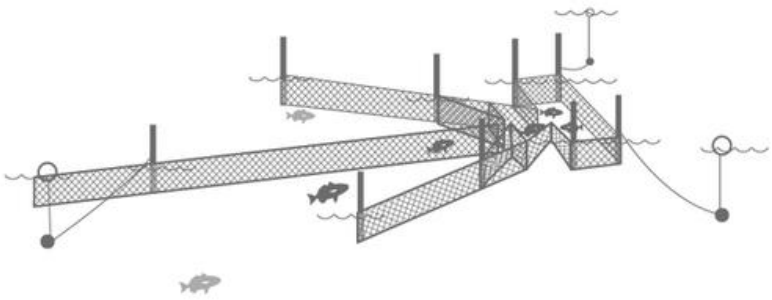
1) Fyke net: the net is cylindrical bag like. It is 7.5 m in length & 1.5 m in diameter. The mouth is wide. Inclined wings are present on either side of mouth which direct the fishes into the net. Sometimes a central leader may also be used to direct the fish into the mouth. The net webbing is supported by 3-18 rigid circular frames called hoops. The mouth and hoops are guarded by funnel like entrances which are facing towards the end. The mouth as well as wings is kept in position by stakes.



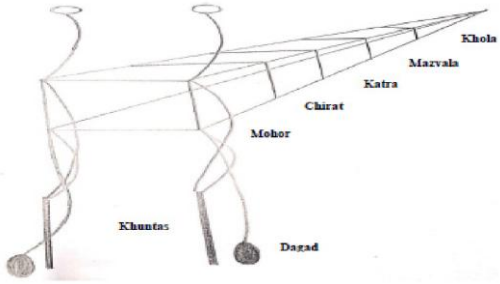
Operation: The fyke nets are operated in shallow waters to moderate current. The

fishes are collected from the pocket.

2) Pound net: pound net is larger trap net. The net is 300-800 m in length. The net includes crib, heart chamber and leader. it is kept in the crib. The crib and heart chamber is large part of net. Leader directs the fishes towards the bait. The pound nets are set in water depth ranging from 2 to 40 m.

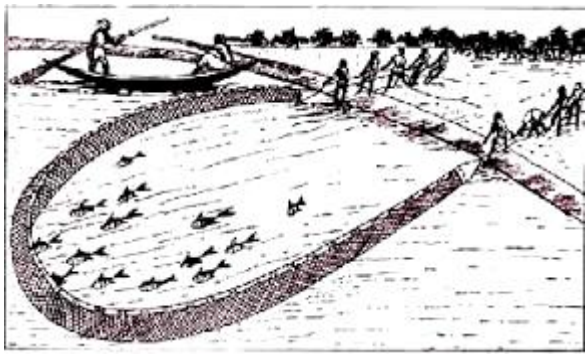


3) Dol net: the net is conical in shape. The mouth is 28 to 32 m wide. The cod end is 0.5 m in diameter. The size at mouth region is 200 mm and at cod end 10 mm. the mouth part of net is tied at wooden poles.



Rampani Net:

1) It is filtering type of net.
2) The net is set around the certain section of water mass and later that section of water mass is filtered by pulling the net.
3) This type of net is commonly used along the Kokan and Kerala coast.
4) It is a large sized net made up of 100 to 600 rectangular pieces. Each piece varies from 2-6 m in length & 5-11 m in height. The pieces are joined end to end.



5) There are two parts in the net, the central piece and the side piece.
6) The mesh size of central piece is 1.2 to 1 cm, while the mesh size of side pieces is 3 to 5 cm.
7) Floats are on the head rope and sinkers are on the foot rope.
8) Long ropes are attached at the two ends.

Operation:

i) To operate full sized net 60-80 men and 4 o5 boats are required.
ii) A Pandi boat is a big boat & Doni is smaller boat these are used as scout boats.
iii) Net is kept in V shaped in pandi boat. One end of net is tied to the pole on sea shore. The boat is rowed perpendicular, parallel & finally towards the shore.

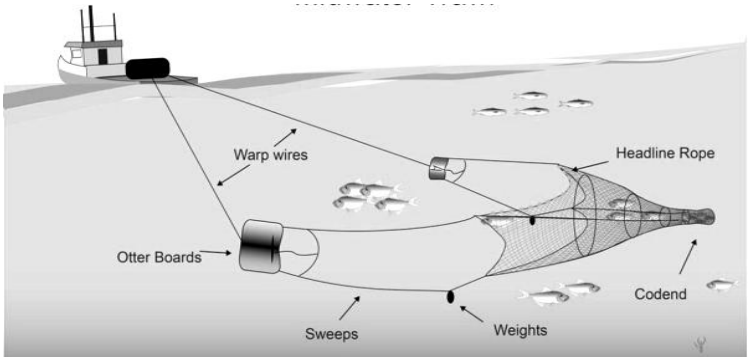
iv) The net is set semicircular in manner in water. The other end of net is handover to a group of 25 fishermen. The pandi boat is finally anchored in the center of the net.

v) Net is dragged to the shore by the two groups, when the two ends are about 150 m apart dragging stopped.

vi) Foot rope is kept in position by keeping sinkers. The head rope is tied to donies.

vii) Inside rampani net fishing is done by a small shore seine, yendi.

Trawl Net:



1) Filtering type of large sized gear.
2) It is towed by the trawler, so called as trawl net.
3) Trawl net is conical in shape and measures about 30 m in length.
4) The net has wide mouth and narrow end.
5) Wings are on either side of mouth.
6) Mesh size decreases from the wings to cod end.
7) Mouth of the net is kept open by the floats and sinkers. Floats are attached on the foot rope. Foot rope is rigged with wooden or metallic bobbins and connected the fishing line. Bobbins prevent wear and tear of the during dragging.
8) Toothed chafing gear and cow hide chafer fitted at the cod end to prevent wear and tear during dragging.
9) Lastridge lines are the additional lines for the reinforcement of the trawl net and also providing longitudinal strength to the net.
10) Splitting strops present in the cod end to prevent the collapse bag.
11) On the basis of structural design trawlers are of two types:
   i) Otter trawl net: otter trawl nets are provided with otter boards. The otter boards keep the mouth of the open during operation.
   ii) Beam trawl net: The foot rope is connected to the wooden beam of about 12-15m long.

Operation: The net is tied by strong warps. The net is dragged by trawler slowly. The water is filtered. The fishes are trapped by special valve like devices.

Maintenance of fishing crafts and gears:

Maintenance of fishing crafts:

1) The bottom of boat should be inspected at regular intervals.
2) The underwater parts of the boat are protected by copper sheeting and copper paints. Paints prevent the growth of the barnacles and grasses. Paints prevent the entry of moisture into the wood.
3) The most common enemy of wood is fungi. The fungi cause rotting. Fungi proliferate in warm and moist environment. Every part of the boat should be well ventilated and should have proper drainage system.
4) Wooden boats are protected by using chemical preservatives and oil preservative.
5) Chemical preservative is combination of Arsenic pentoxide 1 part, copper sulphite 3 parts, and potassium dichromate 4 parts dissolved in 10 parts of water.
6) Timber can be protected by injections of salt solution.

Maintenance of fishing gears:

1) The nets contaminated with algal mats, fish slime, organic debris etc must be thoroughly washed with running water and in shade by hanging or spreading them on beaches.
2) they should be dipped into brine (salt solution) or sufficient amount of salt should be sprinkled over the net.
3) The nets are cleaned and preserved by chemicals such as ammonia, coal tar, copper sulphite etc.
4) To protect the nets from bacterial action the nets are dipped in the tannin and chemicals. Vegetable tannins are formed from bark of Kalasan, Babul, nuts of Myrobalan and Panchikka fruits.
5) Nets are treated with 1% potassium dichromate solution for protection.
6) Treatment of nets with hot tar or kerosene diluted tar increases the strength of the fiber and makes them waterproof.

FISH PRESERVATION & PROCESSING TECHNIQUES

Preservation of fishes is a very important art of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of taste, odor, flavor, nutritive value and the digestibility of their flesh. Fishes are quickly perishable commodities and are spoiled if not properly preserved. During peak period, large quantities of fish are caught and require proper preservation so as to be available during lean period.

Fish spoilage occurs chiefly due to three reasons:

1) Microbial action: Microbial action involves chiefly bacterial spoilage of the fish flesh. A large number of bacteria present on the body, gills and gut of the fish find a good medium for development due to high moisture contents in the fish flesh. Fishes get cuts, abrasions etc, during catching operations, leading to hemorrhage. These provide an ideal environment for bacterial activity which are most destructive to the fish. Protein, Carbohydrates and fat content are degraded because of bacterial action.
2) Fish spoilage due to enzymatic action: Quite a large amount of fish flesh is spoiled by the action of digestive enzymes, which remain active even after death of the fishes and soften the flesh by autolysis and make the fish susceptible to bacterial infection.
3) Fish spoilage due to chemical action: Spoilage of fish flesh due to chemical action is the least important as it occurs in fatty acids only. It is more pronounced in fatty fishes like Sardines, Mackerels, Trout, Catla etc. which as result become decolorized.

Objectives of fish processing:

1) To prevent fish spoilage and maintain nutritive value of fish upto marketing.
2) To help or facilitate good transport and distribution of fishes from landing of fish and markets of fish.
3) To stabilize price level of fish throughout year.
4) To prepare various kinds of fish products according to the taste and demand of consumers.
5) To help in export of flesh of fish, crustaceans and mollusks to obtain foreign currency from canned, smoked fishes and freeze forms of fishes

Methods of fish preservations:

The most important principle of preservation of fishes is cleaning and sanitation. Preservation can be done, both for short and long duration by employing methods.

Short duration preservation: When preservation is required for short duration (2-4 days), the captured fishes are kept in crushed ice and transported to the market for their sale.

Long duration preservation: when the preservation is needed for a long period of time.

I) Refrigeration:

The recent method of preservation is refrigeration as it prevents putrefaction and decay. Frozen fishes retain their nutritive qualities for a long time, perhaps even for a year. Fishes are packed in ice layers for short-time preservation in markets or for transport. For long time preservation, large electric refrigerator or deep freeze cabinets are employed.

Lowering of the temperature to about 0oc (chilling) is the most effective method of preventing putrefaction and extending the life of the dead fishes. For chilling, large amount of ice is used to lower the temperature of the fish. Large fishing vessels are provided with such facilities. Alternate layers of ice and fish must be arranged to bring down the temperature of the flesh to about 0 oc. in large fishes, ice must be applied in the abdominal cavity after gutting. Antibiotics like terramycin and aureomycin can be incorporated in the ice to inhibit the microbial growth. Chilling does not alter the physical state of the fishes and keep them in palatable state for a few days. However, this method is not suitable, when the intention to keep fishes for a period of more than two weeks.

II) Deep freezing:

For deep freezing, captured fishes are cleaned, gutted, sorted and trimmed to suitable sizes. They are frozen either immediately within 30 minutes of theircatch or within a period extending from 3 to 72 hours. The freezing is achieved in ice, mixed with salt. Addition of salt brings the temperature gradually down from -1oc to -18oc. by deep freezing, fishes may be preserved for a very long period. Preservation by deep freezing often causes loss of flavor and slight damage to tissues, sometimes the fish becomes tasteless. This may be prevented by wrapping the fishes in wax paper or cellophane and by glazing the fish. Glazing preserves the colour and flavor of the fishes.

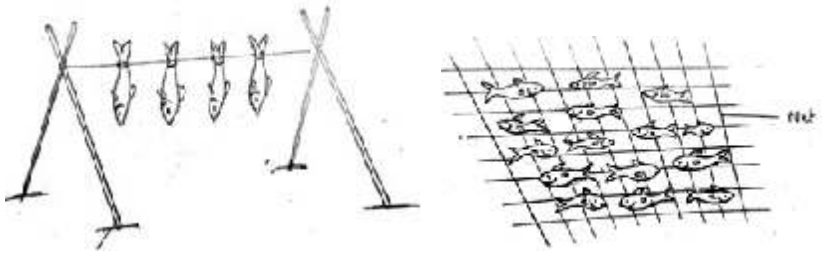
III) Drying:

This process is used to remove water or moisture from fish tissues. This help to arrest bacterial and enzymatic putrefaction. When moisture contents reduce upto 10-20%, the fishes are saved from being spoiled, provided they are stores in dry conditions. Sun drying is the most ancient method. Drying process can be done by the two methods:

1) Natural method 2) Artificial method

1) Natural method: Drying in the sun is the natural drying or solar drying method. In natural drying, the caught fishes are cleaned and dried in the sun shine, so called sun-drying. In these method fishes are first washed and cleaned. Then they are spread on the seashore. Fishes are dried in coir mats, sacks, racks or hung on wooden frame, bamboo mats, used nets, cement platforms. The fish is turn over often to ensure a uniform dried material. The sun heat

remove water from the fish tissue and heat also destroys bacteria. It is actually not the ideal way of preservation. It has certain disadvantages. It is not hygienic. It is slow results in much loss through purification and spoilage and the dried fish develops a peculiar odour. It can be carried out only in dry, well aerated climate receiving sunshine, which is not too hot. It thus depending upon the environmental factors and availability of space. So only thin fishes can be preserved by this method, because the fat fishes have much flesh allowing microbial decomposition to continue in deeper parts of their body.



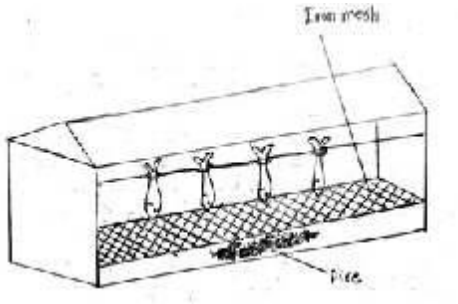
2) Artificial drying: In artificial drying, the killed fishes are cleaned, gutted and decapitated. They are then cut lengthwise to remove large parts of their spinal column, followed washing and drying them mechanically. This process yields a high quality product, which retains the natural flavor and nutritive values.

Salting is form of pickling and is widely used in India. Common salts acts as a preservative by preventing bacterial growth and by inactivating enzymes. There are two methods develop:

1) **Dry salting:** fishes are first rubbed with salt powder and then packed in tubs or in cement tanks. Dry salt powder is sprinkled in between layers, as the fishes are arranged in the container. The ratio of salt to fish varied from 1:3 to 1:8 depending on local practice, whether conditions and type of fish. For example oily fish require more salt. After a period of about 10-20 hours, the fishes are removed from the tubs and tanks washed in their brine solution and dried in the sun for 2-3 days.
2) **Wet salting:** wet salting is mostly practiced on the Kokan coast. Fishes are cleaned and packed in large vats containing a concentration salt solution and stirred daily till properly pickled. Large sized fishes are gutted first and their insides cleaned. Also longitudinal slits are made in the fresh to allow penetration of salt. Salt in the proportion of 1:3 is applied in three successive stages. On the first day, half of the salt is rubbed into the incisions and the fish is stored on the cemented floor of the curing-yard. On the second day, the fish is shuffled, so as to bring the bottom layer on top and half of the remaining salt is rubbed and the fishes are restacked. The stock is left undisturbed for 7 to 10 days. The salty water that

oozes out from the fish is allowed to drain of. Wet salted fish is sold without drying.

IV) Smoking:



Preserving salted fishes with smoke treatment this process is called smoking. It is traditional method in which combination of salting and drying method. Sardine, Mackrel, Seerfish, Pomphret. Jew fish and Hilsa are considered good varieties for smoking.

Fishes are first cleaned and gutted and then soaked into salt solution or brine. They are taken out from the salt solution and are suspended on rods in smoke house. Smoke house is merely a shed or box over afire which is controlled so that it produces smoke instead of flames. The fishes are merely hung inside the smoke house, so that they are surrounded by smoke. It takes about 6 hours to smoke fishes so that they can be eaten or stored.

Smoked fish does not last as long as salted fish, because it must be refrigerated, frozen or canned, if it is to be stored. Smoking removes additional moisture and increases the flavor of the fish flesh.

Canning:

Canning is the process evolved in Europe and now introduced into other countries. In canning process fishes are pack in boxes and preserved them for long time. Canning is complicated process. The canning process includes packing of fishes in tin boxes which are sealed and sterilized by heat. The fishes are cut into slices, salted and dried. The cut pieces are dipped in brine to remove blood from tissue. Then pieces are immersed in hot water to remove adhering materials. Pieces salted and dried. They are then mixed with a spicy paste ground by mixing vinegar, red chilies, mustard, garlic, turmeric and tamarind in a medium of oil. Finally processed pieces are sealed in containers or tin box.

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About Authors

Ms Gayatri Shankarrao Madakai, is working as an Assistant Professor in the Zoology & Fisheries Department in Yashvantrao Chavan Institute of Science, Satara. She completed her M. Sc. (Cell Biology) post graduate degree in the year of 2015 from Shivaji University, Kolhapur. She has published 2 research papers. She also participated in conferences and conducted Zoology and Fisheries workshops, webinars and competitions.

Ms. Madhuri Dharmendra Sawant is working as an Assistant Professor in the Zoology & Fisheries Department in Yashvantrao Chavan Institute of Science (Autonomous), Satara. She has completed her M. Sc. (Cell Biology) post-graduate degree in the year of 2015 with the distinction from Shivaji University, Kolhapur. She has also qualified for CSIR-UGC NET(Life Science) Exam in the year of 2016. She has published 5 research papers on various topics & e-books. She has presented and participated in the National & International conferences and workshops. She has also been a Co- principal investigatore of a major research project sponsored by RUSA.

Ms. Priynaka Vilas Ramgude is working as an Assistant Professor in the Zoology & Fisheries Department in Yashvantrao Chavan Institute of Science, Satara. She completed her M. Sc. (Cell Biology) post graduate degree in the year of 2015 from Shivaji University, Kolhapur. She has published a research paper. She has also participated in conferences and conducted Zoology and Fisheries workshops,webinars and competitions.

Prof. Dr. Vishwas Yashwant Deshpande is serving as a Professor in Zoology and Fisheries in Yashavantrao Chavan Institute of Science (Autonomous), Satara. He has pursued his M.Sc. (Fisheries) post-graduate degree and Ph.D.from the Shivaji University, Kolhapur. Prof. Deshpande has a teaching experience of over 33 years. He is a BOS Chairman of Shivaji University Kolhapur as well as Vice-Principal of YCIS Satara. He has presented and participated in the various National & International conferences, symposia and workshops. He has also been a Principal Investigatore of a major research project sponsored by RUSA. He has motivated Thousands of researches as well as guided them for deep study thereon during his career which has resulted into having quality Researchers, Professors, Scientist and others. Dr. Deshpande is the co-author of various zoology books.

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