IVC Course Code : 111

FISHERIES (FISH)

First Year

(w.e.f. 2018-19)

Intermediate Vocational Course

Paper I : **Texonomy, Ecology & Biology of Fishes**

Paper II : **Principles of Fisheries & Aqua Culture**

Paper III : **Seed Production Technology**

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ANNUAL SCHEME OF INSTRUCTION AND EXAMINATION FOR 1st YEAR FISHERIES COURSE

Part-A		Theory		Practicals		Total	
		Periods	**Marks**	**Periods**	**Marks**	**Periods**	**Marks**
1.	General Foundation Course	150	50	-	-	150	50
2.	English	150	50	-	-	150	50
Part-B							
3.	**Paper-1** Taxonomy, Ecology and Biology of Fishes	135	50	135	50	270	100
4.	**Paper-II** Principles of Fisheries and Aquaculture	135	50	135	50	270	100
5.	**Paper-III** Seed Production Technology	135	50	135	50	270	100
6.	**OJT**	-	-	363	100	363	100
	Total	**705**	**250**	**768**	**250**	**1473**	**500**

* On the Job Training **From 1st November to 31st December .**

EVALUATION OF ON THE JOB TRAINING:

The "On the Job Training" shall carry 100 marks for each year and pass marks is 50. During on the job training the candidate shall put in a minimum of 90 % of attendance.

The evaluation shall be done in the last week of January.

<u>Marks allotted for evaluation:</u>

S.No	Name of the activity	Max. Marks allotted for each activity
1	Attendance and punctuality	30
2	Familiarity with technical terms	05
3	Familiarity with tools and material	05
4	Manual skills	05
5	Application of knowledge	10
6	Problem solving skills	10
7	Comprehension and observation	10
8	Human relations	05
9	Ability to communicate	10
10	Maintenance of dairy	10
	Total	100

<u>**NOTE**</u>: The On the Job Training mentioned is tentative. The spirit of On the Job training is to be maintained. The colleges are at liberty to conduct on the job training according to their local feasibility of institutions & industries. They may conduct the entire on the job training periods of I year and (450) II year either by conducting classes in morning session and send the students for OJT in afternoon session or two days in week or weekly or monthly or by any mode which is feasible for both the college and the institution. However, the total assigned periods for on the job training should be completed. The institutions are at liberty to conduct On the Job training during summer also, however there will not be any financial commitment to the department.

FISHERIES

Paper - I

TAXONOMY, ECOLOGY & BIOLOGY OF FISHES

INDEX

Unit- I

1. Introduction to Taxonomy, Ecology and Biology of Fish and Prawn

Structure

1.1. Introduction to Taxonomy
1.2. Introduction to Ecology
1.3. Introduction to biology of fish and prawn.

1.1 Introduction to Taxonomy.

Taxonomy (form Ancient Greek "taxis"- Meaning arrangement and "nomia"-meaning method is the science of defining and naming groups of biological Organisms on the basis of shared Characteristics. The term "Taxonomy was coined by A.P.Tansely. Organisms are grouped together into texa and these groups are given a taxonomic rank, groups of a given rank can be aggregated to form a super group of higher rank, thus creating a taxonomic hierarchy. The principle ranks in modern use are domain, kingdom, phylum (division is sometimes used in botany in place of phylum), class, order, family, genus and species. The Swedish botanist *Carl Linnaeus* is Regarded as the father of taxonomy, as he developed a system known as *Linnean taxonomy* for Categorization of Organisms and binomial nomenclature for naming Organisms.

With the evident of such fields of study as phylogenetics, cladistics, and systematic, the Linnaean system has progressed to a system of modern biological classification based on the evolutionary relationships between organisms, both living and extinct.

DEFINITION

The exact definition of taxonomy varies from source to source, but the core of the discipline remains: the conception, naming, and classification of groups of organisms. As points of reference, recent definitions of taxonomy are presented below:

1. The Linnaean system has progressed to a system of modern biological classification based on the evolutionary relationships between organisms, both living and extinct.
2. Theory and practice of grouping individuals into species, are arranging species into larger groups.
3. A field of science (and major component of systematic) that encompasses description, Identification, and classification.
4. The science of classification, in biology the arrangement, including study of means of Formation of species, etc."
5. "The analysis of an organism's characteristics as applied to living organisms, including study of means of formation of species, etc."
6. "The analysis of an organism's characteristics for the purpose of classification".
7. "Systematic studies phylogeny to provide a pattern that can be translated into the classification and names of the more inclusive field of taxonomy (listed as a desirable but unusual Definition).

The varied definitions either place taxonomy as a sub-area of systematic (definitions 2), invert that relationship (definition 6), or appear to consider the two terms synonymous. There is some disagreement as to whether biological nomenclature is considered a part of taxonomy (definitions 1 and 2), or a part of systematic outside taxonomy. For example, definition 6 is period with the following

Definitions of systematics that places nomenclature outside taxonomy:

Systematics: "The study of the identification, taxonomy and nomenclature of organisms, Including the classification of living things with regard to their natural relationship and the study of Variation and the evolution of taxa " .

A whole set of terms including taxonomy, systematic biology, systematics , biosystematics, scientific classification, biological classification, and phylogenetics have at times had overlapping meanings-sometimes the same, sometimes slightly different, but always related and intersecting . The broadest meaning of "taxonomy" is used here. The term itself was introduced in 1813 by de Condolle.

Alpha and beta taxonomy

The term "**alpha taxonomy"** is primarily used today to refer to the discipline of finding, describing, and naming taxa, particularly species. In earlier literature, term had a different meaning, referring to morphological taxonomy, and the products of research through the end of the 19^{th} century.

William Bertram Turrill introduced the term "**alpha taxonomy**". Ernst Mayr in 1968 defined "**beta taxonomy"** as the classification or ranks higher than species.

An understanding of the biological meaning of variation and the evolutionary origin of groups of related species is even more important for the second stage of taxonomic activity, the sorting of species into groups of relatives ("taxa") and their arrangement in a hierarchy of higher categories. This activity is what the term classification denotes; it is also referred to as **beta taxonomy.**

Species is a unit of classification

The word **species** was coined by **John Ray** (1628-1705). The concept of biological species was put forward by **Mayer.** A Swedish botanist Karl von Linne who later on become popular by the name of **Carolos Linnaeus** (1707-1778), wrote the book **Systema Naturae** (1735). In this book he presented the system of nomenclature for plants and animals known as **binomial nomenclature**. This book is known as the "dictionary of classification" and Linnaeus is known as the **"Father of Modern Taxonomy".**

Modern concept of species.

The modern concept of species is biological or genetic species. Mayer (1942) has defined species as a "population of inter breeding individuals .There is a free gene flow in an inter breeding "population, the genetic changes appearing in a part of population of the species can ultimately appear in the descendents of the species. The population thus tends to evolve as a whole.

An animal's species may have following characteristics:

i. Each species possesses a common gene pool with a free gene flow.
ii. Each species is in a process of continuous adjustment to its environment.
iii. Each species occurs in an ecological niche not necessary occupied by other species.
iv. Each species possesses a constellation of isolating mechanisms that directly or indirectly prevent exchange of genes with related species.
v. Each species has the capacity to give rise to new species.

1.1.2 Nomenclature of Organisms

While classifying any animals its nomenclature is required first. There are two types of names of organisms (i) **common** or **Vernacular names** and (ii) **Scientific names.** The well known animals and plants are known by different names in different countries and languages of the world. An organism may be popular by different local names in different part of a country.

This poses a great problem in the study of an organism because a man o other place or language can not understand about that organism . When **Seton** (1929) wanted to study a big member of cat family, he realized that in different parts of America it is known by different names. Eg., painter, cougar, puma, panther, mountain lion, catamount, variment-red tiger , brown tiger, sneak cat, king cat, purple panther , mountain devil, mountain screamer and mountain demon. The easiest solution to all such problems was , only to assign one scientific name for this animals-Felis concolor, so that it can be studied easily throughout the world

Mononomial nomenclature. To assign name of one word in classification is called mononomial nomenclature. While writing the names of **taxa** or **supraspecitic groups,** mononomial nomenclature is used e.g. name of family, order , class, or phylum, etc.

Binomial nomenclature. The system of writing scientific names of the organisms adopted by Linnaeus is called binomial nomenclature. He gave system of writing the name of organisms in two words. The first word of the name belongs to the **genus,** other word belongs to that specific plant or animals and is called **species.** According to the binomial nomenclature the very popular Indan major carps named as catla (catla – hindi; Botcha – telugu); Labio rahitha (Roha – Thelugu); cirrhinus mrigal (seelavathi – Telugu)

Autonymy: The practice of naming the organisms, in which the generi name and species name are the same , is called tautonymy. So the name is called tautonym.

Ex: catla catla (India major carp)Basic method of classification.

1.1.3 Basics Methods of Classification

In every system there is a graded organization or every arrangement is organized in ranking manner such as best , better, good , poor etc.

This is evident that form the very beginning all living organisms have been divided as Animals and Plant Kingdom. In the Animal kingdom a proper arrangement exists . Our ancient observes classified the animals as vertebrates and invertebrates. We now have the animals broadly grouped as Fishes, Ampphibions,Reptiles, Birds, Mammals as vertebrates and Cnidaria, Arthopoda, Molluskans, Echinodermatas etc. as invertebrates. This gradation is according to their status in the evolution ary ladder. Mammals being the most highly evolved and Prorozoans the least.In a similar fashion in taxonomy also a system of hierarchy wqas developed based on their evolutionary history, non varying and constant structural patterns and group characters. Animals are grouped under Phylum, Class, Orders, Families, General and Species. Subdivision of each one the3se is also known such as subphylum, subclass, suborder, subfamily, subgenera, subspecies etc. many more divisions like tribe are also known but it is sufficient to use the broadly accepted classification. These are called systematic categories or Taxon (Tasxa plural). All groups of anyone kind are supposed to differ from its related group by a roughly equal and the same degree of difference. Closely related organisms have more feathers in common.

The various taxa are defined below.

Phylum: One of the major kinds of group used in classification of living organisms. Eg. Phylum Chordata indicating the vertebrates. This consists of one or more number of similar Classes.

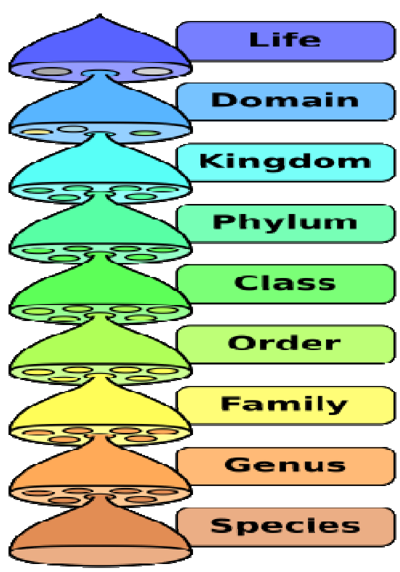
Class: sub-division of Phylum, this includes broadly the major animals each distinct from other by major characters both internal and external. Ex.Class Pisces (Fishes) different from Aves (Birds).

Order: Groups number of similar families; sometimes it may be even one family such as order Gonorhynchiforms with one family Chanidae. All fish orders end with the word 'formes' and mostly the prefixes are the most common fish generic name.ex Cypriniformes, Siluriformes(after genera Cyprinus, Silurus).

Family : This is a systematic category including one or more genera of common phylogenetic origin and separated from other families by a decided gap. This consists of a number of genera similar in most charecters. Even a single genus may constitute a family because of its peculiarities. Ex.Horaichthyidae for the genus horaichthys Kulkarni. All family names end with the word 'idea'.

Genus: This is a systematic category or taxon, which includes one species or a group of species presumably of common phylogenetic origin which is separated from other similar units by a decided gap. Ex. Genus Puntius has an assemblage of 55 species (Jayaram, 1991) but Chanos has only one species *(chanos chanos).*

Species: Species are actually (or potentially) interbreeding groups of populations which are reproductively isolated from similar such groups. For example Mystus cavasius can interbreed among themselves but cannot do so with any other species of Mystus. This is the normal pattern through hybrids are known and are cultured artificially now. The species is the keystone of any taxonomic study. This is because the species is the oly one objective category which one can actually observe, collect, and test for any investigations.



Thus the hierarchy for a fish group is depicted as below:

Phylum- Chordata

Class- Pisces

Order- Cypriniformes

Family- Cyprinidae

Genus- *Puntius*

Species- *Puntius sophore* (Hamilton-Buchanan)

It will be seen that all categories above species have only a single work Species alone and always cited by two names followed by the name of the author or scientist who first gave the specific name. There are several kinds of names used in taxonomy such as descriptive names, ecological names, geographical names, patronymic names and names without definite meaning.

Gender matching: It has been stated that scientific names are derived from Latin or Greek words. Latin in the Code of International Code of Zoological Nomenclature (ICZN) includes ancient, mediaeval and modern names whereas Greek includes only ancient Greek words. Accordingly the specific and generic names should match gender wise.

If an adjectival name is used s the specific name it must agree grammatically with the generic name, even if the species is transferred to another genus its termination must also be changed if necessary to agree with the genus name. Generally the prefix sub is used with Latin words and Pseudo with Greek words.

Author names: These are names of persons or scientists who first proposed the taxa, be it a new species or genus. Names of genera and species and below must be cited with the name of the first author who proposed it, found or described it for the first time. For instance genus Rasbora Bleeker means that the genus ws first proposed by the author Dr. P. Bleeker, though only his surname is cited and not the initials etc. only day for his taxa and not Francis Day. Exception is Hamilton Buchanan since this is the correct name and not Buchanan as often cited. In similar manner the author or the first proposed or founder of the specific name is mentioned immediately often the taxon name and not where else.

Ex. *Barilius bakeri Day* means that Day proposed the name bakeri for this species and described it under the genus Barillius of Bleeker. Author names in brackets. Sometimes some author names are placed in brackets.

Ex. *Puntius ticto* (Hamilton-Buchanan). This means that the name ticto was given by Hamilton-Buchanan, the original author, but he described it under a different genus and not under Puntius. In this case he described it under the genus *Cyprinus* of Linnaeus which later workers found to be incorrect and placed the species under the genus puntius. Hence the author names is within brackets.

1.2. Introduction to Ecology:

Ecology is a subject which deals with the study of the interactions among organisms and between the organisms and their physical (abiotic) environment. The word 'ecology' ws derived from the Greek term *'oikos'* which means 'house', and 'logos' meaning 'study'. Ecology was defined by **Ernst Haeckel** as ***"the study of the relationship of organisms with their environment".*** The environmental science, ecology, has two main branches- ***autecology*** and ***synecology.*** Autecology is the ecology of a single species / population in relation to its environment. It is also known as **'species' (population) ecology'.** Species ecology deals with the dynamics of 'species populations' and how these populations interact with their surrounding environment. It also deals with the study of changes in population sizes **(Population dynamics),** over a period of time. Synecology is a branch of ecology that deals with the structure, development, and distribution of **'ecological communities'. A community,** as you perhaps know, is a group of organisms of different species living together and interacting with the surrounding environment. Synecology / community ecology deals with the interrelationships between organisms of different species living in a specified area and their interactions with their surrounding environment. It takes into consideration the functional roles of different organisms of the community and also the ***community dynamics.***

1.2.1 Importance and scope of Ecology

Civilization initiated with the use of fire and making of tools which led to the modifications in the environment. Gradually the technological advancement changed the life styles and human beings totally forgot their responsibilities to their surroundings. The negligence or ignorance towards 'natural resources' and the 'mother nature', Gradually lead to the disintegration of nature. To overcome this problem, it is time that humans act and save the nature for the future generations. The knowledge of organism, environment and the interrelationships is impotent for the conservation of the nature.

Thus literally, ecology is the study of organisms 'at home'. Ecology has been defined in various ways by different authors. Warming (1895, 1905), who actually employed this science for the study plants, defined Oikologie as the study of organisms in relation to their environment". Woodbury (1954) treated ecology as a science which investigates organisms in relation to their environment. Taylor (1936) defined ecology as "the science of all the relations of all organisms to all their environments"

Tyler (1936) once described ecology as the science of all the relations of all the organisms to all their environments.

During the recent years, ecology has assumed greater importance due to its relation with manking through environment. The various aspects of environment such as environmental pollution and its control, conservations of natural resources and proper monitoring on the consumers and decomposers have a direct influence on the betterment of the manking. Ecological studies of the organisms are very useful in determining the heredity and evolutionary phenomena.

In brief, the scope of ecological studies involves:

1. Determination of population of different niches.
2. Evolution and origin of species as a result of speciation and natural selection.
3. Study of the composition and ecological processes of habitats so as to determine their utlity for the mankind.

4. Monitoring of environmental pollution by testing various ingradients of the biosphere, and
5. Proper maintenance of natural resources,

1.2.2 Basic concepts of Ecology

Like other sciences ecology too has its own principles and basic concepts, which are as follows:

All living organisms and their environment are naturally reactive, effectively each other in various ways. Animal population, flora and vegetatiation are inter dependent through the environment and are mutually reactive. Environment which is actually a complex of several interrelated function and is much dynamic, works as sieve to select organisms.

Sub Divisions

Being a vast and complex subject, the field of ecology can be sub divided in to various ways such as based on taxonomic affinities, habitat, levels of organization etc. However the important subdivisions based on levels of organization are

1) Autecology
2) synecology

1. **Autecology**
   This is also known as ecology of individuals where we study the relation of individual species to its environment. In autecology one studies the factors which influence the growth and life of a particular organisms. With an autecological approach, individual species are the units of study.
2. **Synecology**
   Under natural conditions, however, organisms-plants, animals, microbes, etc. live together as a natural group affecting each other life in several ways. Thus more complex situations exist such an approach where units of study are groups of organisms is called synecological approach dependingupon the conditions syncology may deal with population ;community ecology biome ecology and ecosystem ecology.

1.2.3 Branches of ecology

The specialized disciplines ecology are follows-

1. **Oceanography-**it is the study of marine habitat and organisms
2. **Limnology**- it is the study of physical, chemical, biological and geological characters of freshwater bodies like lakes ;ponds and their organisms;
3. **Terrestrial ecology**- It is the study of biomes and the organisms distributed therein;It can further be differentiated into forest ecology, cropland ecology and grassland ecology
4. **Pedology**- It deals with the study of soils; in particular their acidity; alkalinity, humus-content, mineral contents, soil types etc, and their influence on the plant and animals life
5. **Community ecology**- It the study of distribution of animals in various habitats,
6. **Population ecology-** It includes the study of population its growth competition, means of dispersal etc.
7. **Geographic ecology of Ecogeography-** It includes the study of geographical distribution of organisms.

8. **Ecosystem Ecology-** It is the relation and interaction of both plant and animal communities of organisms.
9. **Animal Ecology-** It is the interpretation of animal behavior under natural conditions.
10. **Cytoecology** – It deals with the cycological details in a species in relation to populations in different environmental conditions.
11. **Palaeoecology**- It deals with the organisms and their environment in geoecological past.
12. **Insect ecology-** It is the ecology of insects.
13. **Mammalian ecology-** Ecology of Mammals.
14. **Avian Ecology-** Ecology of birds.
15. **Production Ecology and ecological energetics-** This branch of ecology deal with the mechanisms and quantity of energy conversion and energy flow through different trophic levels in a food chain and rate of increase in organic weight of the organisms in space andtime.
16. **Applied ecology-** The wild life management, range management forest conservation, biological control, animal husbandry pollution control, are the various aspects dealt within applied ecology
17. **Radiation Ecology-** It deals with the gross effect of radiation of radioactive substances over the environment and living organisms.
18. **Space Ecology** – It is the modern subdivision of ecology it is concerned with the development of thoseecosystem which support life of man during space slight or during extended exploration of extraterrestrial environment.

1.3 Introduction to Biology of Fish and Prawn.

Fish and Prawn save great significance in the life mankind being an important natural source of protein and providing certain other useful products as well as economic sustenance to many nations. The gradual erosion of commercial fish and prawn stocks due to over-exploitation and alteration of the habitat is one reason why the science fish biology came into existence [Royce,1972] .

It is a well known fact that the knowledge on fish biology particularly on morphometry. Length-weight relationship. condition factor, reproduction, food and feeding habit, etc. is of utmost important not only to fill up the lacuna of our present day academic knowledge but also in the utility of the knowledge in increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious pisiculture management. For developing fishery. It is necessary to understand their population dynamics-how fast they grow and reproduce the size and age at which they spawn their mortality rates and its causes, on what they prey upon along with other biological processes.

There are many isolated disciplines in fish and prawn biology, of which the study of morphology is inseparably related to study of the mode of life of the organism. In fact Size and shape are fundamental to the analysis of variation in living organisms. [Grant and Spain, 1977] and morphological variations even in the same species most often related to the varied environmental factors.

Short Answer questions (2 Marks)

1. Define Taxonomy?
2. Define Genus?
3. Define Species?
4. What is **α** (Alfa) and **β** (Beta) Taxonomy?

5. What is Autonym? Give one Example.
6. Who coined the term species?
7. Who is the father of Taxonomy?
8. What is the need classification?
9. Define Ecology?
10. Define Autecology and Synecology?
11. Who coined the term Ecology and its meaning?
12. What is Palaecology?
13. What is population Ecology?
14. Define Biology?
15. Expand ICZN.

Long Answer Questions (6 Marks)

1. Write about the introduction, Importance, Scope and Branches of Ecology?
2. Write about basic concepts of Ecology?

Unit – 2

2. General Character and Classification of Fish and Prawn.

Structure:

2.1. Introduction to fish.
 * General characters, Morphology and classification
2.2. Introduction to Prawn.
 * General characters, Morphology and classification.

1.1 INTRODUCTION TO FISHES:

Fishes are a well defined group of vertebrates. They are the earliest known vertebrates which flourished during the Devonian period, about 400 million years ago. They form a successful group of animals comprising more than 40,000 species inhabiting all seas, rivers, lakes, canals dams, muddy water, brackish water, estuaries and all places where there is water. They differ from each other in shape, size and habits, ranging from less than 1cms to 20 metres. The smallest fish is *Paedocypris progenitica* (6 to 18 mm) and the largest fish is *Rhinodon* (Whild shrk- upto 20meters). A very wide distribution of fishes into a variety of habitats has resulted in numerous adaptations in their morphology, physiology and behavior.

The study of fish is called *'ichthyology'* (derived from Latin word ichthys = a fish, logos = study). Fishery includes the *culture* and *capture* of fish. However, it also includes hydrobiology, limnology, aquaculture, pollution, breeding and conservation, etc. fishery science is taught at many places in the country. Hear we shall apply the term 'fish' to those aquatic animals which have a backbone, breathe throughout life by gills and have fins for locomotion, although 'fish' is a word used very often and very loosely to describe any kind of creature living in water or moist conditions such as *silver fish* and *jelly fish,* etc.

Economically, fishes constitute a very important group of animals and provide a rich source of food, liver oil and a number of other by-products, like fish meal, fish manure, isinglass, etc. Fish biology, therefore, forms an interesting branch of Zoology and has received considerable attention by researchers.

2.1.1 General charcterstics of fishes.

Fishes exhibit the following common characters, most of which are related to their permanently aquatic mode of life.

1. Fishes are **poikilothermic, aqatic** animals, living in freshwater, sea water and brackish water.
2. Body is **streamlined**, neck is absent and laterally compressed
3. Skin contains **multicellular mucous glands**. Their secretions act as a lubricant and prevent friction between water and the body.
4. Exoskeleton consists of **dermal scales** and bony plates.
5. Endoskeleton is composed of bone and/or cartilage. Vertebrae are **amphicoelous** (both anterior and posterior faces of centrum are concave). Ribs are usually present. Sternum is absent. Pectoral and pelvic **girdles** support respective fins.
6. Dorsal, anal (ventral) and caudal fin are median or **unpaired fins.** They assist in stabilizing the body during swimming. Pectoral and pelvic fins are **paired fins.**

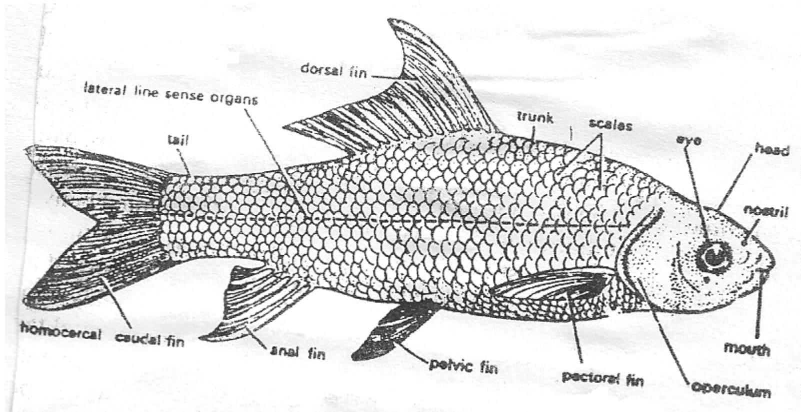
7. **External nostrils** are paired and open into blind nasal sacs. **Internal nares** are present in osteolepids and lung fishes.
8. **Coelom** consists of a small anterior **pericardial cavity** that contains the heart and a large **pleuroperitoneal cavity** that encloses all other viscera except kidneys**.** These two are separated by a **septum transversum.**
9. Dentition is **polyphyodont** (teeth are replaced many times), **homodont (**similar shape), **acrodont** (attached to jaw summit). Some have a **spiral valve** in intestine**.** It increases absorptive surface area.
10. Exchange of respiratory gases is primarily through gills **(branchial respiration).** There are **gill arches** on each side of the head. Gill arches bear fill filaments. The direction of blood flow in gill filaments is opposite to the direction of flow of water through gill-slits. This **countercurrent flow** enhances oxygenation of blood. An **air bladder** or **swim bladder** is often present in bony fishes.
11. Heart is two-chambered, with one atrium and one ventricle. **Sinus venosus** and **conus arterious** are present. Heart is termed **branchial heart** as it pumps blood only to gills. It is also called **venous heart** as only deoxygenated blood passes through it. **Single circulation** occurs. Blood passes only once through heart in one circuit. Aortic arches are four to seven pairs. **Hepatic and renal portal systems** are present. Erythrocytes are nucleated.
12. Functional adult kidneys are generally **mesonephros** pronephros in few teleost species .most fishes possess urinary blader formed by the enlargement of mesonephric duct. Fishes are generally **ammonotelic**.Cartilaginous fishes are **ureotelic**.
13. The brain and the spinal cord are covered by a single meninx, **meninx primtiva.** Cerebral hemispheres are inconspicuous. Cranial nerves are ten pairs**.**
14. **Lateral line organs or neuromast organs** occur in lateral line canals that open at intervals by pores, they act as **rheoreceptors**. Each internal ear has three semicircular canals. Middle ear and external ear are absent. Ears primarily serve as organs of equilibrium.
15. **Sexes are mostly separate. Fertilization** is usually external. Internal fertilization occurs in most cartilaginous and some teleost fishes. Fishes are animates. Development is direct in viviparous forms and indirect in oviparous forms.

2.1.2 Morphology of fish (Eg. *Labeo*)

The body of Labeo is elongated, laterally compressed, shaped tapering at either end. The color of the body is dark gray and the back and sides are pale yellow or while below. The fish grows about a meter and weight ten kilograms. The body is divisible into head, trunk and Tail

Head

The heard is depressed and is produced anteriorly as shout, obtuse, depressed and swollen snout, this makes the mouth sub–terminal instead of terminal. It is large transverse aperture bounded by thick and fleshy lips.



Fi.2.1 External features of Labeo

There is a pair of short, thread like, tapering, sensory processes on the snout. One is on the either side, just above the mouth. These are the maximally barbell. Jaws are without teeth instead, there are three rows of teeth in the pharynx. The paired eyes are large, without eyelids but a transparent membrane covers the cornea. The pupil is rounded. There are town nostrils situated dorsally in front of eyes. They open internally into the olfactory sacs. There is a large, bony flap below and behind each eye. This is the operculum which is also called the gill cover. Between the gill-slits and the operculum lies a spaceous bronchial cavity or opercular chamber, which communicates with the exterior by a single aperture, which is crescent and can be shortened and widened by the branchio-stegal fold that borders the opening. There is no operculum in sharks. The mechanism of breathing and gill structure of rohu is quite different from that of the sharks.

Trunk

It extends from the posterior borders of the operculum to the aperture. It is the thickest part of the body and is compressed laterally on either side of trunk and tail is a lateral line. The trunk is covered by the dermal cycloid scales which are rounded with free edges and spring. They are arranged lengthwise and differ from those of sharks in being true bony, not provided with enamel. The trunk bear five fins including paired and unpaired fins. The fins are supported by bony fin rays. The single dorsal fin is somewhat rhomboidal and is supported by 12-13 jointed bony fin rays. The anal fin, lying just posterior to the anus and has eight fin rays. The caudal fin arises from the hind end of the tail and is deeply forked into two similar lobes. The epicaudal and hypocaudal lobes are roughly equal. It seems that in rohu and other bony fishes with similar homocercal tails. There are nearly nineteen fin rays in the tail fin of rahu. The movement of this fin pushes the fish to move forward. Amongst the paired fins, the pectoral fins are found vertro-laterally behind the operculum. The pectoral fin bears 19 fin rays each. The pelvic fins are found more or less in the middle of the body, lying ventro-laterally, and have nine fin rays each

There are three apertures in the trunk region. These include the anal.urinary and genital apertures. The anal aperture is the posterior opening of alimentary canal and lies on the ventral side just in front of the anal fin. The urinary aperture is present behind the anal aperture. The genital aperture lies between the anal and urinary opening.

Tail

The tail forms about one third of the body. It is laterally compressed and narrower behind. It bears tail fin. The tail makes the principal locomaotory organs. Tail is also covered over by cycloid scales like the trunk.

Fins in Fishes

Fins are broaden appendages present on the body of fishes and are the chief locomotory organs. There are two types of fins, unpaired or median and paired fins. The median fins include a dorsal on the mid axis of the body, an anal on the mid ventral side behind the vent and caudal at the end of the tail. Pectorals and pelvics are the paired fins corresponding to the fore and hind limbs of the terrestrial terapod vertebrates. Fins are supported by skeletal rods called the radials and dermal fin rays. In teleosts the fin rays are branched and jointed bony structures and are known as the lepidotrichia. The fins without fin rays called a dipose fins (eg.Mystus)

Unpaired fins or median fins

Due to the differentiation in a continuous embryonic fin fold the median fins of all fishes will develop. During development a continuous embryonic fold tissue is formed dorsally along the back up to the tip of the tail and is then strength and by a series of cortilagenous road and this condition is seen in lampreys and represents the primitive stage of the median fin. In higher fishes separate dorsal, caudal, and anal fins are formed by the concentration of the redials in certain areas and degeneration of the fold in the intervening spaces, between the fins.

The caudal fin of the fish is a vertically expanded structure, lying at the caudal end of the body. It can be differentiated into a dorsal epichordal lobe and a venral hypochordal lobe. The internal and external architectural design of caudal fin varies, depending upon the swimming habits of the fish. As such several tail types are observed among the actiooptery gains and described by special terms. The nature of the end of spinal column is considered useful in this descriptive grouping.

Protocercal tail

This type of tail is regarded as the most primitive type. The notochord is straight and extends up to the tip of the tail, dividing latter into two equal parts. The fin fold continues with the dorsal and the anal fins to form a continuous fold, unsupported by the fin rays. Such a type of fin is found in cyclostomes and the living lung fishes.

Protoheterocercal

This intermediate tail type is different from above in having separate dorsal, ventral and the caudal fins, which are formed by the interruption of the continuous fold on dorsal, and ventral side of the fish, From this type of tail the heterocercal and diphycercal tails are said to have been derived.

Heterocercal

In heterocercal tail, the notochord bends upwards at its posterior end, so that the dorsal lobe of the tail is almost lacking or represented by a few spines, while the ventral lobe becomes well developed. Such type of tail is mainly found among the elasmobranches.

Diphycercal

A diphycercal tail as found in dipnoans, *Chimera* and Protopterus is very much like the protocercal tails of earlier forms but the palaeontiological and embryological evidences suggest it to be a modified secondary form of heterocercal tail. The notochord is continued straight upto the end of the tail and the fin lobes are disposed symmetrically above and below to it.

Homocercal

A homocercal tail is a modified form of heterocercal tail. The notochord is tured upwards, the dorsal lobe is not apparent in the fin but the ventral lobe is quite well developed. The latter contributes the formation of two equal sized lobes. Ex. Higher bony fishes.

Isocercal

In an isocercal tail, the spine is drawn out into a long and straight rod like structure. The fin fold develops, both, above and below the rod, in the form of the marginal extensions of the tails and remains supported by the fin rays. Such tails are found in some deep sea fishes and in many fresh water teleost fishes.

Gephyrocercal

This type of tail is very much like the isocercal, but the fins are reduced to vestiges. The caudal lobe or peduncle is truncated and the hypurals in the spinal column ae not found. Such fin types are found in Fierasfer and in Orthagoriscus.

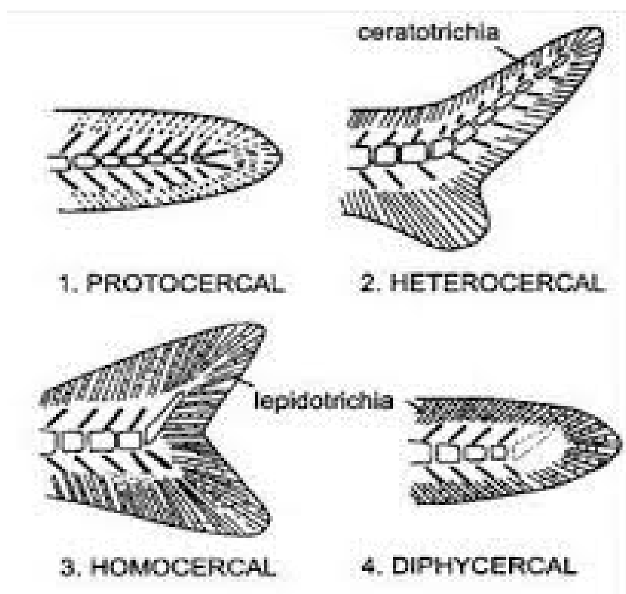


Fig.2.2. various kinds of tails in fishes.

Hypocercal

The hypocercal tail type is derived from the heretocercal type by bending of the hinder end of the notochord downwards. The dorsal lobe thus becomes larger than the vertral lobe which is much reduced.

Paired fins

Paired apprises were not present in the ancestral vertebrates and were developed during the course of early evolution. The supporting endoskeleton of the paired fins varies greatly in different groups of fishes.

Pectoral fins are present behind the gills and horizontal to the ventro lateral portion.

A pair of pelvic fins are present at the ventral side of the body on either side of cloacal aperture. In male sharks a pair of copulatory structures the claspers are present inside the pelvic fins.

2.1.3 Classification of Fishes (Pisces)

Pisces (fishes) is divided into three classes, viz., Placodermi, Chondrichthyes and Osteichthyes.

Class 1. Placoderimi (Gr. placos=plate; derma=skin**)**

This class includes extinct fishes. These are considered ancestors of Chondrichthyes. They originated from ostracoderms during Silurian Period and become extinct in the beginning of Mesozoic era. Some lived in freshwater while others were marine. Body was enclosed in heavy **bony aromur**. It consisted of a bony head and a trunk-shields, both composed of many bones. Paired fins were present. The first pair of gill slits present in front of the hyoid arch is functional. In higher fishes, these slits are modified into nonfunctional spiracles or closed.

e.g., Bothryolepis, Dunkelosteus.

Class 2. Chondrichthyes (Gr.chondros=cartilage; ichthys=fish)

These are commonly called **cartilaginous fishes**. Caudal fin is **heterocercal**. (Two lobes of the caudal fin are unequal externally and internally. Vertebral column extends into upper lobe). Endoskeleton is entirely cartilaginous. Mouth and nostrils are ventral. Intestine has a **spiral valve or scroll valve**. Four to seven pairs of gill-slits are present. Gills are **lamelliform.** Spiracles often occur in front of gill-slits. Gill-slits are anaked, not covered by operculum. Air bladder is absent. In males, the pelvic fins are provided with claspers. Fertilization is internal. Most sharks and all rays are viviparous, with yolk sac placenta for the nourishment of the embryo. Development is direct.

Subclass i. Elasmobranchii

This includes shark, rays and skates. Skin is covered by placoid scales. Digestive tract opens into cloaca. Spiracles may be present. Five to seven pairs of gill-slits are present (e.g. five pairs in Scoliodon, six pairs in Hexanchus and seven pairs in Heptranchus). Operculum is absent.

A. **Sharks**

These usually inhabit open water of the seas. Body is spindle shaped. These are pleurotrematic, with five to seven pairs of lateral gill-slits. Spiracles, when present are small and lie behind the eyes.

Example: *Scolioden sorrakawah* (India digfish), *Rhinodon typus* (whale shark)

Sphyurna zygaena (Hammer-headed shark), Stegostoma (tiger shark or zebra shark)

B. **Rays and skates**

These are bottom-dwellers. Body is dorsoventrally flattened. These are hypotrematic, with five pairs of ventral gill-slits. Spiracles are always present, large and dorsal.

Example: *Myliobatis* (eagle ray or sea vampire)
Torpedo (electric ray, dorsal muscles are modified into electric organs)
Trigon (string ray)
Rhinobatis (guitar fish or banjo ray)
Pristiis (saw fish)
Raja (skate)

Subclass ii. Holocephali or Bradyodonti

Skin is scaleless in adult. Cloaca is absent. Spiracles are absent. Only four pairs of gills are present. Gills slits are covered by operculum.

Example: *Chimaera* (rat-fish)
Hydrolagus (rabbit-fish)
Callorhynchus (elephant-fish).

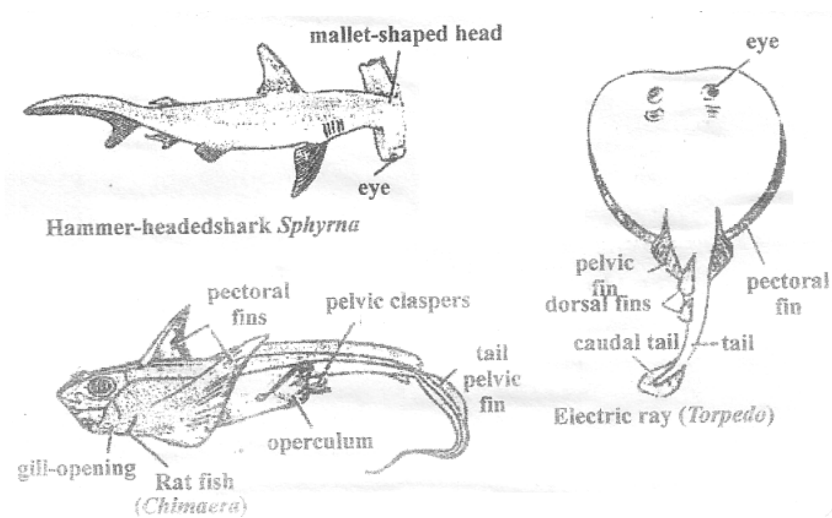


Fig.2.3 Cartilaginous Fishes

Class 3. Osteichthyes (Gr.osteon=bone; ichtys=fish)

These are commonly called bony fishes. Caudal fin is generally diphyceral or homocercal. Scales are ganoid, cycloid or ctenoid. Endoskeleton is bony. Mouth is usually terminal. Alimentary canal opens out by anus.

Subclass i Acanthodii (Gr.acanthus=spine)

These are the oldest known gnathostomes. They became extinct in Permian period. They were small fishes covered by ganoid scales. Fins were supported by large spines. They had a series of lateral fins Tail fin was heterocercal.

Examples*: Climatius*, *Diplacanthus.*

Subclass ii.Sarcopterygii (Gr. Sarkos=flesh)

These are Lob-finned fishes. Paired fins have a fleshy lobe containing jointed skeleton and muscles. Caudal fin is diphycercal (divided into similar halves both externally and internally). Internal nares are present (hence the name **Choanichthyes).** Instestine has a spiral valve. This subclass is classified into two orders, *viz.,* Crosspoterygii and Dipnoi.

Order A. Crossopterygii (Gr.crossoi = fringe; pteryx = fin)

This includes **rhipidistians** (e.g. Osteolepis, Eushenopteron) and coelacanths. Internal nares were present in rhipidistians, absent in coelacanths. Scales are **cosmoid.** Paired fins are lobed. Median fins are separate. Spiracles are present. Air bladder is reduced and acts as a hydrostatic orga. They appeared Ist Devonian Period and were thought to have become extinct in Cretaceous Period. Only one coelacanth genus, *Latimeria* is extant. A living marine specimen was caught in 1938 off the East coast of South Africa. It was steel-blue, about 1.5m long. It has characteristic three-lobed diphycercal tail. It is viviparous. It is described as **living fossil** as it has been persisting since Jurassic time with very little evolutionary change.

Examples: *Latimeria chalumnae, Latimeria menadoensis*

Order B. Dipnoi (Gr.di = twice; pnoe = breath)

These are commonly called **lung fishes.** Exoskeleton consists of cycloid scales. Dorsal and ventral fin are confluent with caudal fin. Spiracles are absent. Internal nares are present. Air bladder forms one *(Neoceratodus*) or two (*Protopterus, Lepidosired*) lungs. There are only three living genera. They exhibit **discontinuous distribution**. Romer described them as **uncles of Amphibians.** Examples: *Neocerotodus* (Burnett and Mary rivers in Queensland of Australia)

Protopterus (rivers of tropical Africa) *Lepidosiren* (rivers of tropical South America)

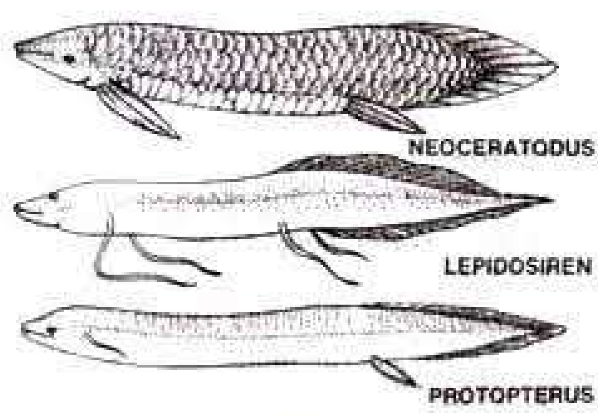


Fig: 2.4 Lung Fishes

Subclass iii. Actinopteryingii (Gr.actics=rays; pteryx=fin)

These are commonly called **ray-finned fishes**. Paired fins lack fleshy lobe and are supported by dermal rays. Caudal fin is generally **homocercal** (two lobesw of caudal fin are equal externally and unequal internally. Vertebral column extends into the upper lobe). Internal nares are absent. Air bladder serves as hydrostatic organ. This Subclass is classified into three Infraclasses: 1. Chondrostei, 2.Holostei and 3.Teleostei.

Infraclass A. Chondrostei (Gr.actis=rays; pteryx=fin):

This includes **primitive** ray-finned fishes. They inhabit freshwater. Skeleton is mostly cartilaginous. Scales are usually **ganoid**. Mouth is large. Caudal fin is **heterocercal** (diphycercal in bichir). Spriacles are present. Air bladder functions as a lung and is connected to pharynx. Intestine has spiral valve.

Example: polypterus (bichir), Acipencer (sturgeon).

Infraclass B. Holostei (Gr.holos= whole; osteon= bone)

This includes **intermediate** ray-finned fishes. They also inhabit freshwater. Skeleton is moderately ossified. Scales are **ganiod** or cycloid. Mouth is smaller than that of Chondroseti. Chudal fin is **abbreviated heteroercal,** slightly upturned. Sparicles are absent. Air bladder mainly hydrostatic and is connected to pharynx. Intestine has a vestigial spiral valve.

Example: Amia (bowfin), Lepidosteus (garpike).

Intraclass c. Teleostei (Gr.telos = end; osteon = bone)**:** It includes advanced ray-finned fishes. These are modern fishes and from the greater part of the world's fish fauna. They inhabit all the types of aquatic habitas. Scales are cycloid or ctenoid. Mouth is small Caudal fin is homocercal. Spiracles are absent. Air bladder is usually not connected to pharynx. Intestine lacks spiral valve.

Example: Exocoetus (flying fish), Hippocampus (sea horse, male has a brood pouch), Echeneis (sucker fish, ectocommensal on sharks, first dorsal fin is modified into sucker), Anguilla (eel; exhibits catadromous migration (Migrates from freshwater to sea for breeding).

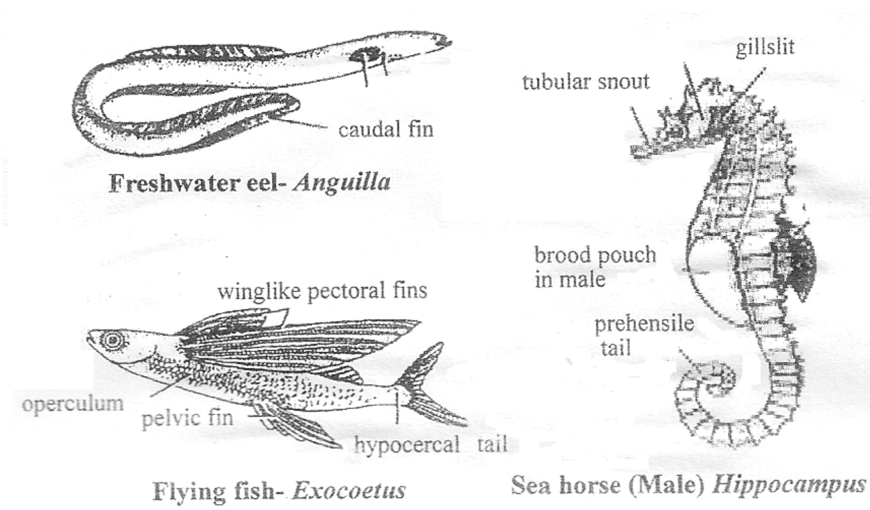


Fig.2.5 Teleost fishes

Toleosts probably arose in the middle or late Triassic or and they are the most species-rich and diversified group of all vertebrales. There are about 23,637 extant species. 96% of all extinct fishes. Plased in 38 order, 426 familes and 4,064 genera.

2.1.4 Meristic Characters and measurements, Meristic Counts

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

Body Measurements

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

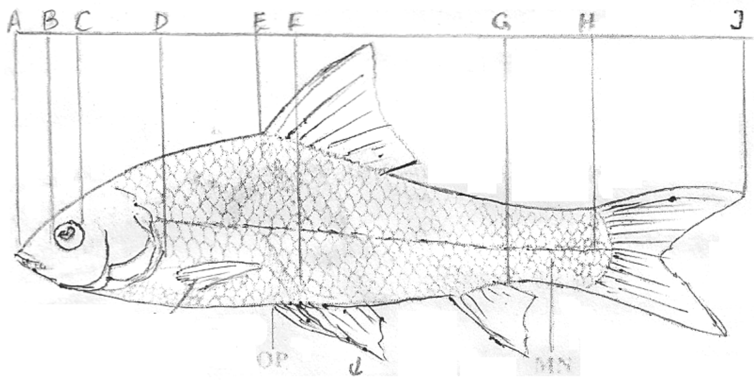


Fig: 2.6 Fish measurements

1. Total length (A-J): It is measured from tip of the snout to end of caudal fin.
2. Standard length (A-H): It is measured from tip of the snout to base of the caudal fin.
3. Head length (A-D): It is measured from tip of the snout to end of operculum.
4. Snout length (A-B): It is measured from tip of the snout to the anterior margin of the eye.
5. Predorsal length (A-E): It is the distance between tip of the snout to origin of the dorsal fin.
6. Pre pectoral length (A-D): It is the distance between tip of the snout to origin of pectoral fin.
7. Pre pelvic length (A-F): It is the distance between tip off the snout to origin of pelvic fin.
8. Pre anal length (A-G): It is the distance between tip of the snout to origin of anal fin.
9. Length of caudal peduncle (G-H): It is the distance measured from the posterior base of the anal fin up to origin of caudal fin.
10. Height of the caudal peduncle: It is measured vertically through the body at caudal peduncles narrowest part.
11. Height of the body: It is measured vertically through the body at its deepest part.
12. Diameter of Eye (BC): It is measured from one margin of the orbit to other.
13. Inter orbital length: It is distance between two orbits on dorsal surface.
14. Fin measurements: The length of pectoral fin, pelvic and caudal fin is measured long their longest fin ray.
15. Profile of the body: It gives the outline of the body of fish, along its dorsal and ventral surfaces.
16. Barbles: The number of barbles ranges from 1-4 pairs. These are named according to their position as nasal, rostral, maxillary and mandibular.

17. Branchiostegal rays: These are slender bony rods found on inner surface of operculum.
18. Lateral line (L.I): This line is found on both the lateral sides of the body. It is a longitudinal row of perforations of sense organs. It may be complete, incomplete or interrupted.
19. Scales: The scales are supposed to be identifying card of fish. These are also useful in identification of fish up to species level. The scales are counted along the lateral line and their number is written after the abbreviation as L.l. In case the lateral line is absent, the scales are counted along the row where the lateral line might has been located and their number is written after the abbreviation as L.r. the transverse rows of scales are counted from the anterior base of dorsal fin to the ventral line and their number is mentioned after the abbreviation as L.tr. In this case the scales above and below the lateral line are separated by an oblique (/) stroke. Pre dorsal scales are counted from anterior extremity to the orgin of dorsal fin.
20. Fin formula: Fin formula is constructed after counting the fin rays of pectoral(P), Pelvic(V), Dorsal(D), ANAL(A) and caudal(C) fins and lateral line scales. This formula provides scientific information to con firm the acual identity of a particular fish. The number after the abbreviation of fin denotes number of fin rays. An oblique (/) stroke indicates the spiny and soft rays of fin. The vertical stroke indicates the separation of two fins, ex rayed dorsal fins.

2.2 General Characteristics and classification of fish and prawn.

It is very important that understand about general characters and classification of phylum Arthropoda organisms before the study of taxonomy and anatomy of prawn, because the species prawn is belongings to the order decapoda of class crustacean in phylum Arthropod. So it is very important to understand about the general characters classification of phylum Arthropod.

2.2.1 General characters of phylum Arthropoda.

Phylum Arthoropoda is the largest phylum in the animals kingdom. It comprise of approximately 80% of all known animals. Arthropods live in all types of habitats. They have adoptive radiation.

The following are the general characters of this phylum.

1. This is the **largest phylum** of the kingdom: Animals, and it includes the **largest class** called **Insecta**. Over two-third of all named species on earth are arthropods accounting for 80% of the animal species,
2. They are bilaterally symmetrical, tripoblastic, metamerically segmented and coelomate (**schizocoelomate)** animals.
3. The body of arthropods is covered by a chitinous exoskeleton as a protection and to prevent loss of water and it is periodically shed off by a process called moulting or **ecdysis** to allow growth of the body.
4. This is segmented and consists of head, thorax and abdomen. They have jointed appendages (arthros: joint ; podium : foot).

5. Muscles are striated and aid in rapid locomotion.
6. Striated muscles appeared for the first time in evolution, in the arthropods.
7. Coelom is reduced to the spaces around escretory and genital organs.
8. Body cavity is a haemocoel, it is not a true coelom but derived from mostly the mbryonic blastocoels.
9. Respiratory organs are gills, book gills, book lungs or tracheae.
10. Circulatory system is of open type. Heart is dorsal in position.
11. In some (crustaceans and chelecerates) the haemolymph contains a ‘copper’ containing respiratory pigment called ‘haemocyanin’ dissolved in the haemolumph.
12. Nervous system is of annelidantype consisting of a nerve ring (around oesophagus) and a double ventral nerve cord.
13. Sensory organs like antennae, eyes (compound and simple), statocysts (organs of balance /equilibrium) are present.
14. Excretion takes place through **malpighian tubules, green glands coxal glands** etc.
15. They are mostly dioecious (unisexual / gonochoric). Fertilization is usually internal. They are mostly oviparous.
16. Development may be direct or indirect. Life history includes one to many larval stages followed by metamorphosis.

Examples: Periplaneta, Palaemon, Cancer, Palamaeus, Aranea; **Econonucally**

2.2.2 Classification of phylum Arthrophoda.

Phylum Arthrophoda is classified into three sub phylumes.

1. **Sub phyla: Prilobita**: These are extent marine froms of arthropods. Ex: *Triarthrus, Dalmanites*.
2. **Sub phyla: Chelicerata:** These subphyla is classified into two classes.

a. **Class:- Xiphosura:** It includes the a large number of extinct lineages and only four extant species in the family limulide :ex: *Limmulus.*

b. **Class:- Arochnida:** All archning have eight legs, although the front pair of legs in some species has converted to sensory organs ex: *spider, scorpion, link, mites*.

3. **Sub-phyla – Mandibulata**: This sub phyla is classified into four classes.

a. Classes –Crustacea:

1. The species of the class Crustacea are the major group of aquatic arthropods. They are predominanlty marine, but there are fresh water species. A few have been invaded into the terrestrial habitat.
2. Crustaceas are unique among arthropodas in having two pairs of antennae. The other characteristic appendages are a pair of mandibles and two pairs of maxillae.
3. The appendages in Crustacea are typically biramous.
4. Gills except very small species are present. They are associated with the appendages. The number, location and shape of these gills very greatly in different crustacean species.
5. Excretory organs are a pair of the green glands. These open at the base of the second antennae or the second pair of maxillae.

6. The sense organs in crustacean include a pair of compound eyes and a small media dorsal nauplius eye. The nauplius eye is characteristic of many crustacean larvae, but does not persist in the adult of many groups.
7. Copulation is typical in several crustaceans, Egg brooding is very common. In the larval history, the first stge to be seen ***nauplius larva.***

Examples: Streptocephalus, Daphnia, Mysis, Palaemom, etc.

Order- Decopoda:

Decopoda is an order of crustaceans with in the class malacostraca, (Greek.deca. ‘ten’, pad-foot) including many familiar groups, such as crayfish, crabs, lobsters, prawns and shrimp most decapods are scavengers, the order is estimated to contain nearly. 15.000 species in around 2,700 genera with around 3,300 fossil. Nearly half of these species are crabs, with the shrimp at about 3000 species and Anomura including hermit crabs, porcelain, crabs, squat lobsters at about 2500 species making up the bulk of the remainder.

Characters of Decapoda:

1. 8 pairs of thoracic appendages,
2. 5 pairs of appendages are consider as the 10 legs (pereiopods), hence the name decapoda.
3. Front 3 pairs of appendages function as mouthparts (Maxillipods).
4. 1 pair of legs (chelipods) are enlarged pincers (clows called chelae)
5. Other appendages located on abdomen where each segment is capable of carrying biramous pleopods.
6. last pleopods from part of the tail fan, and together with the telson are called uropods.
7. Classification depends on structure of gills and legs and larval development.

c. **Class –Chilopoda.** It includes centripedes. They are terrestrial, air – breathing, carnivorous animals each segment of the trunk bears a pair of clawed appendages. First pair of trunk appendages bears poison claws.

Ex: Scolopendra, scutigera.

c. Class Diplopa: Insecta includes millipods . They are terrestrial, air – breathing animals, fetching on decaying plant material. Each trunk segment bears two pairs of logs. Ex: julus, spirostreptus.

d. **Class -Insecta:** Insecta includes the most successful and the largest group of animals on the earth. This class is also referred as hexopda.

Ex: cochroach, housefly, mosquito, silk worm, lac insect etc.

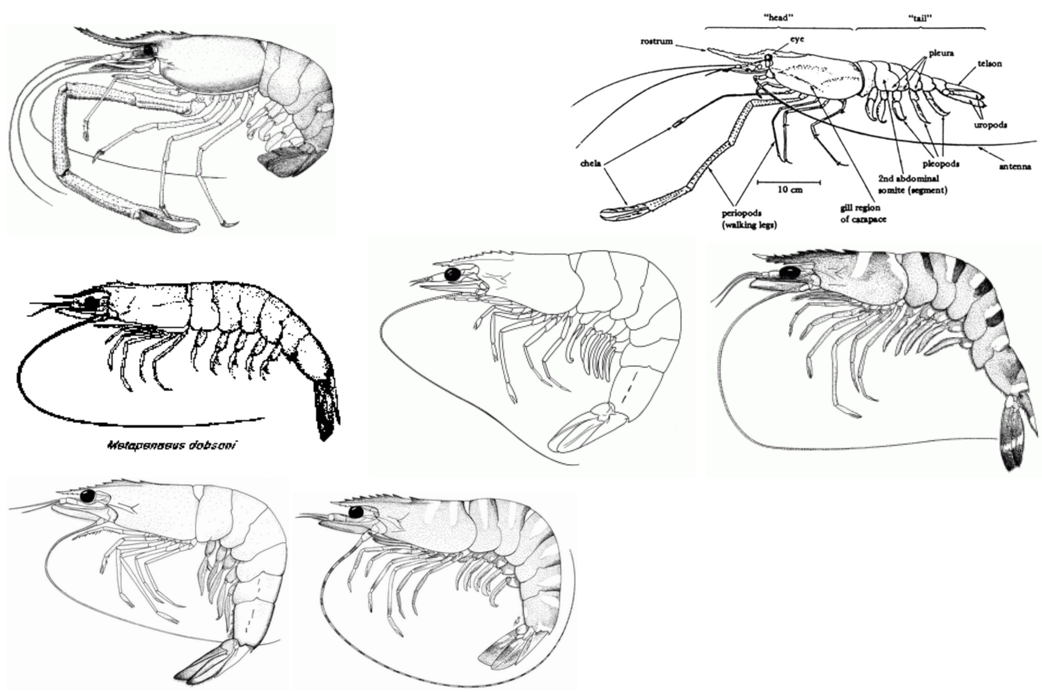


Fig. 2.7: 1 M. rosenbergii, 2. M. molcolmsonii, 3. Metapinious dabsonii, 4. Penaeus monodon, 5. P. indicus, 6. P. semisulkatus and 7.venamia

Key to the identification of different generai of family penaeudae

- Rostrum tooth are well developed
- Carapace without postorbital spine and with a shout cervical well below dorsal midline.
- Last two pairs of pereopods well developed.
- Third two pairs of pereopods well developed.
- Endopods of second pair if pleopods in males bearind appendix masaulina only (lacking of appendix interna and muscular projection)
- Sast three pleurae are keeled dorsally
- Telson sharply pointed.

Pananeustae

Capapace with lateral keels cutting portion of mandibles. Capapace with lateral keels

Elongate. Sickle shaped pelagic sharip. Outing portion

Of mandible short and massive.

Funchalia

Rostrum toothed on dorsal as well Rostrum toothed on dorsal as

As on ventral margin. Dorsal margin only.

Telson tridentate . with a fixed spine on each side of tip. Telson usually without fixed spines. No spin

Rostrum shorter thenthe eyes no spine on inned border on inner border of 1st article of antennular pendyncleRostrum longer thanthe eyes inne border of 1st of antennular penduncle bearing a sp*ine.*

Trachypenaeopsts

Carapace with lagitudinal and transverse sutures.	Carapae without longitudinal and transverse
Males with symmetrical petasma. A single	structure . Males with asymmetrical lpetasma.
Arthobranch on last thoracia segment . no	1 arthrobranchspresent on last therastic segment
Trace of a second arthobranch	one of then welldeveloped the other vestigial.
Penaeopsis.	*Melapenaeopsis*

2.2.4: General characters of prawns

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

1. Prawns are fresh water and animals eg. *Macrobrachium resenbergii* and *M. molcolmsonii* Shrimps are found in both sea and brackishwater eg. *Penaeus monodom , P. indicus* and *Metpenaeus dobsoni*
2. **Symmetry :** These are bilaterally symmetrical .
3. **Coelome :** There are eucoelomates and snhizcoelic animals . The coelome is known as haemocoel due to the presence of blood in the coelome.
4. These are triploblastic animals.
5. **Segmentation** : Segamentation is heteronomous and external.
6. **Shape** : Body is elongated , more or less spindle shaped. Abdomen region is in cama (,) shaped.
7. **Size :** The size of adults varies from species to species. The largest prawn (32cm) is gainst freshwater prawn i.e *Macrobrachium rosernberingii.* Largest shrimp is *penaeus monodon.*
8. **Body farm** : The body is divided into cephalothrax and abdomen Cephalothrax is the fusion of head and thorax and consists of 13 segments. Abdomen consists of 6 segments.
9. **Exoskeleton**: Body is covered by a hard protective calcareous plates, known as sclerites. Sclerites are made up of chitinous cuticle. Adjacent sclerites are connected by thin arthoidal membrane, making the movements feasible.
10. **Rostrum :** The sclerites of dorsal (terga) and lateral (pleura) form a laterally compressed and serrated rostrum . The separations of rostrum are called denticles,

which play a major role in indentificatio of species. The denticles are found both dorsally and ventrally as in Penaeus – sp or only dorsally as in Metapenaeus sp.

11. **Appendages :** Each prawn has 19 pairs of jointed appendages, each pair attached to a segment cephalic region consists of 5 pairs of appendages. Thorax consists of 8 pairs and abdomen consists of 6 pairs of appendages. The cephalic appendages are antennules, antenna, mandible, maxillulae and maxilla. The thoracic appendages are 3 pairs of maxillegapedes or foot-jaws and 5 pairs of periopods or walking legs. The abdominal appendages are 5 pairs of pleopods or swimmerets and pair of uropods, all useful for swimming. All the appendags are biramus and each appendages is with common base or protopodite, bearing 2 rami or branches, an inner endopodite and out exopodite, Both the rami comprise of many segments or podomeres.
12. **Telson :** Last abdominal segment consists of elongated sharp spine known as telson.
13. **Integument :** The intergument consists of outer epicuticle, inner endocuticle, epidermis and dermis composed of connective tissue layer with muscle strands and many tegumental glands.
14. **Endoskeleton :** It is absent in prawns.
15. **Digestive system :** Complete alimentary canal, mouth is large and slit-like, stomach is thin-walled and double-chambered, consisting of cardiac and pyloric stomachs. Intestine is a long and narrow tube. Hepatopancrease is a large, bilobed and produce digestive ebzymes. Prawns are deteritivores, feed on debris of bottom, phyto-and zooplankton. Intercellular digestion.
16. **Respiratory system :** Branchial respiration by giils. Respiratory system is well developed and consists of 8 pairs of gills. 3 pairs of epipoodites and lining of branchiosegites or balars are useful for pumping of water into gill chamber.
17. **Blood vascular system :** Open or lacunar type of blood vascular system. Blood capillaries are absent and blood flows through the lacunae or sinuses. Heart is neurogenic muscular and triangular in shape. Blood is colourless with leucocytes and without erythrocytes. The respiratory pigment is haemocyanin. Prawn blood has remarkable clotting properties.
18. **Excretory system :** The excretory organs are antennary or green glands, renal or nephroperitoneal sac and integument. Prawns are ammonotlic animals.
19. **Nervous system :** Brain is in the form of supra-oesophageal ganiglia. Ventral thoracic mass is found in cephalothorax and a ventral nerve cord is found, sympathetic system is in the form of ganglia and nerves.
20. **Sense organs :** Compound eyes, statocysts, tangoreceptors, chemoreceptors and proprioreceptors are sense organs found in prawns. Eyes are located in ommatophore. Mosaic vision and apposition image are found in prawns.
21. **Endocrine system** : The sinus gland of eye stalk produce growth or moulting inhibitory hormone.
22. **Reproductive system :** Prawns are dioecious and sexual produce dimorphism is well marked. Males are bigger than females. Second chelate legs of males are longer, stronger, stouter and more spiny than in female. Second pleopods of males bears appendix masculine. Gonads are paired. Fertilization is external. The fertilized eggs are placed in thelycum and prawn with fertilized eggs are known as berried prawn. Indirect development, first larval farm is naupleus, second larval form is protozoa, third larval farm is mysis, with developed into post larvae.

23. **Moulting:** Prawns undergo the moulting or ecdysis. During this process, the growth of prawn takesplace.
24. **Migration:** Prawn exhibit breading and feeding migration. Freshwater prawns exhibit breeding migration from freshwater to brackish water. Marine shrimps exhibit feeding migration.

2.2.5 Morphology of prawn

Shape, size and colouration

Body is elongated. More or less spindle - shaped and bilaterally symmetrical. It offers least resistance in swimming. Size of adult varies from species to species. *Macrobranchium malco*msonii. Found in Central India and Tamil Nadu. Measures 25 to 40cm in length. The giant prawn p. mcarcinus from Kerala is upto 90cm long. While the dwarf prawn *P. lamarrei* found almost throughout India, is 25 to 5 cm long. Young stages are translucent and white, but the adults are different tinted according to the species. Usual colour is dull pale-blue or greenish with brown orange-red patches. Preserved specimens become deep orange-red.

Segmentation and divisions.

Body Is of adult prawn is distincty divided into 19 segments or somites all bearing jointed appendages are arranged into two main region an anterior cephalothorax (fused head-thorax) and a posterior abdomen.

Cephalothorax

Cephalothorax is large, rigid, unjointed and more of less cylindercal in shape. It consists of 13 segments. The joints between segments are odliterated. Cephalothorax is formed by the union of two regions: (i) head and (ii) abdomen. Head consists of 5 segments. While thorax includes 8 segments all bearing jointed appendages.

Abdomen

Well –developed abdomen is jointed, unlike cephalothorax. It is composed of 6 distinct movable segments, and a terminal conical piece, the tall – plate or telson. Which is not considered a segments because of post-segmental origin. Abdomen segments are dorsally rounded, laterally compressed and normally bent under the cephalothorax. So that the normally bent under the cephalothorax. So that the animals looks like a comma(,) in shape. The abdomen looks almost circular in a cross section. Each abdominal segment carries a pair of jointed appendages Called plepods or swimmerets.

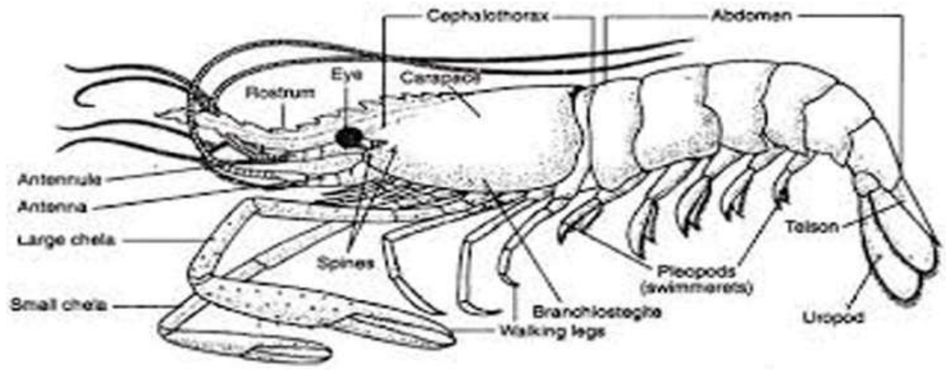


Fig.2.8 *External* features of prawn

External apertures

The slit-like mouth opens mids-ventrally at the anterior end of cephalothorax. Anus is a longitudinal aperture lying vertrally at the base of telson. Paired renal apertures open on raised papillae on the inner surface of coxae of antenne. Paired female genital appertures in female open on the inner surface of coxa of the third pair of walking legs. Paired male gential apertures in the male are situated on the inner surface of coxae of the fifth pair of walking legs. There are two minute openings of statorysts. One lying in a deep depression dorsally on the basal segment (precoxa) of each antennules.

Exoskeleton

Body and appendages are covered by a hard protective calcareous shell or exoskeleton. It is composed of chitinous cuticle which become variously tinted by the depotion of lime salts and sclerotin. The exoskeleton comprises several hardened plates. Called sclerites. Adjacent sclerites are connected by thin, soft and uncalcified cuticle or the arthridial membranes. Making the movements feasible.

Cephalothoracic sclerites

All thye sclerites of dorsl and lateral sides of cephalothorax unite to form a single large and continuous dorsal shield. The anterior and somewhat triangular region of dorsal shield is termed dorsal plate. It extends forward over the head as a laterally compressed and seated vertical process, called rostrum. At the base of rostrum, on either side, is an orbital notch. Which accommodates a stalked, jointed and movable compound eye. Just behind below each orbital notch are two spine– like outgrowths, the anterior antennal spine and the posterior hepatic spine. The posterior region of dorsal shied is termed carapace. On either side of thorax, it hangs down freely as branchiostegite or gill-cover.

Abdominal sclerites

The sclerite of each abdominal segment is separate, ring – like and particulates with the adjacent sclerites by thin, flexible and uncalcfied athrodial membranes providing movable joint . In each abdominal sclerite, its dorsal broad plate is called as tergum, the ventral narrow transverse bar-like plate as sternum, and the two lateral flap-like plate as pleura. An appendage is connected with the pleuron of its side by a small plate the epimeron.

Tergum and pleura of an abdominal segment slightly cover the corresponding parts of the succeeding segment. The overlapping is known as the imbricate arrangement of terga and pleura. However, the pleura of second abdominal segment are much developed and overlap the pleura both the first and third segments, thus disturbing the imbricate arrangement Pleura of sixth abdominal segment are greatly reduced.

Two adjacent abdominal segments articulate with each other by means of a pair of hinge joints, one on either side. A hinge joint consists of a small and peg, fitting into a socket on the succeeding segment. However, the hinge joints are lacking between the third and fourth segments. Abdominal segments can move upon each other only in a vertical plane due to presence of arthoropodial membranes and hinge.

Short Answer questions (2 Marks)

1. Define ‘Ichthyology?
2. Define Fish?
3. Name the ‘Golden age of fishes?
4. Name the smallest and largest fishes?
5. Name the paired fines in fishes?
6. Name the unpaired fines in fishes?
7. Why should fish heart called as ‘venous heart’?
8. What type of kidneys are present in fishes?
9. What is Lateral line and use of it?
10. Give any two examples for extant fishes?
11. Name the largest phylum is kingdom animally?
12. Name the scientific names of any two fresh water prawns?
13. Name the scientific names of any two marine water prawns?
14. What are excretory organs present in prawns?
15. What is moulting and its use in prawn?

Long Answer Questions (6 Marks)

1. Describe the general characters of fishes?
2. Write about the Classification of fishes?
3. Write about the morphology of fish?
4. Write about the general characters of prawns?
5. Write about the order decapods?

Unit - 3

Ecosystem and Limnology.

Structure

3.1 Introduction to Ecosystem and Limnology

Ecology embraces an inter relationships of organisms with the environment. The organisms and environments in a single location constitute *ecosystem* (Tansley, 1935). Ecological system or ecosystem comprises specific unit of all the organisms occupying a given area thereby producing distinct tropic structure, biotic diversity and material cycles. The term ecosystem was first of all coined by A.G. Tansley (1935) and defined it as an "integrated system resulted from interaction of living and non-living factors of the environment". As the term *ecosystem* indicates *'eco'* meaning environmental and "system" implying an interacting inter-dependent complex. Thus ecosystem may be defined as any unit which includes all the organisms (i.e., communities) in a given area, which interacts with the physical environment resulting in the flow of energy and biotic diversity as well as material cycle. Ecosystem is the basic functional unit of ecology embracing biotic communities and abiotic environment both influencing each other. Every ecosystem encompasses interacting organisms that transform and transmit energy and chemicals.

Ecosphere (Biosphere): All the habitable zones on the earth constitute the ecosphere or biosphere. It is the part of the earth that supports 'life'. It extends several kilometers above the earth's surface into the atmosphere and extends several kilometers below the ocean's surface. The biosphere comprises all of the earth's biomes. A 'biome' is a large community of plants that occupies a vast region on earth. Ex" terrestrial biomes and aquatic biomes (freshwater and marine biomes)

Concept of ecosystem: The term ecosystem was first coined by A.G. Tansely in 1935 and it was derived from two Greek words 'eco' and the 'system' where eco mean interaction or independent. According to A.G. Tansely ecosystem is the system resulting from the integration of abiotic and biotic components of an environment. The ecosystem is organized by two aspects. They are Structural and Functional aspect.

Structural aspect:

The structure of the ecosystem is composed of two main components i.e., biotic and abiotic which are interacting together. Abiotic components include inorganic compounds like gases, water, minerals etc., The biotic factors include all the living organism living in an environment. Eg; producers, consumers, decomposers.

Functional aspect:

The functional aspect of the ecosystem is composed of flow of energy and cycling of nutritious which makes ecosystem stable and continues lifecycle.

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

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

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

Ecosystems are also classified into terrestrial and aquatic ecosystems.
Aquatic ecosystem which operates in the aquatic medium is called the aquatic ecosystem.
(i) Fresh water ecosystem
(ii) Marine water ecosystem and
(iii) Estuarine water ecosystem.

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

Limnology is a branch of science, which deals with the study of fresh water ecosystems of all kinds ranging from lakes, reservoirs, streams, ponds, marshes, bogs, etc - physically, chemically and biologically. (FA Forel's Lelemane - 1888 to 1909- Father of Limnology), which was defined as "an ecosystem". In general, lakes vary in altitude, size and depths but each lake constituted as a "closed system". The largest lake in the world is lake Tanganyika in Africa and the Woolar and the Bhopal lakes are considered to be the smallest ones.

3.2 Types of Aquatic Ecosystem and Biotic and Abiotic Components

Pond Ecosystem:

A pond as a whole serves a good example of a freshwater ecosystem. A pond indeed exhibits a self-sufficient, self-regulating system. This would become clear if you examine a bottle full of pond water or a scoop full of bottom mud, which shall show the living organisms (plants as well as animals) and a mixture of inorganic and organic compounds. Some larger forms of life are also present in pond. Thus, whole system becomes much complex indeed. However, we may study the pond as an ecosystem by making its convenient division in some basic components, as shown in Figure 3.1 These components are as follows.

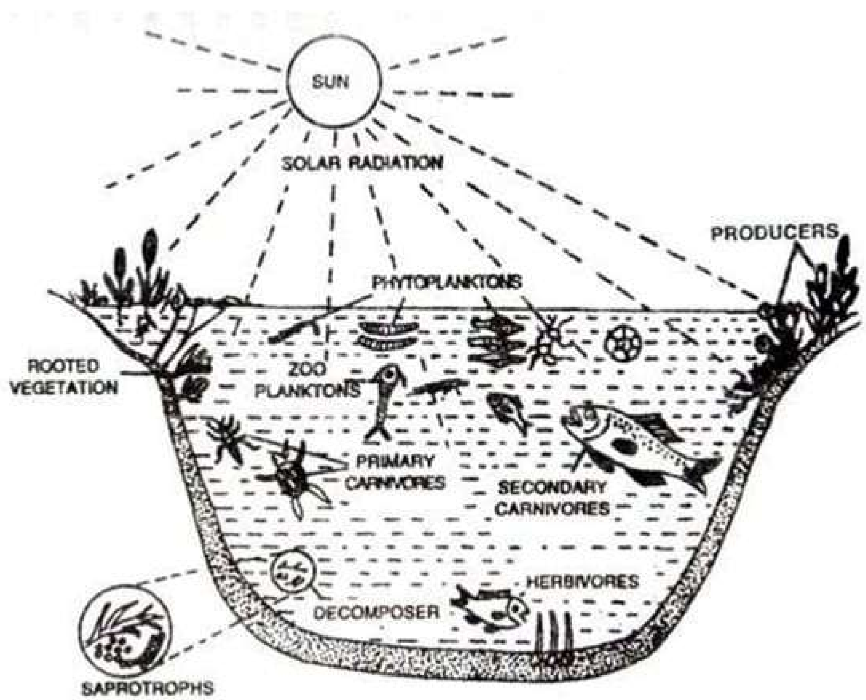


Fig 3.1: Pond Ecosystem

Abiotic Components

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

Biotic Components

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

I. Producers

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

a. Macrophytes

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

b. Phytoplanktons

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

II. Consumers

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

a. Primary consumers (herbivores)

Also known as primary macroconsumers, these are herbivores feeding directly on living plants (producers) or plant remains. These may be large as well as minute in size. The herbivores are further differentiated as:

I. **Benthos**: These are the animals associated with living plants (producers), those bottom forms which feed upon the plant remains lying at the bottom of pond. These are known as detritivores, labeled as 'b' inthe diagram. Benthic populations include fish, insect larvae, beetles, mites, mollusks, crustaceans etc. weight of benthic fauna is estimated in different zones of the pond, and the biomass expressed as g/m2 of water.

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

b. Secondary consumer (carnivores)

They are the carnivores which feed on the primary consumers (herbivores). These are chiefly insects and fish. Most insects as water beetles feed on zooplanktons.

c. Tertiary consumers (carnivores)

There are some large fish as game fish that feed on the smaller fish, and thus become the tertiary consumers.

d. Decomposers

They are also known as micro consumers, since they absorb only a fraction of the decomposed organic matter. They bring about the decomposition of complex dead organic matter of both-producers (plants) as well as the macroconsumers (animals) to simple forms, Thus they play an important role in the return of mineral elements again to the medium of the pond. *Rhizopus, Penicillium, Thielavia, Alternaria, Trichoderma Circinella, Fusarium, Curvu1aria, Paecilomyces, Saprolegnia* etc. are most common decomposers in water and mud of the pond.

Reservoir Ecosystem

River water is usually running or flowing water. Construction of dam turns the section of the river immediately behind it into a lake, called reservoir or dam-lake, in which the lotic water of the upper reaches becomes lentic as water approaches the dam. (Fig. 3.8). Reservoir ecology is thus changed from the usual riverine ecology to lacustrine ecology with passage of time. A reservoir, however, has its own special features in which it differs from natural lakes. But, unlike in natural lakes, the time for which 'cater is retained is relatively very short, and, since the water outflow may take place from deep water also, the hypolimnion is removed in temperate reservoirs. In reservoirs, in contrast to condition in lakes, water level is subject to great fluctuation. The dam in some way interferes with the ecology of the upper reaches of the river. Migratory fishes are completely wiped out from the upper reaches. This often leads to disturbances in the ecosystem especially with advantage to the prey (in the absence of its predator - the migratory fish).

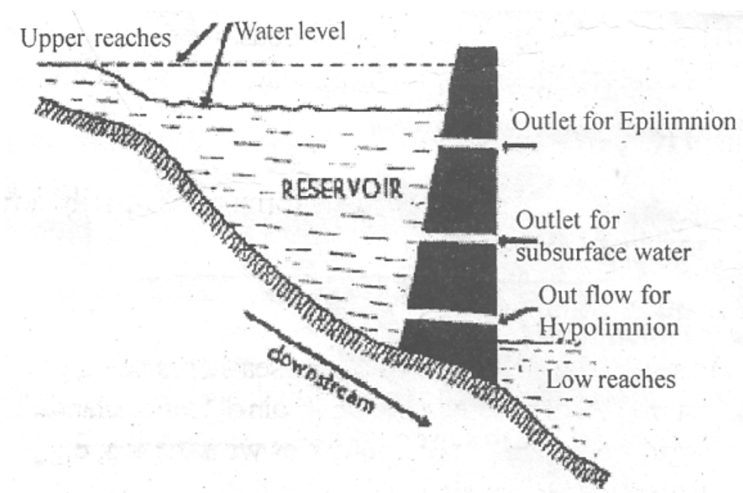


Fig: 3.2 Ecology of Reservoir

The reservoir itself may affect the ecology of the lower reaches of the river. Periodical discharge of sediments from the reservoirs may cause mud and silting in the lower reaches with serious consequences on the fauna. However, plankton is increased in the lower reached due to drift from the reservoir, and turbidity is reduced. Reservoir act as fertility trap reducing the amount of dissolved plant nutrients which would otherwise be freely arriving at the lower reaches. However the tail - water released from the outlet often supports extensive fisheries in the stream below. If the discharge is from the hypolimnion, an excellent sport fishing for angling occurs for cold water species (trout etc.). If the discharge is from upper outlets warm water fish species will largely support fishery.

Estaurine Ecosystem

An estuary is usually defined as a semi-enclosed coastal body of water having free connection with open sea. Thus, it comprises of both sea water and fresh water and occurs, usually nor the river mouths, coastal bays and tidal marshes. Primarily it is a passage or inlet where tidal water comes in contact with a river current. In other words, it may be designated as a confined arm of the sea situated at the lower and / or mouth of a river. Generally, estuaries maybe thought as transition zones (or ecotones) between fresh water habitat and marine habitat. They consist of brackish water which may be either oligohaline, mesohaline or polyhaline on the basis of degree of salinity. They undergo seasonal changes and thus belong to “fluctuating water-level ecosystem”.

Kinds of Estauries

On the basis of geomorphology, the estuaries are broadly classified into four categories. They are:

i. Drowned river valleys

These are very common along the coastlines and are characterized by low and wide coastal planes, e.g., Chesapeake Bay of the United States.

ii. Fjord type estuaries

They are deep, U-shaped coastal formations usually formed by glaciers e.g., Norwegian fjords.

iii. Bar built estuaries

These are shallow basins along the seashores being partly exposed at lowtide and surrounded by a discontinuous chain of barrier islands. The inlets betweenthese barriers connect various estuaries with the sea e.g., ‘sea islands’, saltmarsh estuaries from Georgia.

iv. Tectonic Estuaries

These are formed as a result of local subsidence (sinking) of land or by some geological faulting along the coasts e.g., San Francisco Bay.

v. Other kinds

Besides the above four categories, there are *river delta estuaries* present at the mouths of large rivers e.g., Nile river.

On the hydrographic basis, they are further classified into three categories.

a. High stratified estuaries

These are also called as salt-wedge estuaries, characterized by higher stratification of water. In it, flow of river water is dominant over sea water’s tidal action with the result that fresh water overflows heavy salt water forming a sort of ’wedge’ extending forward. Thus, two layered or stratified estuary isproduced e.g., mouth of Mississippi River.

b. Moderately stratified estuaries

It is also termed as ‘partially mixed’ estuary, where fresh water and tidalinflow balance each other e.g., Chesapeake Bay.

c. Vertically homogeneous estuaries

These comprise of “completely mixed” system in which tidal action isdominant and water mixes from top to bottom. Salinity is relatively higher, e.g., Bar-built estuaries.

d. Turbulence in Estuaries

Generally, the amount of fresh water entering into the estuary at its upper end will vary with the seasonal changes. The flood tide volume of water entering a particular estuary may bring about an increased amount of longitudinal movement of water. Thus in salt-water estuary, a boundary is formed by the mass of fresh water current coming into contact with the underlying mass of salt water and at this boundary, there is great shearing force which causes horizontal turbulence resulting in eddy formation. These eddies contain most of the nutrients of the estuaries and some ecologists call them nutrient traps.

Abiotic Factors

i. Temperature

The temperature in the estuaries varies considerably diurnally and seasonally. The temperature of estuarine waters increases by solar radiation, tidal currents and defect of high tide on the mud flats, etc.

ii. .Salinity in Estuaries

In shallow temperate water estuaries, salinity conditions are varied vertically i.e., fresh water flowing from the river will be less dense than the sea water Salinity conditions may be dependent on the flood tide and on the ebb-tide. The salinity fluctuates between 5 - 35%.

Characteristics of Estaurine Biota

The organisms of estuarine waters must have the capacity to tolerate changing salinity conditions continuously which are mainly of tidal and seasonal nature. Thus euryhaline species are most common inhabitants on a permanent or semi permanent basis. Besides, silt content and turbidity of the water are limiting factor with regard to the distribution of biota. Increased silt contents adversely affect both flora and fauna of the estuary.

Estuaurine species may be grouped into three categories.

(i) Marine species found along the outer limits of the estuary occasionally enter the estuary. e.g., Polychaetes *(Phyllodoce, Lanice)***,** Bivalve (Abra).

(ii) Permanent estuarine animals found primarily in the estuaries but may also be found in certain marine areas if ecological conditions permit. e.g., Polyehaete (*Nephthys*), Gastropods *(Nerita, Littorina)* and Carcinous (Crab).

(iii) Strictly estuarine animals found only in estuarine environment and not in marine. e.g., Nereis, Gastropods *(Neritina Hydrobia)* and crustacean *(cyathura).*

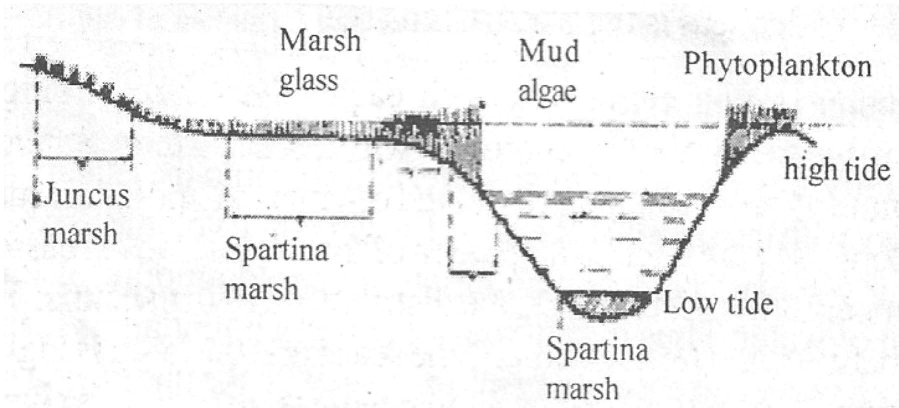


Fig: 3.3 Zones in marsh esuary

Biota and Productivity

The estuarine communities are usually composed of endemic species (i.e., those confined to estuarine zone) and movable species which come in from the sea and also fresh water environment. Most of the estuarine biota is of marine origin. In addition to this, estuaries serve as very good nursery grounds for many fishes, plankton and organisms. Many shrimps pass their larval history in the estuaries, whereas adults inhabit the sea. Fishes like eels, mullets and salmons, etc., remain for a considerable period during the migrations.

Marine Ecosystem

The marine habitat constitutes a dynamic environment with continuous cycles, waves, tides and currents. The oceans and seas cover approximately 71 percent of the earth's surface, an area of about 361 million square kilometers, the great stretches of salt water are termed as the oceans, while the smaller areas are referred to as seas.

There are five great oceans. These are the Pacific, Atlantic, Indian, Arcticand and Antarctic oceans. The largest ocean of the world is the Pacific Ocean. Inspite of their vast size, all the oceans are connected with each other. In addition to the oceans, there are seas. Some of these, such as the Arabian Sea and the Sargasso Sea, are parts of oceans. Other seas are surrounded by continents, such as the Mediterranean Sea, Red sea and the Black sea. Some shallow seas, such as the North Sea and Baltic Sea, are the flooded edges of continents. The largest of the world's seas is the South China sea.

The oceans being connected with each other form a single-phase environment, but the diversity is enormous with respect to temperature, salinity, physical nature, dissolved gases, and dissolved organic and inorganic matter. The diversity, along with the circulatory pattern of the oceanic water masses and the nutrient concentration determines the distribution of organisms. The major difference between the fresh water and the sea is that the latter is highly saline and organisms found here are not only adapted, but also use this characteristic to their own benefit. Some, such as the Dead Sea are so salty that no plants or animals can live in it.

Structure of the Ocean Floor

i. Beach

Where the, land meets the oceans and seas it is called the seashore or beach. A beach is said to extend from the farthest point where sand has been carried by wave action to the depth beyond which wave action does not have sufficient force to move the sand particles.

ii. Sea Floor

Close to the beneath the sea is mostly shallow, the bottom shelving from the shore to a depth of about 200 meters. This coastal ledge of shallow sea bottom is the continental shelf and its seaward margin is termed as the continental edge. Beyond the continental edge, the floor descends downwards steeply, and is known as the continental slope. The slope plunges into the floor of the ocean basin, often reaching a depth of 300 to 6000 meters or even deeper in some places. The slope is often fissured by irregular gullies and steep-sided submarine canyons.

Zonation of the Sea

The marine environment can be classified into two major divisions, the pelagic and the benthic (Fig.3. 4).

1. Pelagic division

The pelagic division comprises the whole body of water forming the seas and oceans. The pelagic part can be divided into the following

i .Neritic province

It consists of the shallow water over the continental shelf. This region has a more dynamic environment due to constant water movement and greater variations in the physical and chemical parameters.

ii. Oceanic province

The deep water beyond the continental edge constitutes the oceanic province. This region is relatively stable with less fluctuations, water movement is very slow and conditions change with depth. The oceanic province is subdivided into three zones which are:

a. Epipelagic zone extends vertically downwards from the surface to a depth of 200 meters. In this zone, sharp gradients of illumination and temperature occur between the surface and deeper levels. Temperature gradients and thermocline is common, and marked diurnal and seasonal changes in light intensity and temperature occur. The effect of water movement (in the form of waves) is prominent, especially in the upper layers, and determines the conditions in the layers beneath.

b. Mesopelagic zone extends from 200 meters to about 1000 meters. Wave action does not reach here, and very little light is available. The temperature gradient is more even and gradual, and there is very little seasonal variation. An oxygen-minimum layer is found here, along with maximum concentrations of nitrates and phosphates.

c. Bathypelagic zone extends from about 100 meters to the sea floor which is typically 3000 to 4000 meters in depth. Here darkness is virtually complete, except for bioluminescence. Temperatures are low and constant, and water pressure is enormous.

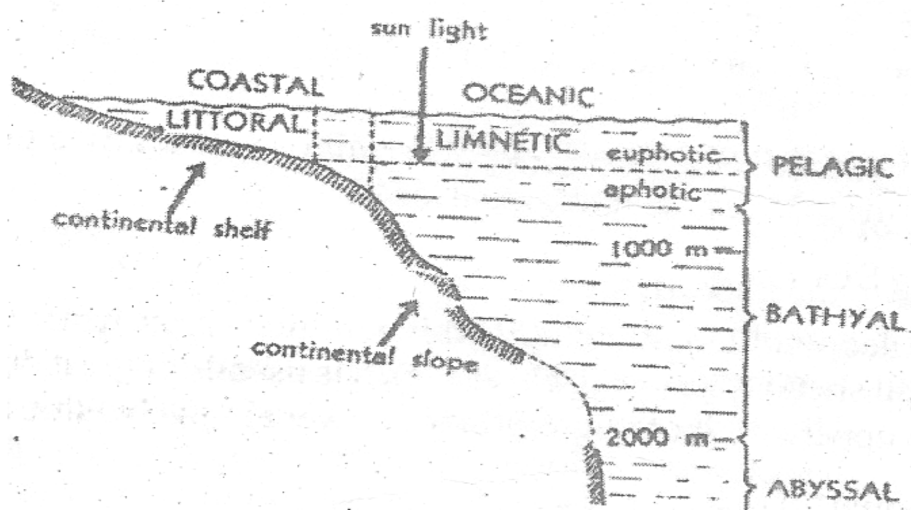


Fig: 3.4 Ecology of sea

2. Benthic division

The benthic division includes all the bottom terrain from the wave-washed shore line at flood tide to the ocean abyss. The benthic division is further classified into the littoral and the deep-sea zones which are:

i. Littoral Zone

The littoral zone extends from the high-tide level to a depth of 20 meters, that is, it includes the benthic region up to the continental edge. It has two subdivisions.

ii. Eulittoral Zone

It extends from the wave-splashed high tide level to a depth of about 40 to 60 meters. The lower border is set roughly at the lowest limit at which the more abundant attached plants can grow. In the upper part of the eulittoral zone is a well-defined tidal or intertidal zone that is bounded by the high and low-tide levels.

iii. Sublittoral Zone

It extends from the lower pit of the eulittoral zone down to a depth of 200 meters, or the edge of the continental shelf.

iv. Deep Sea Zone

The deep-sea zone includes the benthic region from the edge of the continental shelf to the ocean abyss which is usually at great depths. It has two zones, an upper archibenthic zone and a lower abyssal benthic zone.

a. **Archibenthic Zone**
It extends from the sublittoral to a depth between 800 and 1100 meters

b. **Abyssal benthic Zone**
It comprises all the deep-sea benthic system below the archibenthic zone. It is a region of relatively uniform environmental conditions with uniformly low temperatures (50 to1°C), with total darkness and without seasonal changes.

Physical Characteristics of Sea

These are four general types of water movements in the oceans. They are waves, subsurface currents, surface currents and tides.

i. Waves

The most common type of water movement in the seas and oceans are the waves. Waves are caused by the wind. Wind action does not move the water from place to place like currents or tides, but transmits energy into the water, setting it in orbital motion. Where waters are deep and wind velocities are low or moderate, water movements are smoothly progressive. Surface waves do not mix the water to any great depth. Their motion falls off sharply with depth and at a depth equal to the wavelength of the waves, the water is virtually still.

ii. Ocean currents

The ocean waters are constantly moving in a great circulatory system that involves both horizontal and vertical transfers. These movements are initiated by the transfer of kinetic energy from the winds to the surface waters and by variations in the densities of waters resulting from differences in their temperatures and salinities. The resulting flows, involving huge volumes of water, help to transport heat from the tropical and subtropical zone of excess receipt of solar radiation to the pole ward zones where the energy received from the sun is much lower. The movement is aided by the Coriolis force and produces clockwise currents in to the northern hemisphere and anti clockwise in the southern hemisphere.

iii. Tides

Nearly all shores of the open seas experience the distinct periodic rise and fall of sea-level known as the tides. The level of the sea or ocean rises twice in a day, water covers the shore and we say that the tide is in the level of waterfalls, twice in a day the seashore is uncovered and we say that the tide is out. Two important forces involved in a system, are responsible in tide generation:

The gravitational pull of the moon upon the earth and the centrifugal reaction which necessarily accompanies the smaller revolution of th earth. The gravitational attraction decreases rapidly with increasing distance from the moon, and hence it is significantly greater on the side of the earth nearest the moon than on the side opposite. That centrifugal reaction, on the other hand, is the same everywhere on the earth, for as the center of the earth revolves in a circle around the center of gravity of the pair; all points on the earth follow circular paths of the same size and move at the same speed.

At times of new moon and of full moon, the earth, moon and sun are nearly in line, so that the lunar tides and the solar tides occur in the same places, and the height of the solar tides is added to the lunar tides. These causes the high tides of these periods to be unusually high and the intervening low water to be unusually low. These are the periods of spring tide, which occur every two weeks.

When the moon is at its first and third quarters, the earth-sun line is nearlyat right angles to the earth-moon line. The solar tides then fall between, anddetract from the lunar tides, causing the difference between low and high tidesto be less pronounced than usual. These are the periods of neap tide, which also recur every two weeks.

iv. Temperature

Temperature changes with depth differ in different latitudes. In high latitudes, heat passes from the sea to the atmosphere. Surface waters usually have a temperature of -1.9°C there is an inversion around 500 meters, and below 1000 meters the temperature is almost uniform to the bottom.

At low latitudes, a distinct thermocline is formed between 100-500 meters. The thermocline divides the waters into an upper warm thermosphere and a lower cold psychrosphere. The temperature decreases from about 25°C in the surface layers to about 0°C in the bottom layers.

In middle latitudes seasonal thermocline occurs during the summer months at a depth of 15-40 meters. In winter the thermocline disappears, being replaced by a slight permanent thermocline, below which the temperature decreases steadily to around 0°C.

v. Pressure and wind flow

Pressure differences are primarily important in wind generation which leads to the formation of surface currents, wind waves and swells. Major winds which have an influence on oceans are the winds in the equatorial region, the westerlies of the mid latitutde, and the polar winds in the high latitudes.

Apart from these, pressure changes create cyclones and anticyclones. A cyclone has a low pressure center, while an anticyclone has a high pressure center. Monsoonic winds are periodic and create local effects, such as the clockwise and anti clockwise gyre in the Bay of Bengal.

vi. Light

Compared to the great depth of the oceans, light does not reach very far into the sea. Illumination of the surface layer varies with place, time and conditions depending upon the light intensity, transparency of the water and angle of incidence. The strength of the incident light varies diurnally, seasonally and with latitude, and is considerably influenced by cloud cover. Much of the incident light falling on the sea surface is reflected. Depending upon conditions some 3 -50% of the incident light is usually reflected.

Most of the plants are restricted to the euphotic zone by their dependence upon light as the energy source. Animals too are most numerous at or near the surface layers because they derive their food, directly or indirectly from plants.

Below this zone, organisms depend largely on the rain of organic debris coming from the upper layers and consists of carnivores and detritus feeders moving in complete darkness.

vii. Density

Pure water has its maximum/density at 4°C, but for sea water the temperature of maximum density decreases with increasing salinity and at salinities greater than 24.7% (parts per thousand) it is below the freezing point.

The distribution of density in sea waters is characterized by two features. In a vertical direction the stratification is generally stable, and in a horizontal direction differences in density exist only in the presence of currents. In every ocean region, water of a certain density which converges from the sea surface tends to sink to and spread at depths where a similar density is found.

viii. Hydrostatic pressure

Hydrostatic pressure increases with depth at approximately 1 atmosphere per 10 meters of depth. In the deepest ocean trenches, pressures may exceed 1000 atmospheres. Although water is only slightly compressible, such enormous pressures are sufficient to produce a slight adiabatic compression of the deep waters, resulting in a detectable increase in temperature.

ix. Evaporation and precipitation

The oceans have a major role in the hydrological cycle through the processes of evaporation and precipitation. For the oceans, the average annual evaporation is between 116 and 124 centimeters and the average annual precipitation is between 107 and 114 centimeters. This system is controlled by a large number of factors, for instance, temperature, precipitation, evaporation, vapour pressure and relative humidity. All these can be combined to form a hydrothermal indes (Hin).

Chemical Characteristics of Sea

Sea water is an extremely complex solution, its composition being determined by an equilibrium between dissolution and deposition, evaporation, precipitation and addition of fresh water as river run-off. Although it is not known as to what extent the composition of sea water has changed over the geologic period, but large-scale changes are definitely ruled out

Constituents	**Concentration g/kg**
Sodium	10.77
Magnesium	1.30
Calcium	0.409
Potassium	0.388
Strontium	0.01
Chloride	19.37
Sulphate	2.71
Bromide	0.065
Total inorganic carbon	0.023 – 0.027

Table 3.1. Major constituents of sea water aat a salinity of 35 gams per kilo

i. Salinity

The amount of inorganic material dissolved in sea water expressed as its weight in grams per kilogram (parts per thousand) of sea water is termed as salinity. The salinity of sea water varies from place to place. The average salinity of the oceans as a whole is generally considered to be 35 g/kg of which the chloride ion constitutes about 19 gms per kilo and the sodium ion a little over 10 gms per kilo. The salinity is lower where large rivers enter the sea, but in areas where the influx from the land is negligible, and where surface evaporation is great. Surface salinity is closely related to the process of evaporation, by which the salts re concentrated and this varies with latitude.

ii. Dissolved Oxygen

The oxygen content of the sea water is seldom limiting for the occurrence of animals and plants, except in the deeper waters. The oxygen content of the sea water generally varies between 0 and 8.5 mill, mainly within the range of 1-6. Higher values occur at the surface, due to diffusion and photosynthesis, especially in coastal areas where the phytoplankton and benthic algae are numerous. The process of diffusion is enhanced in wave splashed shores. Oxygen is more soluble in cold water than in warm, the oxygen content of the surface water is usually greater at higher latitudes than nearer the equator, and the sinking of cold surface water in polar seas carries oxygen-rich water to the bottom of the deep ocean basins.

iii. Free and bound carbon

40 chemicals elements (including four principal cations $Ca^{++}Mg^{++}$, $K^{+}$and Na^{+}), gases excluded are dissolved in sea water. The abundance of these ions enables. A considerable amount of carbon dioxide to be contained in solution in the form bound carbon (CO_2^{3-} and HCO_3). In fact, the ocean serves as a major reservoir of carbon dioxide, containing about 50 times more CO_2 (47 ml/L) than the atmosphere and serves as a modulator of the atmospheric carbon dioxide.

iv. pH

The pH of sea water in free contact with the atmosphere normally varies within the range of 7.5 and 8.4. The higher values are found at or near the surface layers where CO_2 is withdrawn rapidly for photosynthesis. In general there is a decrease of pH with depth to about the region of minimum dissolved oxygen, and then increases in deeper waters where respiration and decomposition become the dominant metabolic processes.

v. Nitrogen

Nitrogen in the combined form is present in sea water as nitrate, nitrite. Ammonium ions and traces of nitrogen-containing organic compounds. Nitrogen fixing bacteria such as Nitro cystic oceans are known to occur in the sea, but the amount fixed is negligible. Substantial quantities of nitrates nitrites and ammonia enter the sea as river run-off.

vi. Phosphates

Phosphates are typically present in the sea water as orthophosphates. Like nitrates, large amount of phosphates are brought to the sea through river runoff. Phosphates show much the same distribution in depth as nitrates (Fig.3.20) and in broad outline, their seasonal and geographical variation approaches that of nitrate. Phosphates are present in much smaller concentration than the nitrates and appear to be an important limiting factor in the development of phytoplankton. Surface values of phosphate are in the range of 0-20mg per liter while at depths of 500-1500 meters it is 40 -80 rug per liter. The ratio of nitrates of phosphates present in the sea roughly approaches a constant value of 7 1 by weight.

vii. Iron and other elements

The amount of iron present in sea water in solution is about 2 mg per liter, but there are appreciable amounts of iron in particulate form as colloidal micelles, mainly as ferric hydroxide. There is a continuous loss of iron from sea water and accumulation at the bottom due to sedimentation.

Manganese is a plant nutrient which, like iron, is probably present mainly in the particulate form as oxide micelles. The amount varies from 0.3 to 10mg per liter. These two elements along with copper, nickel and cobalt give rise to Poly metallic nodules at the sea bottom.

viii. Silicate

Silicon is present in sea water chiefly as silicate ions. The concentration of silicates is usually low in surface waters but increases with depth to about 1- 5 mg/L.

ix. Dissolved organic matter

Varying quantities of organic matter are present in solution in sea water. Although the concentration is small, it has been estimated that there is on averageabout 15 kg of organic matter beneath each square meter of the ocean surface. The sources ‘are diverse and include materials origination (from the break-downof tissues, excretory materials and organism secretions.

Biotic Components of Sea

The marine community is diverse and diversification is a measure of the success of a species. In these terms, many marine groups are highly successful. The community is segregated into the range of environmental niches provided by the sea. Regardless of their phylogenetic position, marine organisms can be placedin two large categories dependent on whether they live on the water mass pelagic) or on the bottom sediments (benthic). A third category is made of those organisms which live in the air-water interface (pietistic). However, these categories are not rigidly definable. Some species are benthic as adults but pelagic as larvae, and a number of pelagic organisms may spend much time resting on or feeling at the sediment-water interface.

The biotic components of marine ecosystem are of the following orders:

i. Producers

These are autotrophs and also designated as primary producers, since they are responsible for trapping the radiant energy of sun with the help dinoflagellates and some microscopic algae. Besides them, a number of macroscopic seaweeds, as brown and red algae (members of Phaeophyceae and Rhodophyceae), also contribute significantly to primary production. These organisms show a distinct zonation at different depths of water in the-sea.

ii. Consumers

These all are heterotrophic macro consumers, being dependent for their nutrition on the primary producers. They are:

(a) Primary consumers. The herbivores that feed directly on producers are chiefly crustaceans, mollusks, fish etc.

(b) Secondary consumers. Still in the food chain, there are other carnivorous fishes like Cod, Haddock and Halibut etc. that feed on other carnivores of the secondary consumers level. Thus these are the top carnivores in the food chain.

iii Decomposers

The microbes active in the decay of dead organic matter of producers and macro consumers are chiefly bacteria and some fungi.

iv. Pelagic biota

The pelagic region has a larger group of organisms and includes all the species inhabiting the entire water column. These can be divided in to two broad categories, the plankton and the nekton.

v. Plankton

The plankton of the sea includes a great variety of forms and exceeds that of fresh water, but differences in composition usually occur. The phytoplankton population of the sea is dominated by the diatoms and the dinoflagellates also present and are occasionally important. The diatoms tend to dominate in higher latitudes, while dinoflagellates are predominant in the subtropical and tropical waters. As a group, the dinoflagelates are the most versatile of organisms, since they not only function as autotrophs, but some species are facultative saprotrophs or phagotrophs. Some, such as *Gymnodinium brevis, Goiniaulux polyedra* and *Exuviella baltica* give rise to red tides causing death of enormous number of fishes.

The animal planktons are defined according to duration of the life cycle in the pelagic state. The planktonic eggs and larvae of the nekton and benthos constitute temporary plankton or meropilankton. These are especially abundant in the neritic waters and are composed mainly of the developmental stages of invertebrates, but also include the young of fishes.

vi. Nekton

The assemblage of organisms comprising this group are provided with efficient locomotory organs enabling them to swim against currents and waves, The large cephalopod molluscs (squid), crustaceans (prawn) and a great variety of vertebrates fish, turtles, snakes, mammals comprise this group.

The locomotion efforts of necktonic organism are not only capable of being sustained for a considerable length of time, but the movement is also effectively directed towards pursuit of prey, escape from enemies, and instinctive migratory journey. Active swimming requires the development of muscular systems and often of relatively large size. They are the terminal consumers of the sea, mostly carnivorous, while a few are herbivores and even fewer take detritus.

vii. Benthic biota

The benthos consists of diverse group of organisms with specific adaptations and is zonated both horizontally and vertically. These zonations are based on their energy requirements and the physical and chemical factors to which they have adjusted. In the well-lit waters of the euphotic zone are to be found the phytobenthos; they extend down to the compensation zone and are graded atdifferent levels based on environmental factors and community dynamics. The phytobenthos includes three categories of photosynthetic organisms; protists essentially similar to those of the phytoplankton but here associated with soft sediments, symbiotic within littoral animals such as corals, and occurring in various other microhabitats; larger, multicellular algae in a variety of forms but especially as the large, leathery sea-weeds of rocky out crops (forming kelp beds) and the finer, more filamentous species growing on the surfaces of coarser sea-weeds and rocks and the community of marine tracheophytes consisting of sea-grasses, salt-marsh herbs and mangrove- swamp shrubs and trees.

Beyond the euphotic zone the benthos lacks photosynthetic organism and is replaced by chemosynthetic bacteria (nitrifying, sulphur, hydrogen methane, carbonnionoxide, and iron bacteria) which occur in the benthic sediments and fix their carbon dioxide by oxidizing ammonia, hydrogen sulphide, methane and others. These regenerate nutrient materials for the photosynthetic forms.

Benthic animals are very abundant in the littoral zone and decrease in number with depth in the only scattered individuals are found unit deep ocean trenches. These consist of sessile forms such as sponges, barnacles (Fig.3.27), mussels, oysters, crinoids, hydroids, bryozoans, and some worms; creeping forms such as crabs, lobsters, certain copepods, amphipods, crustaceans, snails, echinoderms, bivalves, and some fishes; and burrowing forms including mostly clams, worms some crustaceans and echinoderms.

In the shore zone, organisms are characteristically zonated. This zone represents transition between the marine and terrestrial environments. The organisms living here have to withstand varying degrees of stress resulting from tides, waves, sea-spray, pounding of surf and the alternate inundation and exposure to air. Based on the type of substratum, the zone is classified into rocky and sandy shores. Each has its own peculiar feature and the organisms living in these environments have specific adaptations for the same.

3.3 Energy Flow in Ecosystem

The energy used for all plant life processes is derived from solar radiations. A fraction i.e. about 1/50 million of the total solar radiation reaches the earth's atmosphere. In this about 34% of the sunlight reaching the earth's atmosphere is reflected back into its atmosphere, 10% is held by zone layer, water vapour and other atmosphere gases. The rest, 56% reaches the earth's surface.

Only a fraction of this energy reaching the earth's surface (into 5%) is used by green plants for photosynthesis and the rest is absorbed as heat by ground vegetation or water. In fact, only about 0.02% of the sunlight reaching the atmosphere is used in photosynthesis. Nevertheless, it is this small fraction on which all the organisms of the ecosystem depend.

The behavior of energy in ecosystem can be termed energy flow due to unidirectional flow of energy. From energetics point of view it is essential to understand for an ecosystem (I) the efficiency of the producers in absorption and conversion of solar energy, (ii) the use of this converted chemical form of energy by the consumers, (iii) the total input of energy in form of food and its efficiency of assimilation, (iv) the loss through respiration, heat, excretion etc. and (v) the gross net production.

Single - Channel Energy Models

The principle of food chains and the working of the two laws of thermodynamics can be better made clear by means of energy flow.

From the energy flow, two things become clear. Firstly, there is one-way Street along which energy moves (unidirectional flow of energy). The energy that is captured by the autotrophs does not revert back to solar input; that which passes to the herbivores does not pass back to the autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level. Thus due to one-way flow of energy, the system would collapse if the primary source, the sun, were cut off. Secondly, there occurs a progressive decrease in energy level at each trophic levels it is no longer available to the previous level. Thus due to one-way flow of energy, the system would collapse if the primary source, the sun, were cut off. Secondly, there occurs a progressive decrease in energy level at each trophic level. This is accounted largely by the energy dissipated as heat in metabolic activities and measured here as respiration coupled with unutilized energy.

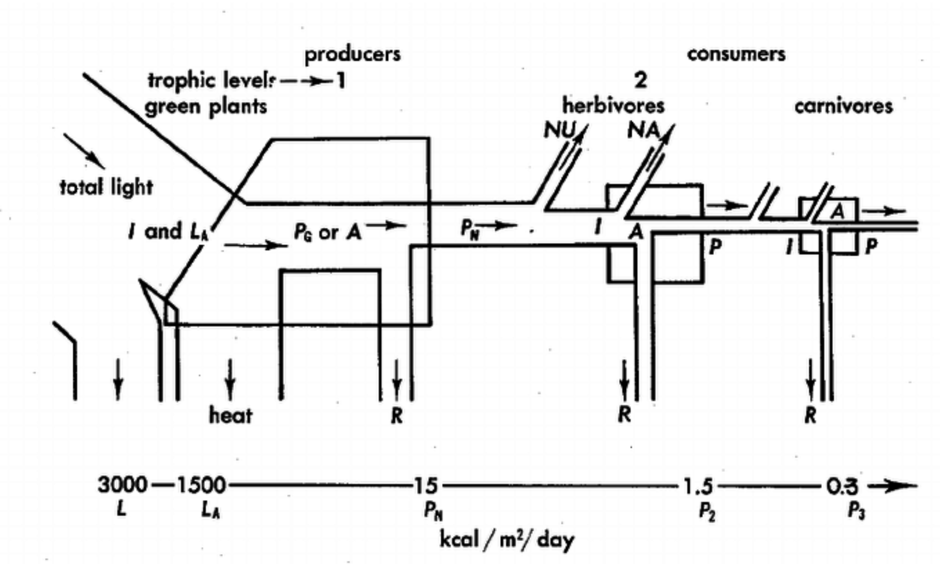


Fig. 3.5. A simplified energy flow diagram depicting three trophic levels (boxes number 1,2,3,) in a linear food chain.

In fig. 3.5 the ‘boxes’ represent the trophic levels and the ‘pipes’ depict the energy flow in and out of each level. Energy inflows balance outflows as required by the first law of thermodynamics, and energy transfer is accompanied by dispersion of energy into unavailable heat (i.e. respiration) as required by the second law. Fig. 3.5 presents a very simplified energy flow model of three trophic levels, from which it becomes evident that the energy flow is greatly reduced at each successive trophic level from producers to herbivores and then to carnivores. Thus at each transfer of energy from level to another, major part of energy is lost as heat or other form.

It is natural to argue that with a reduction in energy flow (shown as ‘pipes’ in the diagram) at each successive trophic level, there is also a corresponding decrease in standing crop or biomass (shown as ‘boxes’ in the energy (Fig.3.5).

3.4 Food Chains and Food Web

The transfer of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten, is known as a food chain. Producers utilize the-radiant energy of sun which is transformed to chemical form, ATP during photosynthesis. Thus green plants occupy, in any food chain, the first trophic (nutritional) level-the producers level, and are called the primary producers. The energy, as stored in food matter manufactured by green plants, is then utilized by the plant eaters the herbivores, which constitute the second trophie level - the primary consumers level, and are called the primary consumers (herbivores).

Herbivores in turn are eaten by the carnivores, which constitute the third trophic level-the secondary consumers level, and are called the secondary consumers (carnivores). These in turn may be eaten still by other carnivores at tertiary consumer level i.e. by the tertiary consumers (carnivores). Some organisms are omnivores eating the producers as well as the carnivores at their lower level in the food chain. In any food chain, energy flows from primary producers to primary consumers (herbivores), from primary consumers to secondary consumers (carnivores), and from secondary consumers to tertiary consumers (carnivores / omniovers) and so on. This simple chain of eating and being eaten away is known as food chain.

In nature, we generally distinguish two general types of food chains:

i. Grazing Food Chain

This type of food chain starts from the living green plants, goes to grazing herbivores (that feed on living plant materials with their predators), and on to carnivores (animal eaters). Ecosystems with such type of food chain are directly dependent on an influx of solar radiation. This type of chain thus depends on autotrophic energy capture and the movement of this captured energy to herbivores. Most of the ecosystems in nature follow this type of food chain. From energy standpoint, these chains are very important. The phytoplanktons - zooplankons -fish sequence or the grasses-rabbit-fox sequences are the examplesof grazing food chain.

ii. Detritus Food Chain

This type of food chain goes from dead organic matter into microorganisms and then to organisms feeding on detritus (detritivores) and their predators. Such ecosystems are thus less dependent on direct solar energy. These depend on the influx of organic matter produced in another system.

Based on mangroves leaves falling into shallow estuary waters. Leaf fragments acted on by the saprotrophs and colonized by algae are eaten and re-eaten (coprophagy) by a key group of small detritivores which in turn, provide the main food for game fish, herons, stroke and ibis.

In detritus chain, the detritus consumers, in contrast to grazing herbivores, are a mixed group in terms of trophic levels (Fig.3.23b). These include herbivores, omnivores, and primary carnivores. As a group, the detritus feeders obtain some of their energy directly from plant material, most of it secondarily from micro organisms, and some tertiarily through carnivores (for example by eating protozoa or other small invertebrates that have fed on bacteria thathave digested plant material). But under natural situations, a system must always be self sufficient. In fact this type of food chain (detritus type) is simply a sub component of another ecosystem. And, the above said two types of food chain in nature are indeed limited together belonging to the same ecosystem.

Food Web

However, food chains in natural conditions never operate as isolated sequences, but are inter connected with each other forming some sort of interlocking pattern, which is referred to as a food web. Under natural conditions, the linear arrangement of food chains hardly occurs and these remain indeed interconnected with each other through different types of organisms at different trophic levels.

A similar food web in a pond, with different interlinked food chains is shown in Fig 3.6. The food web are very important in maintaining the stability of an ecosystem in nature. For example, decrease in the population of rabbit would naturally cause an increase in the population of alternative herbivore, the mouse. This may decrease the population of the consumer (carnivore) that prefers to eat rabbit.

Thus alternative (substitutes) serve for maintenance of stability of the ecosystem, Moreover, a balanced ecosystem is essential for the survival of all living organisms of the system. For instance, had primary consumers (herbivores) not been in nature, the producers would have perished due to overcrowding and competition.

Similarly, the survival of primary consumers is linked with the secondary consumers (carnivores) and so on. Thus, each species of any ecosystem is indeed kept under some sort of a natural check so that the system may remain balanced.

The complexity of any food web depends upon the diversity of organisms in the system. It would accordingly depend upon two main points:

(i) Length of the food chain. Diversity in the organisms based upon their food habits would determine the length of food chain. More diverse the organisms in food habits, more longer would be food chain.

(ii) Alternatives at different points of consumers in the chain. More the alternatives more would be the interlocking pattern. In deep oceans, seas etc. where we find a variety of organisms, the food webs are much complex.

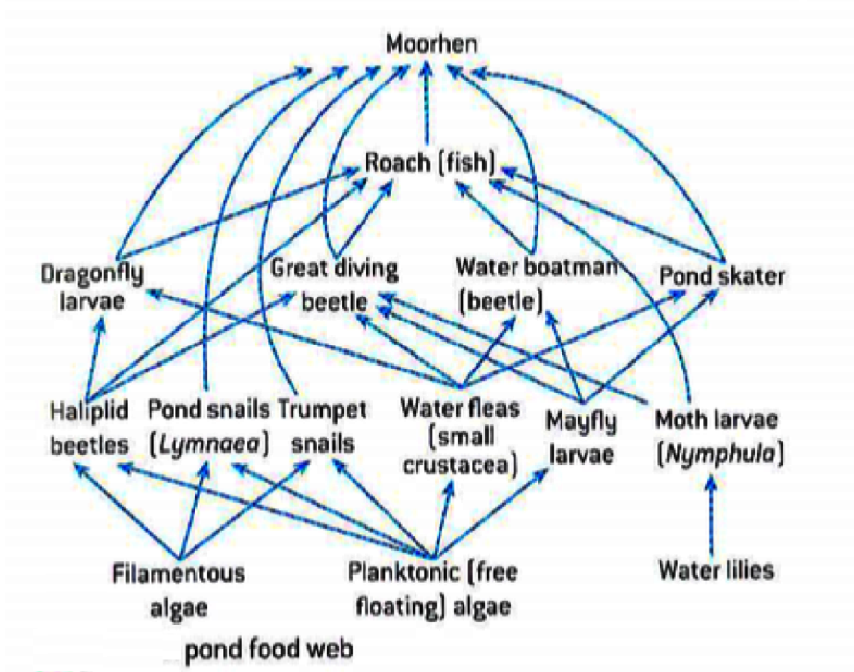


Fig 6. The food web in a pond.

3.5 Trophic levels of Ecological pyramids

The producer organisms are autotrophs, largely phytoplankton and other green plants, that manufacture their food through photosynthetic activity utilizing the abiotic elements of the water. Other organism in the aquatic ecosystem, largely animals are consumers which utilize the producers as their food. These organisms are phagotrophic heterotrophs, micro or macro consumers. Another category of heterotrophs is of those organisms, chiefly bacteria and fungi, which are decomposers (saprophytes) of dead organic matter, partly utilizing these as their food, and partly releasing simple products utilizable as food by both autotrophs and consumer heterotrophs. Fish belongs to the category of phagotrophic hetetroph of the macro consumer type. In this set up, complex patterns of food relationship occurs in which there are repeated stages of one organism eating the other and in turn serving as the food for the third one and so on. Fish populations may be classified, thus, into several trophic levels, depending upon their position in this food chain.

There are some fish communities which occupy the second trophic level (the producers belong to the first trophic level). These are herbivores, eating green plants (the producers) and in which, the transfer of food energy from producers reaches fish in one step. Other fish communities belong to the third trophic level. These are carniovorous fish, eating herbivorous fish or other herbivorous animals like zooplankter (zooplankters belong to the third trophic level, since they eat insects and their larvae and other arthropods living on detritus (these themselves occupying the second trophic level alongside bacteria and fungi). Still other fish commuities occupy the fourth trophic level. These are predatory fish eating carnivorous fish or other carivorous animals. The trasfer of food energy from producers occurs thus in two or three steps in the third and the fourth trophic levels respectively. A relatively simple food chain operates in managed fish ponds but a complex one occurs in large lakes and other fresh water ecosystems. The picture is very complicated in trophic relations is still large and wild water bodies, especially in seas, where complicated food chains are referred to as food webs which infact represent several food chains interconnected into a whole.

There are again fish communities which occupy multiple positions or mixed positions between different trophic levels. Such fishes consume a variety of food, both plants and animals. These are called omnivorous fishes and these cannot be naturally classified with any one particular trophic level.

Ecological Pyramids

Trophic structure i.e. the interaction of food chain and the size metabolism relationship between the linearly arranged various biotic components of an ecosystem is characteristic of each type of ecosystem. The trophic structure and function at successive trophic levels, i.e. producers herbivores carnivores, may be shown graphically by means of ecological pyramids where the first or producer level constitutes the base of the pyramid and the successive levels, the tiers making the apex.

Ecological pyramids are of three general types - (i) pyramid of numbers, showing the number of individual organisms at each level, (ii) pyramid of biomass, showing the total dry weight and other suitable measure of the total amount ofliving matter, and (iii) pyramid of energy, showing the rate of energy flow and orproductivity at successive trophic levels. The pyramid of numbers and biomass may be upright or inverted depending upon the nature of the food chain in the particular ecosystem, whereas pyramids of energy are always upright.

i. Pyramids of Number

They show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number. The pyramids of numbers in three different kinds of ecosystems are shown in Fig. 3.7 (A-C). In a grassland (Fig.3.7A) the producers, which are mainly grasses are always maximum in number. This number then shows a decrease towards apex, as the primary consumers (herbivores) like rabbits, mice etc. are lesser in number than the grasses; the secondary consumers, snakes and lizards are lesser in number than the rabbits and mice. Finally, the top (tertiary) consumers hawks or other birds, are least in number. Thus, the pyramid becomes upright. Similarly in a pond ecosystem (Fig. 3.7B) the pyramid is upright. Here the producers, which are mainly the phytoplanktons as algae, bacteria etc. are maximum in number; the herbivores, which are smaller fish; rotifers etc. are lesser in number than the each other, water beetles etc. are lesser in number than the herbivores. Finally, the top (tertiary) consumers, the bigger fish are least in number. In a forest ecosystem (Fig. 3.7C), however, the pyramid of numbers is some what different in shape. The produces, which are mainly large-sized trees, are lesser in number, and form the base of the pyramid. The herbivores, which are the fruit-eating birds, elephants, deers etc. are more in number than the producers. Then there is a gradual decrease in the number of successive carnivores, thus making the pyramid again upright. However, in a parasitic food chain (Fig.3.7D) the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasites, which support many hyper parasites. Thus, from the producer towards consumers, there is a reverse position, i.e. the number of organisms gradually shows an increase, making the pyramid inverted in shape.

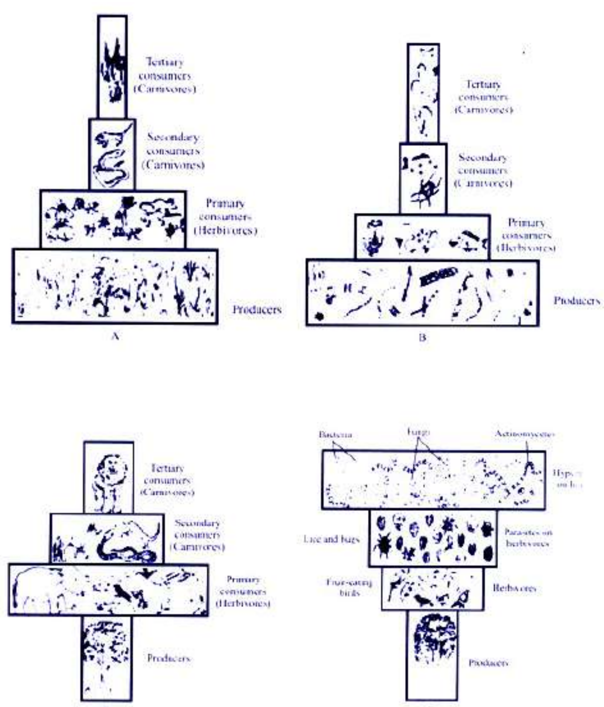


Fig. 3.7: Pyramid numbers

Actually the pyramid numbers do not give a true picture of the food chain as they are not very functional. They do not indicate the relative effects of the 'geometric', 'food chain' and 'size' factors of the organisms. They generally vary with different communities with different types of food chains in the same environment. It becomes sometimes very difficult to represent the whole community on the same numerical scale (as in forests).

ii. Pyramids of Biomass

They are comparatively more fundamental, as they, instead of geometric factor, show the quantitative relationships of the standing crops. The pyramids of biomass in different types of ecosystem are shown in Figure 3.8 (A-C). In grassland and forest (Fig. 3.8 A.B), there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. Thus pyramids are upright. However, in a pond (Fig. 3. 8 C) as the producers are small organisms, their biomass is least, and this value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted in shape.

iii. Pyramid of Energy

Of the three types of ecological pyramids, the energy pyramid gives the best picture of overall nature of the ecosystem. Here, number and weight of organisms at any level depends not on the amount of fixed energy present at any one time in the level just below but rather on the rate at which food is being produced. Incontrast with the pyramids of numbers and biomass, which are pictures of the standing situations (organisms present at any movement), the pyramid of energy (Fig. 3. 9) is a picture of the rates of passage of food mass through the food chain. In shape it is always upright, as in most of the cases there is always a gradual decrease in the energy content at successive trophic levels from the producers to various consumers.

The species structure includes not only the number and kinds of species but also the diversity of species i.e. the relationship between species and number of individuals or biomass; and the dispersion (spatial arrangement) of individuals of each species present in the community.

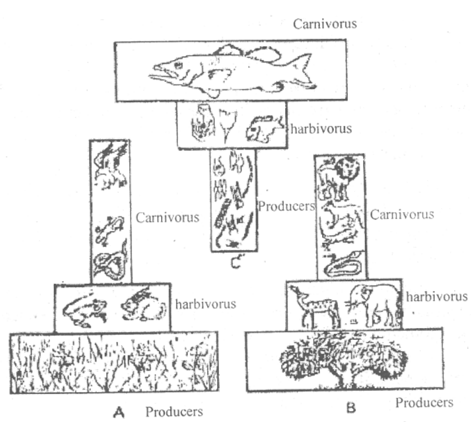


Fig 3.8 (A-C) Pyramids of biomass (g. dry wt. per unit area) in different kinds of ecosystems.
A-grassland, B-forest, C-Pond

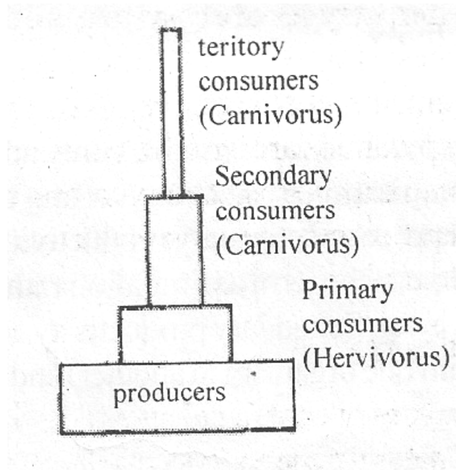


Fig. 3.9 Pyramid of energy (K cal per unit area within unit time, seasons or years) in any eco system)

3.6 Productivity of Ecosystem

The productivity of an ecosystem refers to the rate of production i.e. the amount of organic matter accumulated in any unit time. Productivity is of the following types:

Primary productivity

It is associated with the producers which are autotrophic, most of which are photosynthetic, and to a much lesser extent the chemosynthetic microorganisms. These are the green plants, higher macrophytes as well as lower forms, the phytoplanktons and some photosynthetic bacteria. Primary productivity is defined as "the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers". Primary productivity is further distinguished as:

(a) Gross primary productivity. It is the total rate of photosynthesis including the organic matter used up in respiration during the measurement period.

(b) Net primary productivity. It is the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by plants during the measurement period.

Secondary productivity

It refers.to the consumers or heterotrophs. These are the rates of energy storage at consumers level. Since consumers only utilize food materials (already produced) in their respiration, simply converting the food matter to different tissues by an overall process, secondary productivity is not divided into 'gross' and 'net' amounts. To use the term assimilation rather than 'production' at this level the consumers level. Secondary productivity actually remains mobile (i.e. keeps on moving from one organism to another) and does not live in situ like the primary productivity.

Net productivity

It refers to the rate of storage of organic matter not used by the heterotrophs (consumers) i.e. equivalent to net primary production minus consumption by the heterotrophs during the unit period.

3.7 Limnology of Pond Ecosystem

Limnology is a branch of science, which deals with the study of freshwater ecosystems of all kinds ranging from lakes, reservoirs, streams, ponds, marshes, bogs, etc., - physically, chemically and biologically. (Forel's Lelemane - 1888 to 1909-Fathwr of Limnology).

Limnological studies such as physical, chemical and biological forms a part of limnology.

(i) **Physical***:* Physiography, morphometry, bathymetry, temperature, turbidity, conductivity, water volume, water current etc. are covered in this area of study.

(ii) **Chemical**: Study of H^+ ion concentration dissolved oxygen, CO_2, alkalinity, NO, PO, Silicate, calcium hardness, chloride, ammonia in solution, H_2S and trace elements like B, Mn, Mg, Fe, Cu, etc.

(iii) **Biology**: Study of plankton (phyto, zoo, nanno plankton); nekton (fish, Insects, crustacea, annelids, molasses and other free swimming animals); Benthos (phyto benthos, zoo benthos); pedon (botton fauna or zoo benthos) and microorganism inform of dead organic matters (DOM, bottom mat etc.,)

Apart from these studies (Qualitative), quantitative production studies are also forms a part in limnology. It also comprises, the correlations between an organism or a community with other organisms and physico - chemical environment (climate and rainfall).

The food chains (in water) of fishes, plankton, pedon, other animal's and macrophytes are all studied under limnology. Limnology requires a multidisciplinary approach. Besides physical, chemical and biological studies, it also encampass some area of other disciplins, such as geology, geography, metrology, hydrology, statistics, biochemistry, bacteriology, geodesy and engineering.

i. Plankton

The plankton is nothing but a group heterogenous tiny paints and animals adopted to suspension in the sea and fresh waters. Their intrinsic movements are essentially depends upon the mercy of water currents. The plankton occurs in all natural waters as well as in artificial impoundments like ponds, tanks, reservoirs, irrigation channels etc.

Depending upon the ability to carry out the photosynthetic activity, planktons are classified into

(i) Phytoplankton (plant plankters) and
ii) Zooplankton (animal plankters)

Planktons are having an immense value as a food and play an important role in the disposal of sewage and in natural purification of polluted waters. But some plankton form a harmful bloom that may cause a high mortality among the aquatic organisms and pose a serious hazard in the water supply for domestic and industrial use.

The fish culture practices attaining a greater importance in the field of aquaculture throughout the world as well as in India. For an efficient fish culture, the fish seed should be properly feed with sufficient natural food organisms. These small microscopic organisms are nothing but the ‘Planktons’. As far as freshwater fish ponds concerned, the planktons comprises both the phytoplanktonas well as Zooplankton.

ii. Phytoplankton

The phytoplanktons mainly consists of the groups of Chlorophyceae, Bacillario-phyceae, Eugleninaceae, and Myxophyceae and some extent a few Dinophyceae. Some of the common phytoplanktons found in lakes and ponds of India are listed.

Ex. Microcystis, Aerginosa, Spirulina, Oscillatoria, Anabaena, Schizothrix, Vaucheria, Euglena, Melosira, Navicula, Nitzschia, Chlamydomonas, Volvox, Ulothrix, Spirogyra, Pediastrum.

iii. Zooplankton

Animals, which are carried along by the moving waters are known as ‘Plankton’. The planktonic animals are virtually at the mercy of the currents and generally drift about passively. Zooplankton consists mostly of invertebrates and larvae and immature stages of both invertebrates as well as vertebrates. The planktonic community exhibits considerably variety as it is composed of every group from protozoa to chordata. However, coelenterats, and crustaceans predominates. Siphanophorans, ctenophorans and chaetognathans among invertebrates and Larvacea among chordates are exclusively planktonicforms. Planktonic animals must necessarily have the capacity to remain afloat, Among the unicellular organisms of the plankton, there are a few, which are neither plants nor animals. Flagellates are of this type and are classified as ‘Protophyta’. These protophyta includes the members such as plants, animals (or) of both.

The zooplanktonic forms shows a great variability ranging from protozoans to chordates. Several members of the class Sarcodina are planktonic among the protozoans. Even the chordates, specially of protoehordates are also represented as planktons.

The zooplankons, protozoans (Diffiugia, Arcella and many ciliates), rotifers (Keratella, Polyarthra, Pedaliaetc), crustaceans (Cladocerans Daphnia,Meriodaphnia, Monia and copepods, Cyclops, Diaptomus and Crustacean larvae and other Zooplanktons were discussed briefly, and some of the more common zooplanktons found in lakes and India.

Examples: Spongilla, Branchionus, Keratellatropica, Daphnia Moina, Cypris, lacustris, Chilomonas, Amoeba, Paramecium, Mesacyclops, Diaptoinus, Neodiaptomus,

v. Nekton

The nekton consists of actively swimming organisms, including a diverse group of insects and fishes. Most of these insects can spend their time on the water surface and frequently dive inside the water for feeding. These are voracious feeders, feeding on plant oozes *(corixa),* Insects and crustaceans (*Nepa: Ranatra: Hydrophiues):* eggs, fry and fingerlings of fishes *(Lethocerus, Belostoma, Diphonychus).*

While going under water, Notonecta usually enter the water with a store of air under wing covers, or beneath the abdomen. The hydrofhge hairs and body surface cause the surface film to form a more (or) less complete envelope about the body, there by enclosing an air space. The surface film acts as a diffusion membrane through which gases pass from the air space to the water and vice versa.
Examples: *Nownecta, Nepa, Ranatra, Lethocerus, Belostoma, Diplonucychus, Corixa, Cybister, Laccophlius, Dytiscus, Hydrophilus, Dineupes, Catla catla, Labeo rohita, Cirrhina mrigala, Labeo calbasu, Labeo bata and Labeo fimbniatus*

vi. Benthos

The Benthos included all bottom dwelling organisms. This group comprises both plants and animals that are graded from the upper most water – bearing portions of the beach down to the greatest depths. Thus the benthos may be broadly divided into the littoral benthos; the sublittoral benthos and the profoundal benthos. The littoral and sublittoral benthos exclusively consists of the microscopic forms of insects and molluscs.

Hutchinson in 1967 has divided the benthic community based on the nichethey occupy into 5 groups. They are.

(i) Rhizo benthos	- rooted in the substratum by well - extended into the aqueousphase.
(ii) Haptobenthos	- Attached to an iinmessedsolid surface
(iii) Herpobenthos	- growing (or) moving through mud
(iv) Psammon	- growing (or) moving through sand
(v) Endobenthos	- boring into solid substrate

The littoral benthic region may or may not be occupied by the roots of macrophytes. They may be completely absent in unstable sand or bare rocks. Species such as Ulothrix ;Oedogonium; Spirogyra; Pandorina are commonalgae. The Animals inhabiting the littoral benthie region include protozoans, Coelentarates, Nematodes, Gastrotrichs, Insect larvae, Ogochaetes, Ostracods, Mites and Molluscs

The profoundal benthic zone is typically anaerobic, with a diversified group of microorganisms including cabo, sulphur and nitrogen bacteria. Some colourless algae may also occurs. Animals like bivalve molluscs and tubified oligochetes are common. Some dipteran insects such as chaoborus are also present along with few numbers of turbellarians, Ostracods and hydracarines.

vii. Periphyton

The under water stems and leaves of aquatic macrophytes are generally colonized by epiphytic organism (periphytons) such as algae, bacteria and protozoa. They acquire a covering of detritus which may in turn be followed by a covering of algae (or) fungi.

This rich substrate forms the grazing ground of many animals such as snails (Lymnea, Gyraulus); Chironomid larvae, May fly nymphs (Baetis, Caenis) and many species of Caddisfly larvae. Among the carnivores, the active hunters and lurkers are also found attached to weed beds. Among the hunters, various freshwater beetles such as Dytiscus, Laccophilus. Even different species of annelids, such as Dero, Nalas, and Chaetogaster are also found

Role of Plankton in the Survival and Growth of Fish

Experiments have shown that the main food of the young carp fry is zooplankton, and in the absence of enemies, their survival depends entirely on the production of thick swarms of zooplankton, and the time of stocking the ponds. However, development of thick algal blooms causes super saturation of dissolved oxygen in water, often resulting in gas trouble to the fry and large scale mortality.

Heavy manuring of ponds with cow dung almost invariably results in the production of swarms of zooplankton consisting of rotifers, cladocerans and copepods, in about 10 days. Volvox, Eudorina, Anabaena frequently occur in blooms of varying intensity, Algae also develop and Euglena may form surfaces cum.

Laboratory experiments have shown that 90-100% fry survive if the fry are stocked during swarms of zooplankton and abundant food is available. Zooplankton is preferred by fry as they are easily digested. Phytoplankton is not utilized as food and is difficult to digest. The nutritional value of phytoplankton is also less than the zooplankton. However, production of zooplanton in a pond after heavy manuring is a matter of chance. It is not certain whether zooplankton will be produced or phytoplankton will appear. Application of heavy dose of cow dung in tanks, usually results in early production of zooplankton swarms, and the stocking of the fry has to be adjusted with time of its maximum production.

The ecosystem is an integrated system resulted from interaction of living and non-living factors of the environment. The lentic ecosystems consists of pond, lake, reservoir and ocean. Pond is a small impondment which is the typical example of an ecosystem. Lake and reservoir are the large water bodies which consists of both abiotic and biotic factors. Ocean is a largest ecosystem with different types or organisms in epipelagic, bathypelagic and abyssopelagic regions. Estuari is a semi-enclosed postal body of water having free connection with open sea. It comprises of both sea water and fresh water and occurs usually the river mouth, coastal bays and tidal marshes. The lotic waters consist of rivers.

Ecosystem is self supporting system where both abiotic and biotic factors acts and interact with each other to bring a structural and functional change. The abiotic factors components refer to non-living elements or factors present in the ecosystem, whereas the biotic factors include the living elements. The behavior of energy is termed as energy flow and it is unidirectional in an ecosystem. The energy in an ecosystem is represented in the form of energy pyramids. The transfer of the food energy from the produces, through a series of organisms with repeated eating and being eaten, is known as food chain.

Limnology is a branch of science, which deals with the study of freshwater ecosystems of all kinds ranging from lakes, reservoirs, streams, ponds, marshes, bogs, etc - physically, chemically and biologically. Limnological studies such as, physical, chemical and biological forms a part of limnology.

The plankton is nothing but a group heterogenous tiny plants and animals adopted to suspension in the sea and fresh waters. Their intrinsic movements are essentially depends upon the mercy of water currents. The planktons are classified on the basis of the ability to carry out the photosynthetic activity. They are (i) Phytoplankton (plant plankters) and (ii) Zooplankton (animal plankters).Planktons also includes nektons, periphyton and benthos. These planktons forms chief food component for growth and development of fish.

Short Answer questions (2 Marks)

1. Define Ecology, who coined the term Ecology?
2. What is Biome?
3. Define Limnology?
4. Differentiate between ‘Lentic and Lotic’ ecosystem?
5. Define plankton? Give two types of planktons?
6. Mention the names of zones in pond ecosystem?
7. What is ‘Estuary’?
8. Differentiate between tides and waves?
9. What is Nekton? Give two examples?
10. What is the role of sunlight in pond ecosystem?
11. What is primary productivity?
12. What is secondary productivity?
13. Define food chain give an example?
14. What is food web?
15. Define nekton and give an example?

Long Answer Questions (6 Marks)

1. Write about the pond ecosystem?
2. Discus the energy flow in ecosystem?
3. Describe the different zones of sea?
4. Write an essay on food chain in detailed?
5. Describe the food web?
6. Describe the limnology of pond ecosystem?

Unit - 4

Soils.

Structure

4.1 Introduction to Soil

Soil is one of the most important ecological factors. Plants depend for their nutrients, water supply and anchorage upon the soil. Even for the free floating aquatic plants which derive their nutrients dissolved in the water medium around them, soil (mud) as chief storage of all the nutrients, which are made available to the water medium. Soil system is indeed very complex and dynamic; undergoing continues change, and the rates of such change being influenced by a number of other factors of the environment. Marsden-Jones Tussil after growing plants is different types of soil concluded the soil may affect plants by affecting seed germination, size of the erectness of the plant, vigour of the vegetative organs, woodiness of stem, depth of root system, susceptibility to drought, frost and parasites, number of flowers per plant, and the time of flowering etc.,

Soil can be defined as the organic and inorganic materials on the surface of the earth that provide the medium for plant growth. Soil develops slowly over time and is composed of many different materials. Inorganic materials are those materials that are not living, including weathered rocks and minerals. Weathering is the mechanical or chemical process by which rocks are broken down into smaller pieces. As rocks are broken down, they mix with organic materials, which are those materials that originate from living organisms. For example, plants and animals die and decompose, releasing nutrients back into the soil.

The study of soils is known as Pedology.

4.2 Definition and Composition of Soil

Any part of the earth's surface that supports vegetation also bears a covering of soil. Soil is thus usually defined as any part of earth's crush in which plants root". As we know that soil is actually formed as a result of long-term process of complex interactions leading to the production of a mineral matrix in close association with - interstitial organic matter-living as well as dead. Soil is thus not merely a group of mineral particles. It has also a biological system of living organisms as well as some other components.

SOIL FORMATION

Soil is formed by the interaction of several mechanical forces such as oxidation, carbonation, hydration, solution, temperative, effects and the effects of bacteria, fungi and other animals on rocks. The forces which are responsible for the decomposition of rocks under natural conditions are not get known fully. The earth's crust composed of minerals is said to give way due to oxidation. Carbon dioxide is credited with the power of weathering the rocks. Water by its solvent action plays a major part as a weathering agent. It is also responsible for effecting chemical changes. Fission among the rocks is effected when the temperature is lowered particularly below the freezing point of water. The temperature by its influence on chemical reaction helps the disintegration process of rocks. Bacteria and lichens pave way for the colonization of other organisms. Earthworms, millipedes, burrowing mammals bring about an admixture of soil and they serve to aerate the soil as well as to increase the water holding capacity of the soil. Thus soil is a complex system to living and non-living components. It is an example to illustrate the intimacy of the organism with the environment. .

There are three basic types of soil: Sand, silt and clay. But, most soils are composed of a combination of the different types. How they mix will determine the texture of the soil, or, in other words, how the soil looks and feels.

Sand: Sand within soil is actually small particles of weathered rock. Sand is fairly coarse and loose so water is able to drain through it easily. While this is good for drainage, it is not good for growing plants because sandy soil will not hold water or nutrients.

Silt: Sift can be thought of as fine sand, and it will hold water better than of dry silt in your hand, it could feel almost like flour. If you were to add water to the silt in your hand, it would do a fair job of holding the water and feels slick and smooth.

Clay: Clay is very fine soil. Its particles are even smaller than silt, so there is very little space between the fine grains for air or water to circulate. Therefore, clay does not drain well or provide space plant roots to flourish. If you were a former, you would not want your field to be mostly clay. However, if you were a potter, you would think clay was the best type of soil. When moisture is added to clay, it can be molded into shapes, such as pottery bowls or a building brick.

Loam: Loam is the fourth types of soil. Even though it is a combination of sand, silt, and clay. It is the gardener's favorite kind of soil. Among all these three types of soil, this loamy soil is more suitable for farming. Loam soil is also referred to as an agriculture soil as it includes an equilibrium of all three types of soil materials being sand, clay and silt and also happens to have humus. Apart from these, it also has a higher calcium and pH levels because of its previous organic material content

Soil Components:

1. **Mineral Matter:** A matrix of mineral particles derived by varying degrees of breakdown of the parent material-rock.

2. **Soil organic matter or humus:** An organic component derived from long and short-term addition of material from organisms growing above and below ground i.e.,plants, animals, microorganisms.
3. **Soil Water/ Soil Solution:** Water contained in soil together with its dissolved solids, liquids and gases. Soil water is held by capillary and absorptive forces both between and at the surface of soil-particles. Soil water in reality is a dilute solution of many organic and inorganic compounds, which is the source of plant mineral nutrients.
4. **Soil Atmosphere:** It occupies the more space between soil particles, which at any time, is not water-filled. Its composition differs from the above ground atmosphere in the sense that it is normally lower in oxygen and higher in carbon dioxide content.
5. **Biological System:** To the above, there may also be added, the biological system, as each soil has a distinctive flora as well as fauna of bacteria, fungi, algae, protozoa, rotifers, nematodes arthropods.

4.3 Types of Soils

There is no humanity among the pedologists as to the classification of soil. Lyon and Buckman proposed six major types of soils, namely. Alluvial soils, Black cotton or Regur soils, Red soils, Laterite soils, Mountain soils, Desert soils.

Alluvial Soils:

These soils are formed by river systems through deposition of fine grained sediments. There soils are of two types, the older alluvium and the newer alluvium. The older alluvium is more clayey and darker colour whereas the newer alluvial is generally sandy in texture and -light coloured. In general, alluvial soils are rich in lime and potash but deficient in nitrogen and organic content. Phosphorus is also deficient in some areas.

Black cotton or Regular soils:

Black soils have developed over Deccan lavas, gneisses and granites under semi-arid conditions. The soils are tropical chenozems with vary in colour from deep black through light black to chestnut. Their black colour largely due to the fine iron content. The texture of black-soils is mostly clayey and are known for high moisture retentive capacity. During hot weather period, these soils deep cracks are the fields which help in their aeration and absorption of nitrogen from the atmosphere. During dry period, they are hard baked and during rainy period, they are sticky and as a result difficult to work and tillage. Black-soils are well-known for their fertility. They give good yields with less manuring. Block soils are ideal for dry farming due to the moisture tentative capacity.

Red Soils:

Red soils derived from weathering of crystalline and metamorphic rocks specially in the low rainfall conditions. These soils are generally - characterized by lighter texture with porous and friable - structure; absence of like, konkar and free carbonates and presence of soluble salts in a small quantity. There are deficient is nitrogen- humus. Generally these soils are less fertile and are deficient in nitrogenous and organic matter and phosphoric acid. Red soil are airy and need protective irrigation for successful cultivation. All kinds of crops are grown on red soils.

Laterite Soils:

Laterite soils are formed under the conditions of high temperature and rainfall with alternative, wet and dry seasons. It leads to the lee'-hing away of the much as silica from the original rock. Those soils are composed of a mixture of hydrated oxides of aluminum and iron. The soil consists of honey-combed mass iron oxides in nodules form which turns black after exposure to rain. Literate are very poor in fertility and deficient in nitrogen, organic matter, potash, lime and magnesia contents. Due to very poor fertility status, there soils generally support postures and scrub forests. In agricultural sector, when these soils are manured and irrigated they support tea, coffee, rubber and coconut plantation

Mountain Soils:

The soils in the mountains posses a variety of soil texture, colour, profile and degree of development. They are the immature soils usually deficient is nitrogen, phosphorus and humus. Because of low chemical weathering and mass movement, the mountain soils are immature and skeletal which are of low fertility. Suitable for orchard crops, forest trees and plantation crops.

Desert Soils:

These soils are formed under the arid and semiarid conditions. They include wind blow loss formations. They are very light consisting of Aeolian sand with high soluble salt content and very low humus content. They are also mostly arable and low in moisture content. Rich in phosphate content but poor in nitrogen. These sandy soils are very poor fertility but very high in salinity which restrict the growth of variety of crops. Suitable for high salt tolerant crops, such as barley, grape and cotton and also for medium salt tolerant crops like wheat, millets, maize, and pulses.

The soil may also be classified into four groups:

Coarse textured soils*:* It consists mainly of sand and gravel and is capable of holding only a small amount of water.

Medium textured soil: It is composed of mixture of sand, silt and clay. Moderately fire textured soils: High proportion of stray is present in such soils.

Fire textured soil: It contains more than 40 percent of clay which is more stick and can hold more water and nutrients in it.

4.4 Soil Texture

Since soil influences the flora and fauna of the area, its texture Table 4.1 is of considerable ecological interest. Texture is determined by the size of constituent particles which have been named differently by the International Society of Soil Science.

Table 4.1: The diameter of soil particulars

S.no	Name of Particles	Diameter of Particles
1	Gravel	2.00 mm and more
2	Coarse sand	2.00 mm to 0.20 mm
3	Fine sand	0.20 mm to 0.02 mm
4	Silt	0.20 mm to 0.002 mm
5	Clay	Below 0.02 mm

Soils formed with various integrations of soil particles (Fig. 4.1) are of the following main types:

(i) Sandy soils mainly consist of sand particles. These are loose, dry and poor in nutrients. The water holding capacity of such soil is poor.

(ii) Clay Soils chiefly consist of clay particles. The day particles are of colloidal dimensions. They have high plasticity and possess high water holding capacity. Clay particles have very small interspaces between them so that neither water nor air can circulate freely. Such soils on getting water become water logged. Thus they are not suitable for plant growth.
(iii) Loam soils have sand, silt and clay particles in more or less equal proportions. Such soils are the most suitable for plant growth.
(iv) Sand barns soils are those spils in which sand particles predominate.
(v) Clay loam soils have a predominance of clay particles. Both sandy and clay loam soils are suitable for plant growth.
(vi) Silt loam soils have predominance of silt. On getting water, silt loam becomes water-logged with poor air circulation. Such soils are not suitable for plant growth.

Most soils are mixtures of the above mineral particles. Based on the proportion of various particles contained in them, soils can be grouped into the following five groups.

Table 4.2 : Percentage of Sand, Silt and Clay in Main Soil Types Percentage

S.No	Soil Class	Sand	Silt	Clay
1	Sandy soil	85-100%	0-15%	0-15%
2	Clay	0-59%	50-0%	31%
3	Loam	23-52%	28-50%	7-27%

4	Sandy loam	50-80%	0-50%	0-20%
5	Clay loam	20-80%	15-53%	20-30%
6	Silt loam	0-50%	50-88%	0-27%
7	Siltolay loam	0-20%	40-73%	27-40%

1. **Coarse textured soils -** These are loose soils consisting mainly of sand and gravel. These retain only a small amount of moisture and supply some nutrients to the plants.
2. **Moderately coarse soils -** These include sandy loam to very fine sand loamy.
3. **Medium textured soils -** These are mixture of sand, silt and clay. They hold enough water and nutrients.

4.5 Soil Structure

The primary soil particles i.e. sand, silt and clay, usually occur in the form of aggregates. The arrangement of these individual particles into defined patterns is called soil structure.

Natural aggregates are called peds whereas artificially formed soil mass is termed clod. Broken peds are called fragments.

Soil structure is influenced by texture, air, moisture, organic nutrients, microorganisms, root growth and soil chemical nature. The best structure for favorable physical properties of soil are crumby and grannular.

Abiotic Factors:

Physical Properties of Soil

Soil possesses many characteristic physical properties which can be studied under the following headings

Soil Density

Though the average density of soil is 2.65gm per ml, it varies greatly depending upon the degree of weathering. The spaces present between soil particles in a given volume are called pore-spaces. The percentage of soil volume occupied by the pore spaces is called porosity of the soil. The porosity of soil depends upon the texture, compactness and organic contents of the soil. The increase in organic matter increases porosity of the soil.

Soil Permeability

Soil permeability depends on the size of the ores. It is higher for the loose soil, which has large number of macro-pore spaces and is low in compact soil with micro-pore spaces.

Soil Temperature

Soil temperature is effected by its colour texture, water contents, slope, altitude of land and by climate and vegetation. Evaporation of water from soil makes it cooler. Black soils absorb more heat as compared to white soils. Sandy soils absorb more heat but radiate it out quickly at night than the loamy germination of seeds, normal growth of roots and activity of soil organisms require specific temperature.

Soil Air

Soil air is essential for the respiration of soil micro-organisms and underground parts of the plants. The oxygen present in the soil air is an important factor in soil fertility.

Soil water

The amount of water present in the soil (Fig. 4.2) depends upon several factors. Soil water has been classified into different categories which are follows:

1. Gravitational water (free water) - The water that moves downwards into the soil due to gravity pull is known as gravitational water. Such water is not available to plants.
2. Capillary water: This water is available to plants and is responsible for providing moisture and nutrient to them. It fills the spaces between the non-colloidal soil particles or forms film around soil particles and is held by capillary forces around and in between the soil particles.
3. Hygroscopic water: It is absorbed by soil colloids and is not available to plants.
4. Combined water: It is a small amount of water, chemically bound to soil minerals.
5. Water vapor: Some soil water present as moisture of water vapor in the soil atmosphere.

The total water present is the soil is known as holard and chreased is the amount of water available to plants and the remaining of water available ‘plants and the remaining water is terned as Echard.

Chemical Nature of Soil

1. Hydrogen ion concentration (pH)

The pH of soil depends on various factors. In pond mud’s, the decomposition of organic matter is slow due to lack of O_2. The H_2S, CH_4 and short chain fatty acids. These compounds make the condition acidic and lead to less productive. The release of essential nutrients at soil-water interface is greatly hampered due to low pH. pH range of 5.5 is highly acidic 5.5-6.5 moderately acidic, 6.5-7.5 nearly 7.5-8.5 moderately alkaline, 8.5 above (highly alkaline). However, moderately alkaline pH for soil has been considered favorable for fish ponds.

2. Phosphorus

The importance of available phosphorus in soil for increasing productivity is well recognized. The total phosphorus in soil is not so important owing to the fact the PO_4 ions in the form of calcium phosphate is insoluble in alkaline condition and (Ferric Iron phosphate) $Fe_2(PO_4)_3$ are $Al_2(PO_4)_3$ are insoluble in acidic conditions, rendering the phosphorus ion unavailable to the water. The available soil phosphorus (P_2O_5) below 3mg/l00gm (30ppm) as poor productivity, 3-6 mg/100gm (30-60ppm) as average, above 6-12 mg. /l00gm (60-120ppm) as high productivity and above l2mg/l00gm (120ppm) as excess are indicated.

3. Nitrogen

Nitrogen in soil is present mostly in organic forms as amino acids, peptides and easily decomposable proteins whereas the inorganic forms NH_4^+ and $NO_3$are utilized by green plants. The conversion of complex organic forms of nitrogen to simple inorganic forms are carried out the bottom

4. Organic carbon and C/N ratio

Compared to the mineral constituents of the soil, organic compounds are more varied and complex. Microbiologists believe that the bacterial activity depends not only on the carbon content but also on the ratio of C/N in the parent substance.

5. Calcium

Calcium is generally present in the soil as carbonate. The deposition of $CaCO_3$ in freshwater are referred as marl. The amount of exchangeable phosphorus in pond mud is inversely related to the marl organic matter. It was however, noted that no marked influence of exchangeable calcium upon productivity could be noticed.

Biotic Factors

Depending upon the size, the vast majority of organisms, found in soil are classified into four major groups, namely microflora, microfauna and macrofauna. The meso and macroflora, no doubt, rooted in the soil, occur above the surface of soil.

1. Microflora

The microflora of soil comprises of bacteria, blue green algae, soil fungi and actinomycetes fungi.

2. Microfauna

It includes animals with body size within the range of 20µ - 200µ. These include protozoans, mites, nematodes, rotifers, tardigrades, etc.

3. Mesofauna

This group includes micro-arthropods and insect larvae. These organisms play a great role in marketing the soil fertility. This size varies frim 2000µ to 1cm. i). Collembola, ii) Acarina (mites).

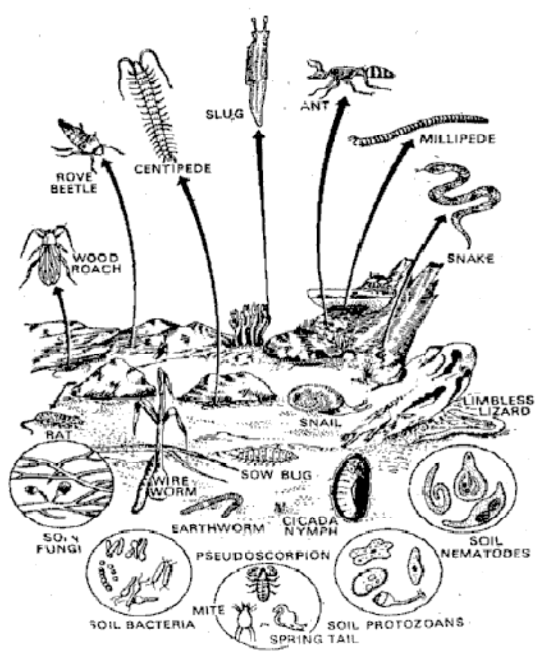


Fig 4.1 Soil Organism

4. Macrofauna

It includes those animals whose body size is greater than lcm. It includes earthworms, centipees, millipedes, pseudoscorpions, wood lice and insects belonging to different orders such as Psocoptera, Embioptera, Zapatero, Hemiptera and grasshoppers.

Summary

Soils defined as any part of earth's crust in which plants root. Muddy bottom of ponds, porous rock surfaces, ravines orgiacial-deposits, bottoms of lakes, peats etc., all are soils. The soil has five categories of components, mineral matter, soil organic matter or humus, soil water or soil solution, soil atmosphere and biological system of soil. Soil is formed by interaction of several mechanical forces such as oxidation, carbonation, hydration, solution, temperative effects and the effects of bacteria, fungi and other animals on rocks. The soils are six major types, alluvial soil, black cotton, red, laterite, mountain and desert soils. Soils also consists of both abiotic and biotic factors.

Short Answer questions (2 Marks)

1. Define soil?
2. Define pedology?
3. What types of soils are suitable for fish culture?
4. What is the suitable soil for fish culture ponds?
5. Write the two names of microfauna present in soil?
6. Define the 'capillary water'?
7. What is 'holard' and 'echard' water?
8. What are coarse textured soils?
9. What are moderately coarse soils?
10. What are medium textured soils?

Long Answer Questions (6 Marks)

1. Defines soil. Describe the soil texture?
2. Give an account of different soils?
3. Write about the suitable soils for fish and prawn culture?
4. Write about the chemical nature soilss?

Unit - 5
Biogeochemical Cycles and Aquatic Pollution

Structure

1.1 Introduction to biogeochemical Cycles
1.2 Gaseous, Sedimentary Cycles
1.3 Aquatic pollution and its effect on fisheries.

1.1 Introduction to Biogeochemical Cycles

Living organisms in the biosphere require about 30-40 chemical elements or nutrients for their normal growth and development. They are distributed in various compartments of the earth.

All these chemicals are tending to circulate in the biosphere in characteristic circular paths from non-living environments to living organisms and back to the environment. These circular paths are known- as “inorganic cycles” or “bio-geo chemical cycles”. The-cycling of these biogenic slats are quite essential for the working of any eco-system.

A bio-geochemical cycle may be defined as “the more or less circular paths, which bring about the circulation of chemical elements, including all essential elements of protoplasm, from environment to organisms and back to the environment.

In the circulation of these essential elements, each cycle has consists of 2 compartment or pools. They are:

a. **Reservoir pool:** Large, show moving, generally non-biological comportment, consists of the nutrients in an utilizable or non-utilizable form.
b. Exchange pool: Smaller, but more active, which under goes a rapid exchange of materials between organisms and to their immediate environment.

Characteristic features of the Biogeochemical Cycle

All biogeochemical cycle possessing certain characteristic features. They are

i. Presence of a geological, reservoir (Atmosphere, Hydrosphere or Lithosphere)
ii. Involvement of biota both in the cycling process and in the release of elements from the organic to inorganic world.
iii. Movement of the elements from the environment to the biota and back.
iv. Chemical changes occur in the process and
v. They cycling linked with natural, physical processes (wind, water currents, erosion, sedimentation).

5.2 Gaseous, Sedimentary Cycles

Basic, Types cycles broadly divided into two basic types.

Biogeochemical cycles broadly divided into basic types.

a) **Gaseous nutrient cycles:** In this the atmosphere acts as a major reservoir, where the nutrient accumulates. During The cyclic process, a little (or) no loss of the nutrients will be taking place. It consists of gaseous nutrients such as carbon, nitrogen and oxygen. There cycles can be considered as 'perfect' in the global sense, because of natural, negative feedback control.

b) **Sedimentary nutrient cycle**: In this cycles, the sedimentary rock (or) Lithosphere is acting as major reservoir. The cycle is slower and tends to excreta more limiting impact. It comprises of the sulplur and the phosphorus cycles. The circulation will be taken place through the agents like erosion, sedimentation, volcanic activity and biological transport.

The above two cycles are more (or) less dependent upon the 'hydrological cycle' for efficient transport matter through the biotic and abiotic compartments of the ecosystem.

As the water cycle plays a signification role in all biogeochemical cycles, the dissolved nutrients are carried from the earth's surface either into the soil (or) in to the oceans. Atmospheric nutrients are often brought to the earth surface by rain water. Nutrients held in rocks are gradually released by weathering, erosion through flowing water, and by freezing and defrosting of Ice. Nutrients are dissolved in water when they are absorbed into the roots of plants. Water is critical in accomplishing various chemical changes that nutrients experience as they pass through the bio and geo phases of the cycle.

5.2.1 Water / Hydrological Cycle

Water as a resource is present in extremely small quantities, when compared to that of the earth. Water covers 71% of the surface of the planet. The water is present, 97.5% in the form of ocean water and rest is as land ice, lakes, soil moisture, rivers, ground water and as the water content of the atmosphere. A large part of this water locked up in the form of land Ice.

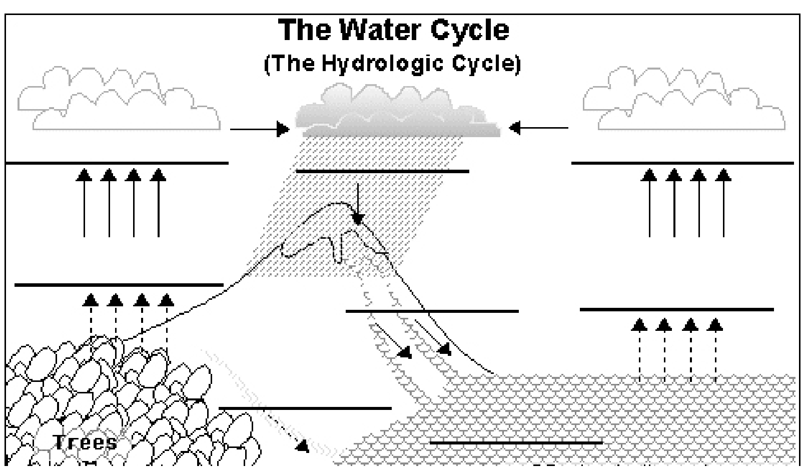


Fig. 5.1 Water cycle

The water in the atmosphere is limited, but it is very mobile and circulates continuously from air to land and sea and back to the atmosphere. This circulation is generally known as ‘hydrological (or) water cycle (Fig.5.1).

The water cycle is controlled by three main confounding factors like temperature, precipitation and evaporation. The energy that drives the cycle is obtained from the solar radiations, which intern brings evaporation of water. When the relative humidity in the atmosphere increases to saturation levels, precipitation takes place, there by the cycle tend to continues.

The water cycle can be defined by reservoirs and transport pathways.

Reservoir or pool

a. **Ocean Subsystem:** About 97.5% of the combined total liquid water, ice and vapour consist at present of ocean water. There is sonic exchange between ocean water. There is some exchange between ocean water and ice, and some leakage into the oceans as ground water. Output occurs through evaporation and input through runoff and precipitation.
b. **Ground Water system:** Ground water is contained in rocks and forms the water table. It has about one-fifth of the ocean water not contained in oceans. The amount increases with rainfall and decreases with drought.
c. **Lake Subsystem:** The lake subsystem contains about 0.1% of the water not contained in oceans
d. **Soil Moisture**: Includes water passing down to the ground water table and water taken into the substance of the soil.
e. **Rivers:** Storage in rivers involves only about 0.005% of the water not contained in the oceans.
f. **Atmosphere:** The atmosphere contains as much water as much water as rivers. Mean residence time is about 10 days.
g. **Biological Water:** Biological water amounts to an extremely small total and the residence time varies from is minutes to a lifetime.

Thus water as a resource of the earth-atmosphere system is limited. Most of it is locked In the form of water in the deep sea, ocean ice, and land ice, while the small amounts that are present in a utilizable form have to be recycle so that the ecosystems can function properly.

Cyclic Water

The water involved in the recycling process at any given time is called cyclic water. Precipitation on ocean surfaces amounts to 78 % of the cyclic water. The output of water from ocean and land surfaces is matched by inputs from land to ocean as run-off over the land surface, there is an exchange of water between the air and the ground. Evaporation delivers moisture to the air, but is compensated by precipitation back to the ground. A bout two-thirds of the precipitation over land originates by evaporation from the land surface, the other one-third coming from the oceans.

Local Cycling

In local cycling evapotranspiration occurs from water and land surface, as well as from plants. The return from the atmosphere occurs through precipitation.

Rain under most conditions does not fall directly upon the ground but is affected by branches and foliage of plants. This is termed as interception. Precipitation caught on vegetation can follow three possible routes. First, it can drip off the plant leaves to reach the ground beneath and so join the surface and soil water movement. This is known as through flow.

5.2.2 Carbon Cycle

Carbon is a basic component of all organic compounds, the buildings material of which all living things are constructed, Carbon is present in a variety of carbohydrates, fast, proteins and nucleic acids. The carbon cycle is essentially a perfect cycle in the sense that the carbon is returned to the environment about as fast as it is removed. It is an example of gaseous cycle as it involves a gaseous phase-the atmospheric carbon dioxide, the basic movement of carbon is from the atmosphere reservoir to producers, to consumers and from both these groups to decomposers, and then back to the reservoir i.e., the atmosphere. In atmosphere the concentration of carbon dioxide is about 0.03-0.04%. The main source of all carbon found in the living organisms is free atmospheric carbon dioxide and dissolved carbon dioxide in water (Fig.5.2).

The first step in the utilization of CO_2 by living organisms is photosynthesis by green plants. In photosynthesis, plants synthesize simple carbohydrate, which in turn are converted into polysaccharides and complex fats in plants. The polysaccharides and fats stored in plant tissues are eaten by animals, who digest and resynthesize these carbon compounds into others. Meat eating animals (carnivores) feed upon the herbivores and carbon compounds are again redigested and resythesized into other forms.

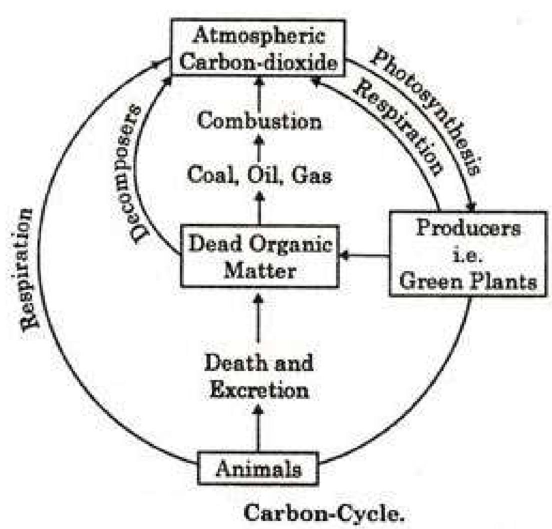


Fig. 5.2 Carbon Cycle

The respiratory of producers and consumers accounts for return of considerable amount of the biologically fixed carbon as gaseous CO_2 to the atmosphere. The carbon locked up in the animals wastes and in the protoplasm of the plants and animals is released by the bacteria and fungi when the former die.

Part of the organic carbon becomes incorporated in the earth's crust as coal, gas, petroleum, limestone, etc. The carbon present in such deposits is removed from the circulation for long periods of time. Some of the carbon dioxide from such deposits is liberated by our agricultural and industrial use of these products. Some of the co_2 is released from limestone by weathering.

There is a considerable interplay between atmospheric and aquatic CO_2 which is considered briefly as. The inter-change between the two phases occurs through diffusion. The direction of diffusion as dependent on relative concentrations in the two environments. The dissolved carbon dioxide reacts with water in the soil or an aquatic ecosystem to form carbonic acid (H_2CO_3). This reaction is reversible and may proceed both forward and backward. In turn carbonic acid dissociates in a reversible reaction into hydrogen (H^+) and bicarbonate (HCO_3^-) ions. The bicarbonate ion, gives hydrogen (H^+) and carbonate (CO_3^-) ions. The various reactions maybe summarized as follows:

Atmospheric $CO_2 <=> C+O_2$)

Dissolved $CO_2 + H_2O <=> H_2 CO^3 <=> H^+ + HCO_3^- <=> H^+ + CO_3^-$

Thus we find the carbon cycle is relatively a complicated one. Actually there are a number of inlets and outlets by which carbon can enter or leave the cycle. Collectively these various pathways constitute self-regulating feed-back mechanisms resulting in a relatively homeostatic system.

5.2.3 Nitrogen Cycle

Nitrogen is an essential element in the living substances like proteins and nucleic acids. Though the atmospheric air contains 79% nitrogen, yet most of the plants and animals cannot make use of this gaseous nitrogen. Animals must have their nitrogen in-the form of amino acids and plants in the form of soluble nitrogen salts like nitrates. From the nitrogen of soluble salts, plants manufacture their proteins and amino acids.

Essentially, the nitrogen cycle (Fig.5.3) involves about five main steps. (i) When any organism dies, or any leaf or tree falls, or when an animal excretes its waste products, the nitrogen compounds pass into the soil or into the water. (ii) Certain bacteria begin to break down these organic nitrogen compounds. In this process, organic nitrogen is converted into ammonia. Even in this form the nitrogen is of little use to the plants. (iii) The ammonia is converted into soluble ammonium ions (NH_4^+) as well as some ions with negative charge (NO^-_2). Recent researches have demonstrated that many higher plants are able to absorb and utilize ammonium ions as the major source of nitrogen. (iv) it is carried out in the soil by nitrifying bacteria. Some of these, like Nitrosomonas, convert ammonia into nitrates, Where others, like Nitrobactor, act on nitrites and convert them into nitrates. These nitrifying bacteria are all chemosynthetic autotrophs. (v) the highly soluble nitrates dissolved in soil water are taken up by the roots of the plants.

Another way in which nitrogen is made available to the plants for protein synthesis is by nitrogen fixation. Nitrogen fixing bacteria, such as Rhodospirillum, live freely in the soil. Other nitrogen fixing bacteria, like Rhizobium, grow in the roots if plants called legumes. These are symbiotic bacteria, which take carbohydrates and oxygen needed by them from the plant roots and fix nitrogen into nitrates for the use of plants.

The process of nitrifitcation in the open ocean and its sediments is very poorly understood at present. Some blue green algae, such as Anabaena and Nostoc, are reported to play a singnificant role in the fixation of nitrogen in the aquatic medium, other blue-green algae which can fix nitrogen include Gleotrichia, Enchinulata, Trichodesmium, Nostoc, etc. to name a few.

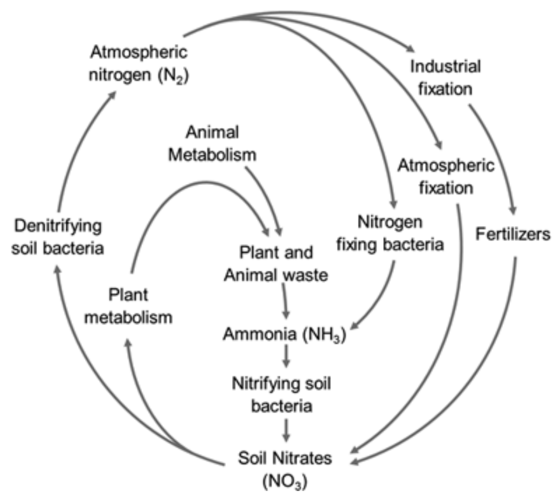


Fig.5.3 Nitrogen Cycle

There are yet other aspects of the cycling of nitrogen which could be assessed, among others, the role of volcanic action or sedimentation. Thus we find, the movement of nitrogen is by means unidirectional, unregulated, norenergy-independent. There are various routes available, each route is biologically and or non-biologically regulated and energy is released or consumed in each process these numerous self regulating, energy dependent, feedback mechanisms result in a steady state of nitrogen balance.

5.2.4 Oxygen Cycle

Oxygen is the life supporting portion of the earth's atmosphere. Our atmospheric air contains about 21% oxygen. It is also present dissolved in water. Oxygen is given out as a by product of photo-synthesis. Plants and animals utilize oxygen in respiration and return it to the atmosphere and water in the form of carbon dioxide. The carbon dioxide is utilized is utilized by green plants as an essential raw material for carbohydrate synthesis. In such a simple yet cycle, oxygen is replenished and maintained in the ecosystem (Fig .5.4).

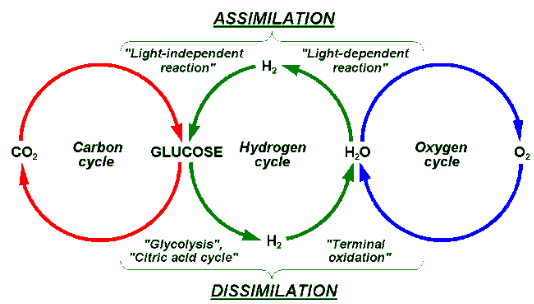


Fig. 5.4 Oxygen Cycle

RESERVOIR

The main reservoir of oxygen is the atmosphere, which contains about 21% of volume. This is equivalent to about 1.2×10^{18} kg of oxygen. Since this oxygen has been provided by green plants through photosynthesis, and because carbon dioxide transfers between the atmosphere and the biosphere correspond stoichiometrically to oxygen transfers in the opposite direction, the oxygen present in the atmosphere represents as graphite, coal, oil, gas and other carbonaceous compounds which have not been oxidized through respirations. The other two non-living sources of oxygen are water and carbon dioxide. In fact, a large amount of it the locked up as sulphates, carbonates, organic matter and ferric ions. However, these represent non-utilizable forms.

Transfer Pathways

Withdrawal of oxygen

a. **Respiration:** The main withdrawal of oxygen from the atmosphere by the biota is through the process of respiration. It has been estimated that the total oxygen requirement of the biosphere for respiration is about 246 billion tons annually.
b. **Decay:** A large amount of oxygen is also used up for the decay and Decomposition of organic compounds by various decay bacteria such as the nitrogen, sulphur and phosphate bacteria. This accounts for about 150 billion tons annually.
c. **Oxidation of rocks:** A varied amount of oxygen is consumed in the oxidation of rocks.
d. **Ozone formation:** A part of the oxygen is used up for the formation of ozone, but-the rates formation and break down are not available.

Return pathway

The main return pathway is the photosynthetic process occurring in plants and microorganisms. From the point of view of generation of organic material, the overall photosynthetic process consists of the formation of carbohydrates by the reduction of carbon dioxide, and oxygen is a by-product.

Since photosynthesis and respiration occur simultaneously it would appear that all the oxygen released through photosynthesis is consumed during respiration and decay. The overall photosynthetic process releases about 400±100 tons of oxygen annually into the atmosphere.

5.3 Aquatic pollution and its effect on fisheries

Environment pollution is a global problem and is common to both developed as well as developing countries. Environmental pollution is the result of urban-industrial technological revolution and speedy exploitation of every bit of natural resources. The oraze of progress in agriculture, industry, transportation and technology is taken as the general criterion of development of any nation. Such activities of man have created an adverse effects on the survival of man himself and other living organisms in the biosphere. Thus pollution is generally defined "the addition of the constituents to water, air or land, which adversely alter the natural quality of the environment".

Definition

The word 'pollution' derived from the latin word 'pollutionem' (meaning to defile or make dirty). The term pollution is defined as undesirable changes in our environment is known as **"pollution''** or any deviation from the natural composition of the environment which causes adverse effects is also describe as pollution.

Pollutant

The agents which cause to pollution are called pollutant. In general, Pollutants are residues of substances made by us, used by us and even thrown away by as waste products. Which pollute the environment in one way or the other.

1. Basing up on the basis of their forms of existence in the environment, they are

a. Primary pollutants: Those substances emitted directly from an identifiable source

b. Secondary pollutants: These are the substance, derived by primary pollutants by chemical reactions.

2. Basing on the ecosystem point of view,

a. Biodegradable pollutants: It includes domestic sewage, heat etc. that can be readily decomposed under natural circumstances.

b. Non-biodegradable pollutants: The substances, plastic, synthetic by micro organisms.

These include substances like heavy metals, aluminum cans, plastics, synthetic compounds such as pesticides, detergents and others.

Aquatic/Water Pollution

Modern civilization with its rapidly growing industrial units and an increase in the population, has led to an accelerated degradation of the freshwater resources. The water bodies are subjected to wide variety of human activities such washing, Swimming, bothing and waste disposal, disposal of industrial effluents etc., these modifies the environment of the natural waters, in a way that leads to a potential health hazard.

Water resources are said to be polluted, when because of man's activity in adding or causing the addition of matter to the water or altering the temperature, the physical, chemical (or) biological characteristics of the water are changed to such an extent that its utility for any reasonable purpose or its environmental value is demonstrably depreciated.

Types of Pollution

Kendeigh (1975) classified the pollution of aquatic bodies into four main types. They are:

a. Natural – Pollution brought about by naturally.
b. Siltling – Resulting from excessive erosion of the surrounding upland.
c. Industrial– Produced by inorganic chemical wastes from tarmeries, breweries, paper and mills, gas plants, mines, metal industries, petroleum industries etc.,
d. Organic municipal sewage and drainage of agriculture land.
e. Thermal –As hot water effluent from industries and atomic power plants.

Main Sources of Water Pollution

Discharge of solid or liquid waste products containing pollutants into surface or coastal water, or on to the land surface is the main cause of water pollution.

Main sources are identified as follows:

Sewage and Domestic Wastes

About 75% of water pollution is caused by sewage and domestic wastes. Organic pollution originates from incompletely digested sewage, which usually has some remaining biochemical oxygen demand (BOD) went it is released.

Industrial Wastes

All industrial plants produce some organic or inorganic chemical wastes, which cause water pollution. Sometime major part of the industrial waste is discharged directly into rivers, canal, and the sea, and not into the sewerage system. The largest volume of discharged waste is in the form of an "effluent", which may be solid, liquid, or gaseous product, in a treated or untreated condition. Industrial effluents may contain water, organic solvents, oils, suspended solids, and dissolved chemical compounds.

Pesticides, Fertilizers and Detergents

Major source of pesticides on the rivers, streams and likes is run-off from agricultural fields. The optimum condition for run-off is when there is heavy rainfall soon after the pesticide application. Pesticides also reach aquatic systems from discharge of industrial effluents into water. Pesticides can reach water in such effluents, either as waste from pesticide factories, or as discharge from factories.

Toxic Metals

Toxic metals are often described as the heavy metals, and these includes iron, lead, mercury, cadmium, zinc, copper, nickel and arsenic. Very small quantities or traces of some metals are required for normal growth and metabolism, for example, copper, iron, nickel and zinc. However, if the threshold limit value (TLV) is exceeded, these metals may cause variable deleterious effect on plants and animals.

Thermal Pollution

Thermal pollution may be defined as the warming up of an aquatic ecosystem to the point where desirable organisms are adversely affected. A large number of industrial plants (electric power, steel and chemical industries) use cold water, from the rivers and discharge it hot. A single 1000 MW power plant may use one-half million gallons of cooling water per minute. At some places atomic energy plants have become a major source of thermal pollution, which is harmful to fishes and aquatic invertebrates.

Effects of Water Pollution on Fish

Effects of Water Pollution on the different components of the biosphere are too many as are the sources of water pollution. The effects of water pollution may be consider an under the following six headings. However, many factors including the quantity and composition of the effluent, the value of water, and weather conditions govern the overall effects of pollution.

Physical Effects

a. Turbidity*:* Various types of suspended solid particles, discharged into water bodies, cause water turbidities are seldom, directly lethal to fish. But the turbidity may affect the productivity of an aquatic ecosystem, and also hampers spawning and growth of fish. Fish and some invertebrates suspended matter.

b. Heat: Other physical effects of water pollution include heat water discharge from power stations, causing arise in water temperature or the so-called thermal pollution. The rise in water temperature will lower dissolved oxygen content, and speedup the biodegrading of pollutant organic matter. Since each species has its own metabiolic rate, most aquatic animals can only exist within a specific temperature range. For example, trout are killed by temperature of over 25°C and their eggs will not develop in water above 14°C. Rivers affected by thermal pollution support only coarse fish. Raised water temperature vulnerability of fish to disease.

c. Oxidation Effects: Oxidation effects are caused by (a) bacterial action upon organic pollution and (b) through chemical oxidation of inorganic and organic substances present in industrial wastes. Both types of oxidation required the use of dissolved oxygen, thereby producing an increased BOD and COD. Fishes are usually eliminated for long distances by severe organic pollution.

Toxic Chemical Effects

Toxic chemical effects are caused by a range of substances that cause immediate or cumulative physiological changes in plants, animals and humans. Toxic are absorbed into the tissues from polluted water, and their effect varies with the type of chemical substance, the concentration in the tissues, and the metabolism of the organism.

Chemical toxics can be broadly described as (i) metals and salts, (ii) pesticides, (iii) acids and alkalies, and (iv) other organic compounds such as polychlorinated biphenyls or PDBs, phenols and cyanides.

Chemical Nutrient Effects

In the context of water pollution, the two most important nutrients are nitrogen and phosphors, usually present in all natural waters as nitrates and phosphates. The natural process of lake-ageing characterized by nutrient enrichment over a long period of time is called eutrophication.

When the process of eutrophication is speeded up by human activity, it is called cultural eutrophication. About 80% of the cultural eutrophication. About 80% of the nitrogen and 75% of the phosphorus added to lakes and streams in developed and developing countries has its source in human activities.

Pathogenic effects caused by Micro-Organisms

Inland coastal waters that receive sewage discharged and other water are a potential health hazard, as they contain pathogenic organisms. Fish diseases caused by bacteria are fin and tail rot, ulcer disease, dropsy and eye disease.

Fish are more prone to diseases in polluted water and the incidence of diseases in polluted waters and the incidence of disease can be minimized by improving sanitary conditions prevalent in the water and by good pond management.

Effects caused by Accumilation of Radioactive Substances

Radionuclides ultimately become concentrated in bottom living food organisms and produce deleterious effects on human body. However, close monitoring of radioactive pollution in necessary in order to assess their build up and harmful effects in fish, shell fish and crustaceans, which are used as food.

Industrial Pollution and Fisheries

At present, all the major rivers of India are polluted by a vast array of industrial effluents. Since these effluents have very low DO, high BOD and many types of toxic substances, causing various effects on the aquatic communities, including sudden fish kills and other ecological problems. All river systems of India are polluted by tanneries, textile, wood and jute mill wastes, besides effluents from sugar mills, distilleries, pulp and paper factories, synthetic rubber industry, fry ash from coal washeries and DDT factories. Industrial wastes from oil refineries, steel plants, paint and varnish manufacture plants, and cement and pesticide factories also pollute the inland wastes. The distillery waster of low pH and high oxygen demand created problems causing asphyxiation and mortality of fish. The industrial pollution not only degrades the natural water quality of streams and rivers, it also causes heavy losses of fishery.

Use of Fish as Biological Indicators of Water Pollution

Besides algae, macrophytes, and bethie macroinvertebrates, fish are considered excellent indicators of the water quality. The presence of a species indicates that the habitat is suitable, and since some of the environmental requirements are known for many species, their presence indicates something about the nature of the environment which they are found. A close examination of fish species if the river Ganga at Rishikesh-Hardwar, Garhmukteshwar, Kanpur, Patna, Bhagalpur, and Calcutta makes this point clear. Fish species which occur in the upland reaches of the Ganga are clean water forms adapted to living in cold waster (5°C to19°C) having high amount of dissolved oxygen (9ppm and more). *Barilis bendelisis*, *Puntius chilinoides, Schizothorax richardosnii*, and *Tor putitora* are a few example of coldwater fish. But as we gradually move downsteam, in the potamon zone, the shithsonic fish species are replaced by *Labeo rohita, Catla catla, Cirrhinus mrigala, Notopetrus notopetrus* and *Bagarius*, etc. Further downstream we find *Channa marulius, Macrognathus aculeatus, Labeo gonius, Gadusla chapra,* and several other species adopted to resisting low dissolved oxygen concentration and high temperature and pollution load.

Pollution of any kind usually affects both abiotic and biotic environment of fishery waters. The interrelationships between the fish and the elements of its abiotic and biotic environment are interdependent, any changes in one system of relationships inevitably produce changes in the other. The interaction of fish with any particular elements of its environment/total environment / the effect of total environment is greatly depends upon the condition of the fish itself.

The topic of water pollution and fish will continue to be a subject of zero interest and inquiry for future generations of fish biologists, fishery scientists and limnologists.

Prevention and control of water pollution:

Treatment of effluent aims at the removal of BOD, COD, chemicals, solids (dissolved and suspended), pathogens and the oxidation of the effluent. The treatment process is generally divided into three stages.

Primary treatment

The primary treatment includes screening, griding, flocculation and sedimentation involving physical systems. The screening system uses wire meshes with a range of spacings, which screens out larger particles. The next step involves waste aeration using high powered aerators. Apart from oxygenation of the waste water, it also results in the violent agitation of the water. The process results in the flocculation of smaller suspended particles, which settle out rapidly. In this phase the BOD and COD is reduced considerably through oxygenation. The chemicals present are oxidized and precipitated. Phosphorus is also precipitated in this stage and the processes used are pre-precipitation, simultaneous precipitation, post precipitation and contact filtration.

Secondary treatment

In the secondary treatment, both the anaerobic and aerobic phases are utilized. Here the waste water from the first phase is passed into closed tanks where putrefaction of the sewage takes place. The second step involves the trickling of the waste water over a bed of clinker and stones. The fluid passes as a trickle, so that the interstices remain full of air, and oxygen is readily available. The microorganisms enhance the oxidation of the organic matter. The decomposition and oxidation processes are carried out by bacteria, fungi, algae and protozoans. The primary and secondary treatment causes a reduction of about 90% BOD, 80% COD, 50 % total nitrogen, 30% total phosphorus and 90% suspended matter.

Tertiary treatment

Tertiary treatment aims at further purification of the waste water. The aerobic and anaerobic biological liquid waste treatment processes just discussed are designed to reduce the BOD of biodegradable organic substrates and oxidizable inorganic compounds. Tertiary treatment is designed to remove non-biodegradable organic pollutant and mineral nutrients, especially nitrogen and phosphorus which are involved in eutrophication of water bodies.

Oxidation ponds

At present, a sysmiotic method is being utilized whereby water with sewage pollutants is passed through a series of tanks. The first is the settling tank, where the sewage settles down. The second is the putrefaction tank where oxidation of organic matter takes place by bacterial action and the oxygen requirements are furnished from a third tank containing stable algal cells such as Chlamydomonas, Scenedesmus, Euglena, Chlorella, and others. There algal cells provide oxygen through photosynthesis, and in turn receive nutrients of value liberated through bacterial oxidation from the second tank.

Summary

Biogeochemical cycling is the movement of materials from global biosphere through biochemical reactions including exchange of elements between the biotic and abiotic portions of the biosphere.

There are two main types of biogeochemical cycles, gaseous in which the atmosphere is the major reservoir, and sedimentary in which the lithosphere serves as the reservoir, These are closely tied to the water cycle. The prime force in the movement of these cycles are the solar radiation which moves the water cycle through evaporation and precipitation processes, and the biotic cycle via the food chain.

The water cycle is driven by heat received from the solar radiations, and regulated by evaporation and precipitation. The cycle may be differentiated into global and local cycles. The water cycle drives the biogeochemical cycles of elements and nutrients, controls the climatic feature of the earth, and modulates the salinity and hydrodynamics of the oceans.

The reservoir origin by volume and withdrawn. It moves from this reservoir occurs through respiration, decay, oxidation of rocks, and ozone formation. The main return pathway is photosynthesis. The oxygen thus produced comes from the photolytic splitting of water.

The carbon cycle is the simplest and the most perfect gaseous cycle since carbon is returned as fast as it is withdrawn. It moves from the producers, to consumers, and then to decomposers which return it to the reservoir. The main reservoir of the carbon is the atmosphere. Withdrawal occurs through photosynthesis, calcium carbonate precipitation and deposition of marine organic sediments. Return of carbon dioxide to the reservoir is brought out by respiration, decay of organic matter etc.

Nitrogen cycle is a typical gaseous cycle. The major reserve of nitrogen is the atmosphere. It is an essential element for the biosphere, because it is necessary in the formation of nucleic acids, amino acids and proteins. Since dinitrogen cannot be used directly, various microorganisms convert it in a step-wise manner, into utilizable forms. These are taken up by plants and chemical through the food chain. The return of dinitrogen to the atmosphere from dead material and wastes is also controlled by microorganisms.

Pollution is defined as the addition or the presence in the environment of one or more contaminates in such quantities and of such duration which tends to alter the physical, chemical or biological characteristics in a way that it becomes injurious to human health or welfare, animals or plant life. Pollutants are grouped into two major categories, primary and secondary pollutants.

Like pollution of air and water land pollution is slowly increasing. Pollution of water bodies affects all the biotic communities, including fish. Main sources of water pollution are sewage and domestic wastes, industrial wastes, industrial wastes and effluents, pesticides, fertilizers etc.

Fish are excellent indicator of water quality parameter such as fish population size, growth rate, condition factor and diversity is also indicative of the total health of water.

Short Answer questions (2 Marks)

1. Define bio-geo chemical cycles?
2. What is the percentage of Nitrogen and Oxygen in atmosphere?
3. What is the Nitrification?
4. Name the Nitrifying the bacteria in the nature?
5. In which form the Nitrogen was utilized by the plants?
6. Define pollution? Write the two sources of water pollution?
7. Expand ‘BOD’ and ‘COD’.
8. Define ‘Eutrophication’?
9. Mention the names of cities that polluted the river Ganga?
10. Define thermo pollution?

Long Answer Questions (6 Marks)

1. Describe the Nitrogen cycle?
2. Give an account on Carbon cycle?
3. Define the pollution and describe the water pollution?
4. Write about the effect of water pollution on fisheries?

Unit - 6

Skeletal System of Fish and Prawn.

Structure:

6.1. Skeleton of Fish.

6.2. Skeleton of Prawn.

Introduction to Skeleton.

The hard parts or the supporting structures of an animal constitute skeleton. The skeleton of vertebrates is of two types namely. 1) exoskeleton and 2) endoskeleton, but invertebrates have only exoskeleton.

Exoskeleton: (Gr, exo = outside, skeleton=hard). It is the skeleton present outside the body or within the limits of the skin. It is in different forms among vertebrates. In fishes the exoskeleton it in the form of scales. It is mainly protective in function.

Endoskeleton (Gr, endo = within, skeleton=hard). The skeleton present inside the body beneath the body muscles constitutes endoskeleton. It is mesoderm in organ. Endoskeleton is made of cartilage and bone. Initially it is laid down in the form of cartilage in the embryonic stage. Some of it remains as cartilage throughout life. But most of the cartilage throughout life. But most of the cartilage is replaced by bones. The bones are of two types based on the nature of development. 1. Cartilage bones 2. Dermal bones.

Cartilage or replacing bones are formed by threw ossification of pre-existing cartilage of embryonic stage. Most of the bones of appendicle skeleton are replacing bones. Dermal or membrane bones are formed by the ossification of connective tissue of dermis. Such bones invest the cartilages and are also known as investing bones. These bones does not pass through cartilage stage. Bones of the axial skeleton are mostly dermal in nature.

The key features of Prawn skeleton are that it is an exoskeleton that covers the entire body of the prawn and is made up of chitin, which is a type of sugar. The exoskeleton is absent in prawn while it is the animal of invertebrate.

6.1 Skeleton in Fishes

Endoskelton: The endoskeleton in fishes is mainly bony and is well differentiated into axial and appendicular bones. The axial part includes skull, vertebral column and ribs, whereas the appendicle part includes pelvic and pectoral girdles with their related fin skeleton.

Axial skeleton

Skull:

Skull is cartilaginous in the beginning and then after undergoes ossification and turns bony. The skull comprises cranium and visceral skeleton.

Cranium

The posterior most part of cranium is the occipital region which is made up of four bones supra occipital, basiocciptal, and two exooccipitals. In addition there are three apertures in the occipital region a small median foramen magnum and two large lateral oval fenestrae characteristic of cyprinoid skulls (Fig.4.1 & 4.2). Dorsally supraoccipital is overlapped by the parietals which lie in front. The supraoccipital bears dorsally a median longitudinal vertical occipital spine. Basioccipital is found below the two lateral exocciptals. The dorsal process of ex-occipital meets that of the other side to enclose the foramen magnum dorsally.

The major part of roof of skull is composed of parietals and frontals. There is a pair of parietals above, parasphenoid below and paired alisphenoids on the side. A pair of frontals above, parasphenoid below and paired orbitosphenoids on the sides.

The floor of the skull is composed of parasphenold. There is no bassispheroid. The frontal articulates with the mesethnoid medially. The nasal and the ectoethmoid laterally, supraobital, anterio laterally and post frontal, postero-laterally.

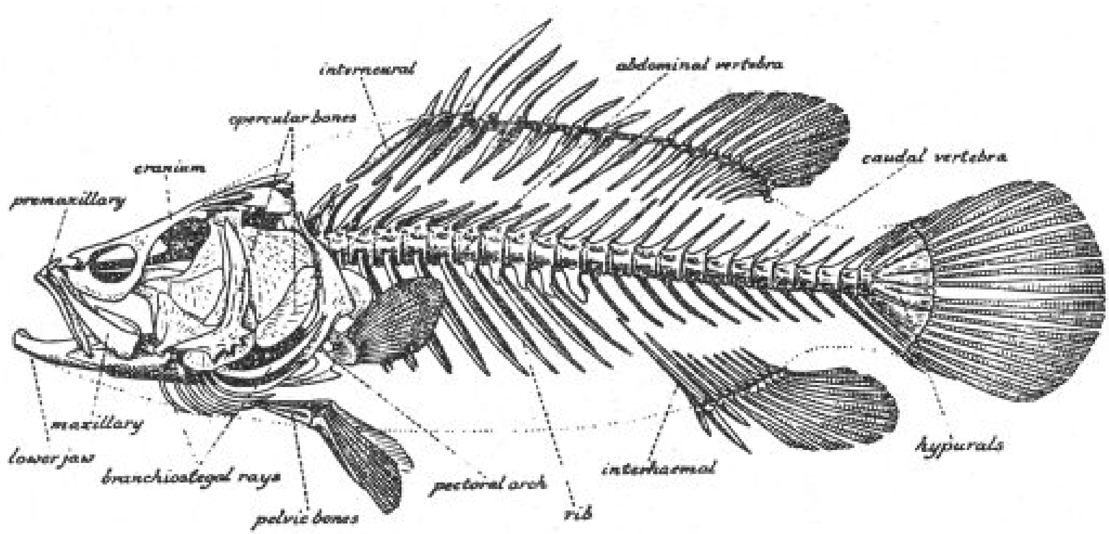


Fig: 6.1 skeletons of bong fish.

Visceral Skelton

The visceral skeleton is made up of several pairs of visceral arches. Among these, first pair is the mandibular, second pair is the hyoid and five brachial arches. The mandibular arch forms the upper and lower jaws.

The upperjaw consists of premaxilla, maxilla, palatine. Metapteryoid and quadrate. Similarly lower jaw consists dentary angular and articular bones. Teeth are never developed on these jaw bones in Labeo. The hyoid arch is formed of hyomandibular dorsallu and the epihyal, the eratohyale and the hypohyale ventrally. The posterior corner supports the tongue and the floor of mouth cavity. The last five pairs of visceral arches are called the gill or branchial arches. First four branchial arches bear gill lamellae while the last one is without gill lamellae. Typically, each arch is made up of four components; Hypobranchial (ventral), ceratobranchial (ventro lateral), epibranchial (dorso-lateral) and pharyngobranchial.

Jaw-suspension in fishes

The lowerjaw in embryos appears as the Meckel's cartilage ventrally to the upper jaw. The cartilages of each side meet ventrally with each other to form the skeleton of the lower jaw. While the upper jaw braces against the chondrocranium the lower jaws gets movably attached with the upper jaw. The hyoid arch also contributes to the bracing of mandibular arch and forms a jaw hyoid complex. Such complexes technically called jaws spension occur in three different forms in fishes, as described below.

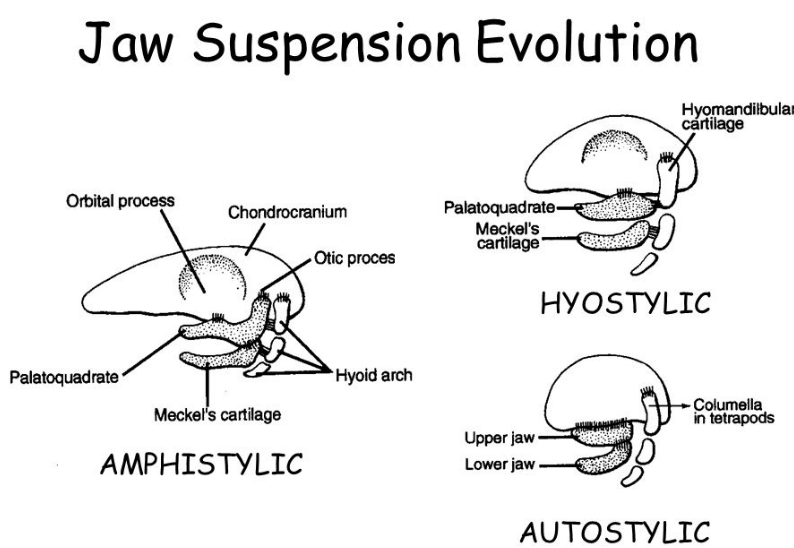


Fig.6.2 Jaw Suspension in fishes

Both the platoquadrate and the hyoid arch connect with the basal and the otic processes of the chondrocranium directly, with the help of ligament's Such an arrangement is regarded as a primitive type and found in ancient acanthodians, crosspterygians and in early sharks (Cestracion. Hexanchus Heptanchus) (Fig.6.2)

Hyostylic jaw suspension

The jaws are suspended to hyomandibular by means of ligamentous connection, and only the hyomandibular attaches to the otic region of the skull. Thus a direct articulation of jaw with the cranium is lost. Such a condition is found in all the extant sharks (Fig.6.2)

Autostylic jaw suspension

This type of jaw suspension appears to have been derived from an amphistylic ancestor. The platoqudrate either articulates or fuses with the chondrocranium and hyomandibular plays no role in bracing the jaws. Such a type of self bracing of jaws is found in lung fishes and chimaeras (Fig.6.2)

Holostylic jaw Suspension

This type is a modified kind of autostylic arrangement. The platoquadrate fuses indistinguishably with the chondrocranium, and the Meckeli's cartilage with the basal part (quadrate) of the platoquadrate. Such an arrangement is found in holocephalians. The platoquadrate in placoderms fuses with the dermal armor covering the cheek.

Vertebral column

Vertebral column is comprised of 37 or 38 well ossified amphiceolous vertebrae. The embryonal notochord in adult is replaced by the centre of a vertebra, but in sturgeon it persists primitively unchanged throughout the life of the fish. All the vertebrae of adult form a long and stiffened, rod like vertebral column that extends from behind the skull of the tip of the tail.

Typically a vertebra (Fig.6.3) consists of a centrum, arches and various processes. The centrum lies immediately under the neural tube. It is concave at both the ends (amphicoelous) and the spaces between them contain the notochordal tissue. Acentrum gives rise to a pair of meural arches dorsally, and a long neural spine, and encloses a space between them the neural canal to lodge the neural tube. Hemal arches similarly meet ventrally and from the hemal spine and the hemal canal.

Many variations are found in the vertebral columns of the bony fishes. The chondrostean Polyterus, has well developed bony vertebrae. Each vertebra has provide surface for articulation of rib in the trunk region and form definite hemal arches in the tail region.

The vertebrae of teleosts are completely ossified with amphicoelous centrum. They often bear a small canal in the centre for much reduced and compressed notochord. The concavities of centrum are filled with pulpy material derived from the degeneration of notochord. In eels, the centrum tends to becomes flattened at each end (amphiplatyan) and sometimes even bear a convexity in front. From the centrum arise the neural arches, which are differentiated for the first time in bony fishes into an anterior pre-end a pro-end a posterior post zygapophysis. Hemal arches are much reduced (parapophyses) in the trunk region, but provide enough surfaces for the attachment of ventral ribs. Behind, in tail region the hemal spine is formed in the usual manner.

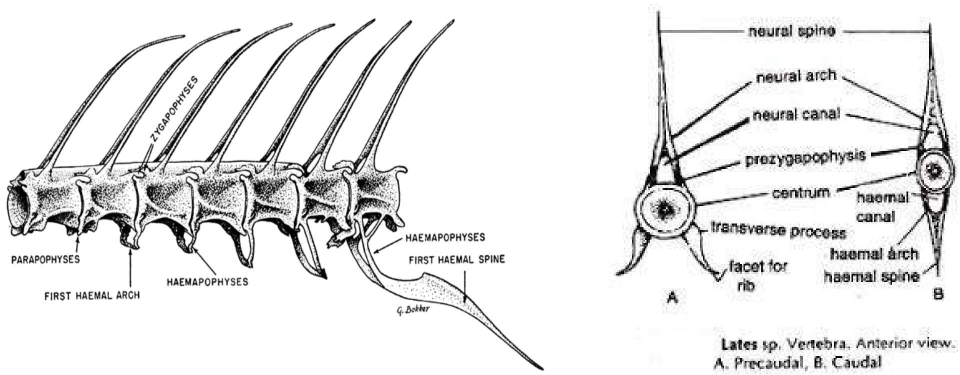


Fig.6.3 Vertebrae of teleost

In many fresh water teleosts, a complex vertebra is formed by the fusion of a anterior vertebrae of the spinal column. These vertebrae are devoid of parapophyses (lateral projection) and serve to connect to the air bladder with the internal ear.

The vertebrae can be distinguished into an anterior complex vertebra, typical trunk vertebrae, precaudal and caudal vertebra, on the basis of modification of various processes arising from the centrum.

Appendicle skeleton

In includes mainly the bones of pectoral and pelvic girdles. The pectoral gridle lies just behind the last branchial arch. It is made up of two lateral halves. These lateral halves do not meet in the middle. Each half of the girdle consists of a dorsal scapula and a ventral coracoid. Thy glenoid cavity is developed at their common meeting points. The pectoral fin skeleton includes four radials a pterygiophore facet at one end while their other ends carry dermal fin rays.

The pelvic girdle lies in the ventral abdominal wall anterior to anal fin. Both the haves of the girdle meet in the middle. Each half is composed of a large basipterygium or pelvic bone. Its anterior broad part with forked end is connected in front by a ligament to the ribs of the 12th trunk vertebra. The posterior narrow rod like part taper behind into a small cartilage and unites with the fellow of the other side in the mid ventral line.

The pelvic fin skeleton includes three radials, carrying nine dermal fin rays which are long and jointed**.**

Exeoskeletin of fish:

The body of a fish is covered by minute or large scales which are formed from the dermis of the skin and hence known as **dermal scales.** Some species like Polyodon and Acipenser will have scales or plates only at some localized regions of the body. Placoid scales are the characteristic of the chondrichthyes; ganoid scales are found in primitive bony fishes; cycloid scales and ctenoid scales are found in the higher teleports. Cycloid and ctenoid scales are helpful in determination of the age and growth rate of fishes. The presence of the scles all over the body is characteristic of fishes and their absence in certain fishes to be regarded as a secondary feature. The fish scales are of various shapes and sizes and are usually composed of substances similar to bone. The most primitive types of scales are made up of dentine, covered with enamel like material.

Types of scales:

Scales first appeared in ostracoderms in which the entire body including the head, and a covering of minute denticles like those of the shark. But they were very primitive, being composed of dentine with only a trace of enamel on the surface and were merely hollow cones without the basal plates. Scales in fishes are of 6 types.

1. **Placoid scales:** These are characteristic of the elasmobranches fishes (e.g., sharks). The placoid scales are the minute dermal denticles arranged in regular oblique rows on the skin. They are similar to the teeth in structure and are actually considered as specialized teeth.

   Each placoid scale has a diamond shaped **basal plate** and a **trident spine.** Basal plate remains embedded in the skin. Lower surface of the basal plate has an opening, which leads into the **pulp cavity** of in the spine. Pulp cavity contains puop which is forme3de by blood capillaries, nerves, lymph channels and **odontoblasts** of dermal organ. Odontoblasts secrete **dentine,** which forms the trident spine. It lies outside the skin and is backwardly directed. Dentine of the spine is covered by a layer of **enamel,** secreted by epidermis.

The placoid scales arise from the dermal papillae covered by the epidermis. The odontoblasts of the dermal papillae produce the dentine of the scales and the epidermal cells secrete the enamel over dentine. Among the cartiainous fishes, the scales are absent in chimaeras.

2. **Cosmoid scales:** These scales were present only in the extinct fishes of Crossopterygii and Dipnoi and were entirely dermal in origin. Each cosmid scale consists of three layers, viz., an outer layer of **cosmin** (akin to dentine), a middle layer of spongy vascular **bone** and an inner layer of **isopedine** (with several laminae of bone). The cosmid scale appears to be a

primitive type found among the early fishes. Their structure suggests that they had been formed by the fusion of a number of placoid scales to a bony dermal plate.

3. **Ganoid scales:** These are characteristic of all ganoid fishes and primitive Actinopterygii. They are more or less like cosmid scales and are in fact derived from them. Each ganoid scale has a vascular layer and an isopedine layer, but the layer of cosmin is absent. On the other hand, each scale is covered above and below with a hard shining substance known as ganoin. In *Lepidosteus,* the ganoid scales are rhomboid in shape. They form a complete armour all over the body. In *amia,* ganoid scales are found on the head, while the rest of the body is covered by cycloid scales.
4. **Palaeoniscoid scales:** These scales are found in *Polypterus.* In structure, it is intermediate between typical cosmoid and ganoid scales. It has an inner layer of lamellate bone (isopedine), a middle layer of cosmin and an upper hard layer of ganoin. However, the scale is most similar to the ganoid scale and is not generally considered as a separate type.
5. **Cycloid scales:** Cycloid scales are found in the modern bony fishes. They are thin and rounded and the bone of the scales is arranged in a series of rings. The scales are dermal in origin and are not provided with enamel. They are distinguished by smooth and free margins (in contrast to the ctenoid scale with a comb like or spiny margin). They are marked by concentric rings called lines of growth, which are continuously added on as the scales enlarge. They lie in the dermal pockets below the epidermis and grow throughout the life of the fish. The concentric rins indicate the periods of growth and the age of the fish can be determined from these rings. Cycloid scales are found in the Dipnoi and in many other bony fishes.
6. **Ctenoid scales:** Ctenoid scales occur in a majority of bony fishes. They closely resemble cycloid scales in structure. They are also thin, flat and rounded plates of dermal origin. They are formed of a hard material akin to bone and are not provided with enamel. They are also marked by concentric rings which increase in number with age and thus help to indicte approximately, the age of the fish. The ctenoid scale differs from the cycloid scale in having small teeth at its free margin. The cycloid and ctenoid scales are called Leptoid scales due to evolution of scales and also called as bony ridge scales.

Peculiarites

In some fishes like the *Tetrodon,* the scales are replaced by movable spines all over the body. In *Ostracion* (coffer fish), the body is covered with hexagonal plates united to form a bony nox. In *Pleuronectes,* ctenoid scales are found on the upper surface and cycloid scales on the lower side.

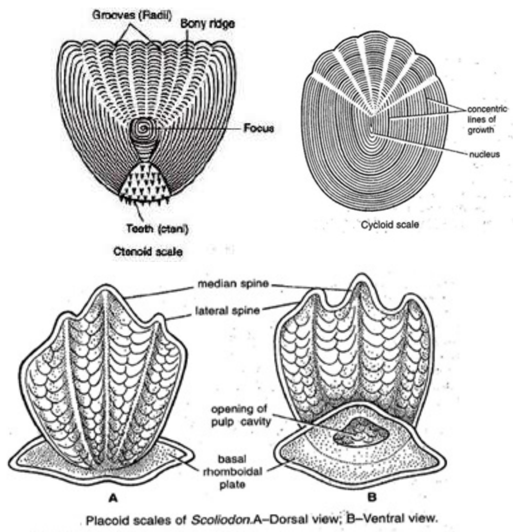


Fig 6.4. Scales in Fishes

Bony ride scales

The cycloid and ctenoid scales are also known as bony ridge scales. Majority of the teleostean fishes possess these scales. They are thin, flexible transparent structures due to the absence of the first and middle layers of other types.

These scales exhibit characteristic ridges alternating with groves and generally the ridges are in the form of concentric rings. The central part of the scale is called the locus and is the first part to develop.

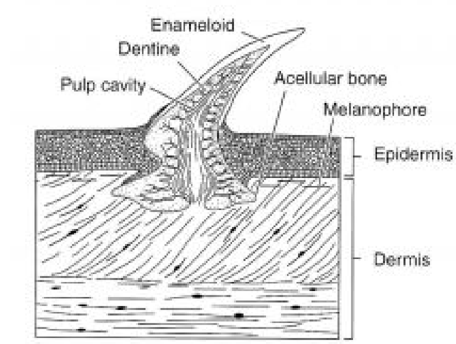


Fig.6.5 Development of Placoid scale

6.2 Skeleton of Prawn

Shape and size and coloration

Body is elongated. More or less spindle-shaped and bilaterally symmetrical. It offers least resistance in swimming. Size of adult varies from species from species to species. *Macrobrachium malcomsonii,* found in Central India and Tamil Nadu measures 25 to 40 cm in length. The giant prawn *p. carcinus* from Kerala is up to 90 cm long. While the dwaf prawn *p. lamarrei*, found almost throughout India, is 25 to 50 cm long. Young stages are translucent and white, but the adults are differently tinted according to the species. Usual colour is dull pale-blue or greenish with brown orange-red patches. Preserved specimens become deep orange-red.

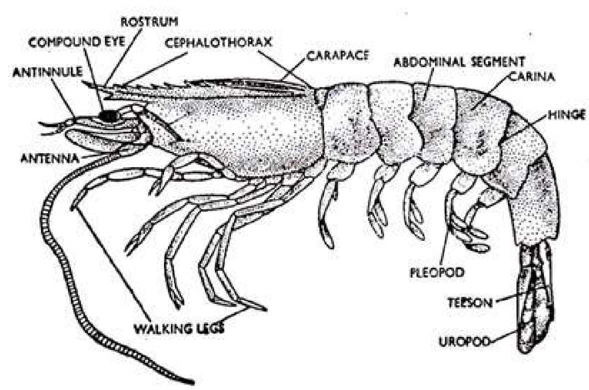


Fig 6.6 External features of prawn

Segmentation and body divisions

Body of adult prawn is distinctly divided into 19 segments or somites, all bearing jointed appendages. The segments are arranged into two main regions: an anterior cephalothorax (fused head –thorax) and a posterior abdomen.

Cephalothorax

Cephalothorax is large, rigid. unjointed and more or less cylindrical in shape. It consists of 13 segments. The joints between segments are obliterated. Cephalothorax is formed by the union of two region: (i) head and (ii) abdomen. Head consists of 5 segments. While thorax includes 8 segments, all bearing jointed appendages.

Abdomen

Well-developed abdomen is jointed, unlike cephalothrax. It is composed of 6 distinct movable segments, and a terminal conical piece. The tail-plate or telson. Which is not considered a segment because of post-segmental origin. Abdomen looks almost circular in a cross section. Each abdominal segment carries a pair of jointed appendages called pleopods or swimmerets.

External apertures

The slit-like mouth opens mid-ventrally at the anterior end of cephalothorax. Anus is alongitudinal aperture lying ventrally at the base of telson. Paired renal apertures open on raised papillae on the inner surface of coxa of antenne. Paired female gential apertures in females are on the inner surface of coxae of the third pair of walking legs. Paired male genital apertures in the male are situated on the inner surface of coxae of the fifth pair of walking legs. There are two minute openings of statocysts, one lying in a deep depression dorsally on the basal segment (precoxa) of each antennule.

Exoskeleton of prawn

Body and appendages are covered by a hard protective calcareous shell or exoskeleton. It is composed of chitinous cuticle which becomes variously tinted by the deposition of lime salts and sclerotin. The exoskeleton comprises several hardened plates, called sclerites. Adjacent sclerites are connected by thin, soft, uncalcified cuticle or the arthroidal membranes, making the movements feasible.

Appendages and locomotion of prawn

Appendages in prawn

Each segment of body bears a pair of jointed appendages. Thus, There are 19 pairs of appendages in prawns. They show considerable variations, depending on the functions they perform. However, they all are of a biramous type, as they are built on the same fundamental biramous plan.

Each appendage consists of a common base or protopodite, bearing two ramit or branches, an inner or median endopodite and an outer or lateral exopodite. Any appendage composed of two branches is called biramous (bi, two+ramus, branch). Typically, the basal protopodite is composed of two segments, a proximal coxa for attachment with the body and a distal basis which bears the two ramii, both comprising several segments or podomeres.

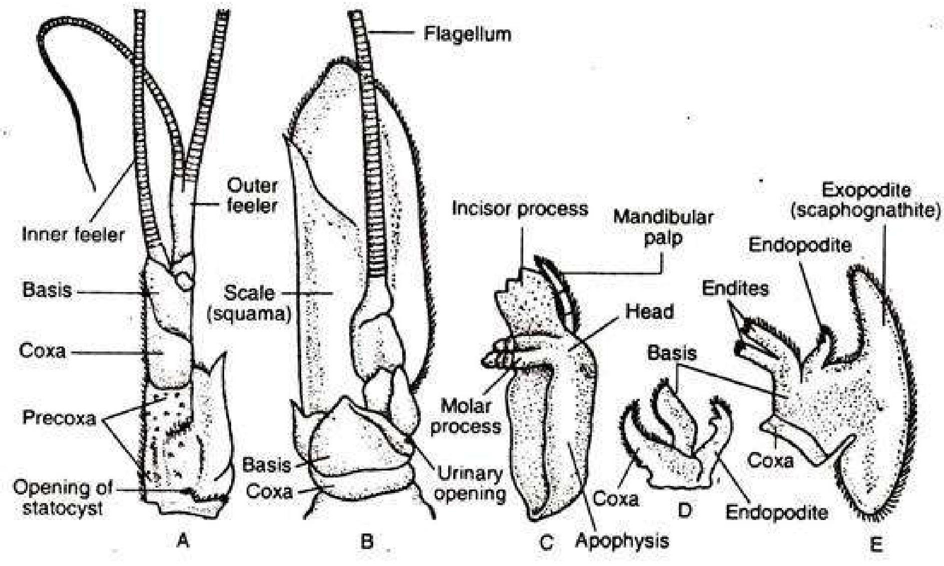
In prawn, there are 19 pairs of appendages, 13 in cephalothoracion and 6 in abdomen. Cephalothorac appendages further include 5 pairs of anterior cephalic appendages and 8 pairs of posterior thorac appendages.

Cephalic appendages

There are 5 pairs of cephalic or head appendages, beginning from the antennules, antennae, mandibles, maxillulae, and maxillae. Antennules and antennae are pre-oral, While mandibles, maxillulae and maxillae are post-oral.

i. Antennules

The antennules are attached, one either side, below the bases of eyestalks. The protopodite consists of three segments-a large proximal precoxa, middle coxa and distal basis. Precoxa bears a depression, containing the opening of statocyst on its dorsal side. Coxa is short and cylindrical. Basis is elongated and without setae. It carries two long many jointed, whip-like feeler, which are probably not homologous with the exopodite and endopodite. Outer feeler is further divided into an inner smaller branch and an outer larger branch. The feelers of antennules bear sensory setae and the tactile in function.



Cephalic appendages of prawn (*Palaemon*). A. Antennule or First antenna. B. Second antenna. C. Mandible. D. First maxilla or Maxillula. E. Second maxilla.

Fig.6.7 Cephalic appendages of Prawn

ii. Antennae

The antennae lie, one on either side, just below the antennules. The protopodite is greatly swollen due to presence of excretory organ within, which opens by a minute renal aperture on the inner margin of coxa. Basis bears a spine. Endopodite is represented by many-jointed sensory, while exopodite is in the form of a broad and leaf-like plate, the squama or scale.

iii. Mandibles

The two mandibles are strong calcified bodies, lying one on either side of the mouth. Almost the entire mandible consists of coxa, which is differentiated in to a proximal, triangular and hollow apophysis and a distal solid head.

iv. Maxillulae

These are small, thin and left-like appendages. Free borders of coxa and basis are covered with pointed spines and project inwards as jaws or gnathobases (Gr.gnathos, jaw). Endopodite forms a curved process bifurcated at the apex. The exopodite is absent. Maxillulae help in the manipulation of food.

v.Maxillae

These are also thin and leaf-like mouth appendages. The small coxa is partially divided, while the large basis forms a bifurcated gnathobase internally. Endopodie is quite small, while exopodite forms a large expanded, fan-shaped scaphognathite or baler, the movements of which create a water current passing over the gills. The whole free margin of scaphognathite is be set with setae. Maxillae help in respiration and in the manipulation of food.

Thoracic appendages

There are 8 parts of thoracic appendages. These are differentiated into anterior 3 pairs of maxillipedes (Gr. Maxilla, jaw+ podos, foot) or foot-jaws, and posterior 5 pairs of paraeopods or walking legs.

i. **First maxillipedes**

These are thin and leaf-like. Inner borders of coxa and basis form endopodites or gnathobases. Outer side of coxa bears a bilobed respiratory primitive gill or epipodite. Endopodite is smaller than exopodte, which gives out a plate-like process from its base. Margin of exopodite and endopodite are fringed with setae.

ii. Second maxillipedes

Coxa bears an epipodite and a gill (podobrach) on its outer margin. Basis carries a long, slender and unjointed exopodite, covered with setae along its distal half, and 5 segmented endopodite.

iii. Third maxillipedes

These look leg-like in appearance and have the same parts as second maxillipedes. Outer border of coxa bears an epipodite. Basis supports a long, slender and unsegmented exopodite covered with setae and a three-jointed endopodite. Proximal podomere of endopodite represents ischium and merus fused together, the middle podomere is the carpus and the distal podomere represents propodus and dactylus combined together. The three pairs of maxillipedes take part in feeding and hold the food in position while the mandibles masticate it. They are also helpful in respiration as they bear gills and epipodites.

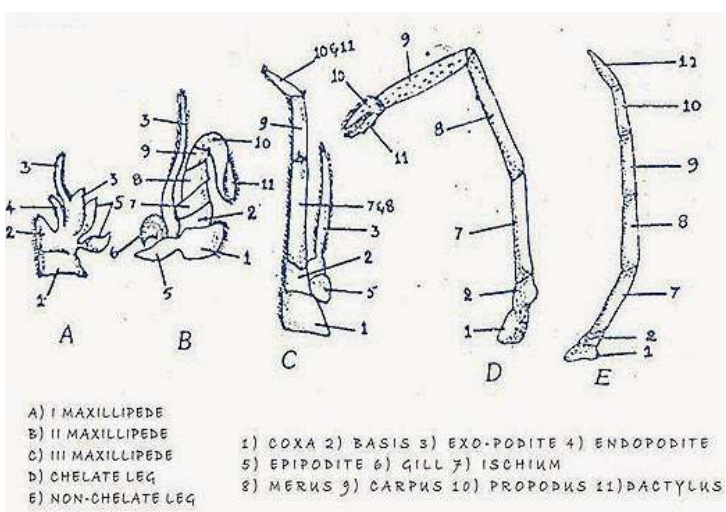


Fig. 6.8 Thoracic appendages of prawn.

iv. **Walking legs**

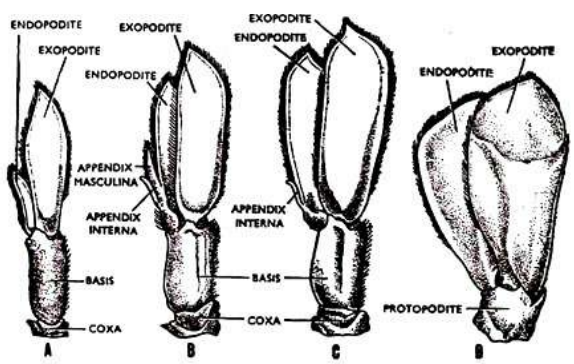
The 5 pairs of walking legs differ from maxillipedes in their greater size and in the absence of exopodite and epipodites. A typical walking leg, the fourth, consists of a two-jointed protopodite and a five-jointed endopooodite. All the seven podomeres, namely the coxa, basis, ischium, merus, carpus, propodus and dactylus are arrange in a linear series and are movably hinged together.

In the first and second pairs of legs, propodus is prolonged beyond its articulation with dactylus, so that the two podomeres work one against the other like the blades of a pair of forceps and form a chela or pincer. Such legs are termed chelipeds or chelate legs. They are used to grasp food and pass it on to the mouth. They also serve as organs of offence and defence. The second chelate legs in male are larger and more powerful than in female.

The third, fourth and fifth pair of legs are non-chelate and typical. In female, each third leg bears a female reproductive aperture on the inner side of the coxa. While in male, each fifth leg bears a male genital aperture on the arthrodial membrane between the leg and thorax.

Abdominal appendages

Abdomen bears 6 pairs of abdominal appendages, one pair in each of its segments. First 5 pairs, are the swimming pleopods or swimmerets, used as paddles, while the 6th pair are the uropod which, along with the post-segmental telson, form the tail fin. All these appendages are of simple biramous type.



Abdominal appendages of a male prawn (right side, ventral view); A=first pleopod, B=second pleopod, C=third pleopod, D=uropod. Fourth and fifth pleopods are similar to C.

Uropods

The 6th pair of abdominal appendages is called uropods. These are large and lie one on either side of the telson. Together with telson, they form a tail-fin which enables the prawn to take back ward spring in water. In each uropod, coxax and basis fuse together to form a triangular sympod, bearing the oar-shaped endopodite and exopodite. Exopdite is bigger than the endopodite and incompletely divided in the middle by a transverse-suture. Their margins, except the outer border of exopodite, are fringed with numerous setae.

Locomotion in prawns

The prawn crawls at the bottom of the river or pond by means of its walking legs. It can swim forward in a leisurely manner by beating its swimmerets or the abdominal appendages. It may take a quick backward spring by sudden contraction of the muscles which pulls the uropods and telson ventrally with a powerfully stroke.

Summary

Fishes is in fusiform shape. Its body is covered with scales. Pectoral fins are locate adjust after operculum and pelvic fins behind pectorals. Dorsal and anal fins are located on dorsal surface and behind anus respectively. The tail consists of a caudal fin. Slit like mouth is found at anterior part of head. Branchial region and gills are enclosed by operculum.

The body of the prawn is divided into cephalothorax and abdomen. Cephalothorax is the fusion of 13 segments of cephalic and thoracic region. Cephalothorax is extended anteriosly in the form of rostrum. The abdomen ends with a telson. Pairs of cephalic, pair's of thoracie and pairs of abdomen appendages are found in prawns.

Nineteen pairs of appendages are found in prawn. The cephalic appendages are antennules, antennae, mandibles, maxillae. The thoracic appendages are three-parts of maxillped or pereopods and five pairs of walking legs. The abdominal appendages are five pairs of pleopods and one pair of uropods. They crawal at the bottom with the help of walking legs. They swim with the help of swimmerets.

The fins and tail are the locomotory organs in fishes. The paired fins are pectorals and pelvics. The median fins are dorsal, anal and caudal fins. The fins are useful for swimming and balancing, whereas tail is useful for changing directions. The myomeres are useful for locomotion in fishes.

SUMMARY

The skeleton in fishes can be divided into axial and appendicle skeleton. Axial skeleton consists of skull and vertebrae. Amphicoelous vertebrae are found in fishes. The appendicle skeleton is poorly developed fishes.

The scales are exoskeletal structures of fish, useful for protection. These are cosmoid, ganoid, placoid, cycloid and ctenoid. Cosmoid scales are with cosmine and were found only in extinct fishes. Ganoid scales are with ganin and are found in dipnoi. Chondrostei and holostel fishes. Placoid scales are with a triadiate spine and basal plate and are found only in elasmobranches. Cycloid and ctenoid scales are bony ridge scales found in teleosts. Ctenoid scales can be identified with ctenoid and are found only in order perciformis. The skin of fish consists outer epidermis and inner dermis. Epidermis consists of stratified and Malpighion layers and dermis consists of spongisum and compactum layers.

Short Answer Questions (2 Marks)

1. Write the names bones present in cranium of fish?
2. Draw the neat labeled diagram of vertebra of fish?
3. Write any two uses of skin in fishes?
4. What type of scales present in elasmobranch fishes?
5. What are the Lepitoid scales?
6. Mention the three body parts of prawn?
7. How many segments are observed in prawn body?
8. How the cephalothrax is formed in the prawn?
9. What is chelated leg? How it is useful in prawn?
10. Write the names of cephalic appendages of prawn?

Long Answer Questions (6 Marks)

1. Describe the various types of scales present in fishes?
2. Explain the fines in fishes?
3. Describe the appendages in prawn?
4. Describe the morphological changes of prawn?

Unit - 7

Digestive System of Fish and Prawn.

Structure

7.1 Introduction to Digestive System

Nutrition deals with the intake of food and water by the organisms. Living animals require food for three main purposes which are as follows:

1. Food provides energy to the body for performing various life activities such as muscle contraction, movements etc;
2. Food is needed for growth and repair of the body.
3. Food is a fuel to supply energy for the maintenance of the body.

The substances required in the food of organisms are carbohydrates, proteins, fats, water, mineral salts and vitamins. The first three are required for energy and building of materials. Various food materials are converted into simple and soluble substances which can be readily absorbed by blood and lymph.

This mechanical and chemical break down of food in alimentary canal is called digestion. Digestive system consists of an alimentary canal and associated digestive glands. It is derived from the embryonic endoderm.

7.2 Digestive System of Fishes

The digestive system of fish includes the digestive tract and the various glands found associated with it. It is concerned with the ingestion, digestion and absorption of food and with the elimination of undigested wastes. The accessory organs like the tongue, teeth, oral glands, pancreas, liver, gall bladder are also associated with the digestive tract.

The digestive tract or alimentary canal comprises three major parts- the fore-gut, mid-gut and the hind-gut. Each of these parts undergoes further differentiation to include several segments of the gut (Fig.7.1). Foregut differentiates to include the parts like mouth, buccal cavity, pharynx, oesophagus, and stomach. Mid gut differentiates into small intestine and the hindgut into the large intestine and the terminal apertures.

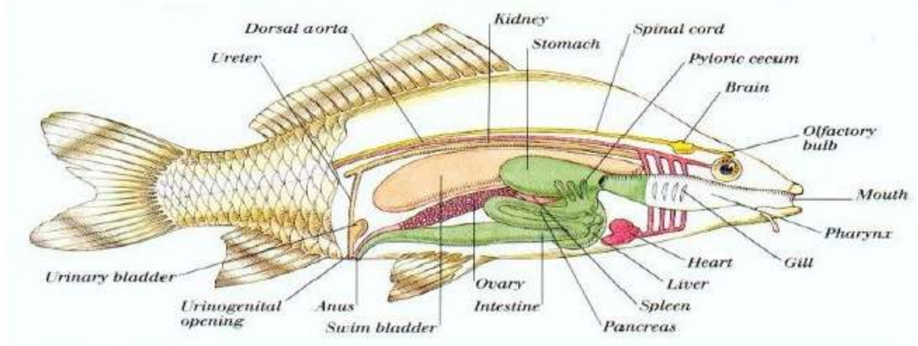


Fig.7.1 Digestive tract of Fish

Digestive tract

Mouth: Mouth is a slit like structure in fishes. It is surrounded by lips.

Buccal cavity and pharynx: The buccal cavity and pharynx are not clearly marked off from each other. A number of perforations of gill slits are found on each side of the pharyngeal wall. Buccal cavity also consists of teeth and tongue.

Teeth: The teeth of vertebrates in general, may be divided into two main types viz, the epidermal (horny) and the dermal teeth. The former types are derived from the stratum corneum of epidermis and restrict to only the buccal funnel and the tongue of agnathans. The general form of teeth varies according to the feeding habits of the fishes. These may be pointed, spherical, curved, dagger shaped. Canine or molariform or fang like in their shape. Occasionally as in dipnoans many of tooth germs fuse to form the compound plate like teeth for crushing the objects of food.

Tongue: The tongue arises as a fold form the floor of buccal cavity. It is devoid of any muscles, but supported by the hyoid arch that often extends into it. Small papillae, sensory receptors and the teeth are variably found on this structure scarcely called the tongue.

Oesophagus: The pharynx opens behind into the oesophagus and the latter in turn passes almost imperceptibly into the stomach. These three parts viz, the pharynx, oesophagus and stomach are not clearly marked off from each other except histologically. Oesophagus commonly bears longitudinal fold to permit a greater distensibility and its mucosal lining comprises largely the squamous cells.

Stomach: The stomach basically is a structure meant for the storage and maceration of food material. Only when its internal lining contains the gastric glands it is properly called a true stomach**.** Stomach assumes different shapes according to the availability of space in the body cavities of different fishes. It is usually differentiated into a board anterior part, lying closer to the heart, and called cardiac stomach and into a posterior narrower part called the pyloric stomach. The opening of latter into the mid-gut is usually guarded by a valve.

A constriction is the only demarcation between the oesophagus and the stomach of lung fishes. Stomach of these fishes lack the gastric glands but remain separated from the intestine by a flap like pyloric valve.

Intestine: The part of digestive tract following the stomach is called the intestine. It is divisible into two main parts, an anterior long but narrower part called the small intestine lying immediately behind the stomach receives ducts from the liver and pancreas and called duodenum while the rest of it is ileum. These various intestinal parts are usually differentiated histological by only a gradual change in the nature of mucosal layer. Only in certain groups there is a fold marking the posterior region of intestine. The length of intestine however depends upon the feeding habits of the fishes. It is relatively shorter in carnivorous than in herbivorous fishes.

Pyloric caeca: Many fishes have pyloric caeca, given off from the portion of the mid-gut, lying immediately being the pylorus. These caeca may be blind, tubular or sc like diverticulas of uncertain functions. They do not follow any definite arrangement of the organization and vary in numbers in different fishes. Only a single such caecum is found in *Polypterus* while the number may go up to two hundred in mackerel.

Anus: The gut ends with the anus, which is a small opening located at the posterior region of the body.

Associated Glands

Liver: The liver performs a number of functions; it is primarily a digestive gland. The first rudiment of liver arises as a hollow diverticulum, from the underside of the prospective duodenum (Fig 7.2). The diverticulum soon differentiates into two parts an anterior part, the proliferates to transform into large, glandular mass of liver and its bile ducts and a posterior part which gives rise to the gall bladder and the cystic duct. The paired hepatic ducts, one from each liver lobe join the cystic duct from the gall bladder to form a bile duct that opens behind into the duodenum (Fig. 7.2).

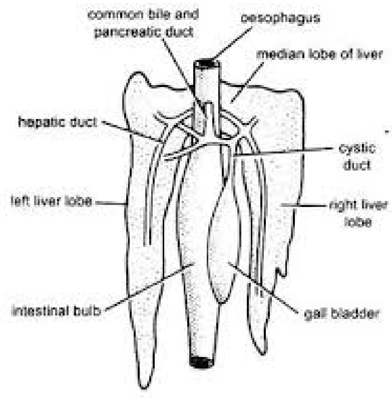


Fig: 7.2 Liver and gall bladder in Rohu

Pancreas: The pancreas is the second large digestive gland in the body of the fish. It comprises two histologically and functionally different components; an endocrinal portion that secretes hormones and an exocrinal portion secreting the digestive pancreatic juice. The rudiments of pancreas appear in the form of one or more buds, arising from the ventral side of the liver, and another similar bud from the dorsal side of fore-gut. The dorsal and ventral buds give rise to the dorsal and ventral lobes of the pancreas in adults.

Gland in digestive tract: The mucosal lining of alimentary canal and the submucosa contain glands of digestive value. Glandular structures of stomach mucosa comprise the goblet glands in the cardiac and pyloric regions of the stomach. These are simple or branched tubular structures containing juice producing grandular cells.

The secretary cells of intestinal mucosa comprise the goblet cells and the granudular cells. Rectum is almost completely devoid of digestive glands in fishes. Rectal glands of elasmobranchs are not the digestive glands instead they secrete a copious amount of sodium chloride from the blood of marine elasmobranchs.

7.3 Physiology of Digestion in Fish

Digestion of proteins

The fishes which possess stomach are generally carnivorous and secrete pepsin enzyme from gastric mucosa. The pepsin is a protease enzyme i.e. it can break down protein. HCl is secreted by the gastric mucosa in carnivorous fishes creating the low pH. Both cholinergic and adrenergic nerves are present in the stomach which stimulate the secretion of gastric juices. The trypsin is secreted by exocrine pancreatic and secreted by hepatopancreas. The inactive form of this enzyme trypsinogen is known as zymogen. It is to be converted into active enzyme i.e. trypsin by an enzymogen. It is to be converted into active enzyme i.e. trypsin by an enzyme enterokinase. The enterkinase enzyme known collectively as erypsin. The intestine secretes aminopetidases. These act on terminal amino acid called as exopeptidases and those act on central bonds are called as endopetidases. Vitamins are essential constituent of the diet and a large number of vitamin deficient syndrome are noticed in fish

Digestion of carbohydrates

The enzymes which break down the carbohydrates in the gut of fishes are carbohydrases. They are amylase, lactase, saccharsases/sucrose and cellulose. The most important enzyme is amalyse which acts on starch, which breakdown to maltose and then to glucose by the process of digestion. The amylase is secreted from the pancreas in carnivorous fishes but in herbivorous fishes, the presence of this enzyme is reported from the whole gastrointestinal tract as well as from pancreas. In tilapia, the herbivorous, the amylase is present throughout the alimentary tract. The starch is digested into glucose by amylase and maltase.

$$\text{Starch} \xrightarrow{\text{Amylase}} \text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose}$$

In those fishes in which sucrose has been reported the effect as follows:

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose + Fructose}$$

Blood glucose is converted with the aid of insulin, to muscle glycogen. Although clear details are wanting, but excess of glucose enters the blood from digestive tract, the surplus is converted to glycogen in liver.

The fishes possess endocomensal bacteria containing an enzyme, the cellulose, which breakdown the cellulose plant material instead of passing out through faeces.

Fat digestion

The lipids are organic substances insoluble in water but soluble in organic solvents like chloroform, ether and benzene. They form important dietary constituents on account of high caloric value and the fat soluble vitamins and the essential fatty acids contained in them. The main enzyme which acts on this lipid is lipase. This enzyme is found in pancreas and mucosa of fishes. Lipase convets the fats into fatty acids and glycerols.

Gastrointestinal hormone

In the teleost, the presence of gastrin and cholecystokinin are reported and are secreted by intestinal endocrine cells which are dispersed and are not grouped in clusters. The cholecystokinin affects the oxyntic cells and inhibit further gastric secretion in bony fishes. Somatostatin is present the stomach and pancreas of fishes. They are called as paracrine substances. It differs from hormone because it diffuses locally to the target cells instead of released into the blood. This inhibit other gastrointestinal and pancreatic islet endocrine cells. Pancreas secretes two important hormone i.e. insulin and glucogen, insulin is secreted from β-cells while glucogen is secreted by α-cells. Insulin reduces the blood sugar, whereas glucagon increase the blood sugar in fishes.

Absorption

Digestive end products are absorbed in to the blood. Inorganic ions uptake in various regions of the alimentary canal in fishes and their subsequent distribution and localization has been reported. The iron (Fe^{++}) ions are absorbed through intestinal columnar cells and then pass into the portal as Fe^{++} binding protein transfertin. The calcium absorbed by the intestinal submucosal blood vessels. Probably, Ca^{++} after entering blood vessels in the intestinal region reach finally in the hepatocytes where it is stored in association with vitamin D depending upon Ca binding protein.

7.4 Digestive System of Prawn

I. Alimentary Canal

Alimentary canal consists of three distinct regions-

(i) Foregut, comprising through mouth, buccal cavity, oesophagus and stomach,
(ii) Midgut including intestine, and
(iii) Hindgut or rectum.

Foregut and hindgut are lined intenally by cuticle, called intima, which is shed with the exoskeleton when the animal moults. Midgut is lined internally by endoderm.

1. **Mouth**: It is a large, slit-like aperture lying mid-ventrally below the anterior end of head. It is bounded in front by the shield-like flesh labrum, laterlly by the plate-like incisor processes of mandibles and behind by the bilobed labium.
2. **Buccal Cavity:** Mouth leads into a short buccal cavity. It is anteroposteriorly compressed and has a thick cuticular lining which is irregularly folded. The molar processes of mandibles lie opposite each other in the buccal cavity to crush the food between them.
3. **Oesophagus:** The short tubular oesophagus runs vertically upwards from the buccal cavity to the floor of cardiac stomach. Internally the thick muscular wall of oesophagus is thrown into four prominent longitudinal folds, one anterior, one posterior and two laterals.
4. **Stomach:** Stomach occupies most of the cephalothractic cavity. It remains buried laterally, ventrally and posteriorly in the hepatopancres. Stomach of prawn is thin-walled and double chambered, consisting of two parts
   (i) A large anterior bag-like cardiac stomach, and
   (ii) A much smaller posterior pyloric stomach.

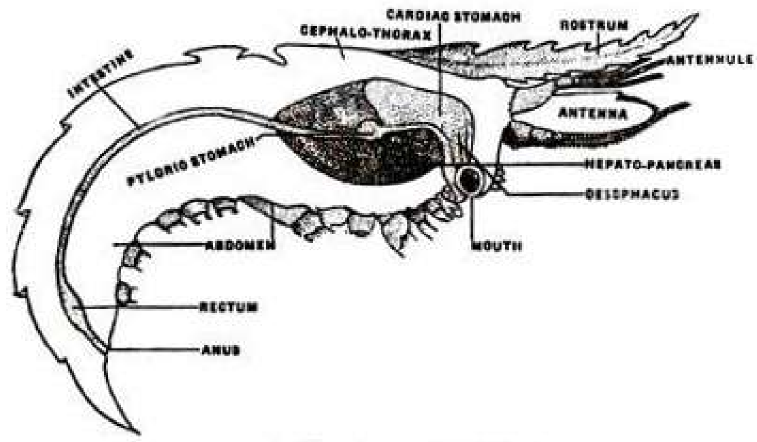


Fig: 7.3 Palaemon. Alimentary canal in lateral view

Midgut

Midgut or intestine is along, narrow and straight tube running back along the median line, between the extensor and flewor muscles, upto the 6^{th} abdominal segment. Its lumen is wide sat the anterior end but reduced posteriorly due to the presence of longitudinal folds.

Hindgut

It is the shorts portion of the alimentary, canal, leading from midgut to anus. Its anterior Swollen muscular part, called the intestinal bulb or rectum, bears many internal longitudinal folds. The terminal narrow, tubular part opens to the exterior through anus, which is a sphinctered mid-ventral longitudinal slit-like opening, situated on a raised papilla at the base of telson.

II. Hepatopancreas

It is large, bilobed, dense and orange glandular mas, which lies below gonads and nearly fills up the cephalothoracic cavity. It surrounds stomach on its lateral, ventral and posterior sides. Hepatopancreas combines in itself the functions of pancreas, small intestine and liver of higher animals.

III. Food and Feeding

Prawn feeds mainly on algae, moss and other aquatic weeds. It occasionally feeds on small aquatic animals such as insects, snails, tadpoles, fish; and debris of the bottom. It feeds at night, being more active at dawn and dusk than at any other time.

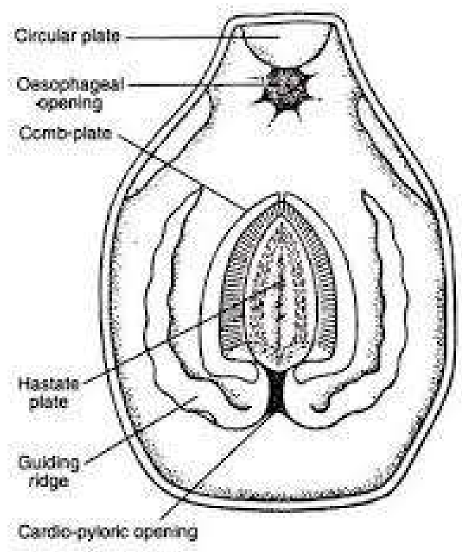


Fig. 7.4 Floor of cardiac stomach of prawn

7.5 Physiology of Digestion in Prawn

The enzymatic digestive secretion of hepatopancreas flow through the two hepatopancreatic ducts into the ventral chamber of phyloric stomach, from where it reaches the cardiac stomach and mixes with food. Cardiac stomach expands and contracts to effect the churning of food passes over the hastate plate, the moving bristles of combed plates cut it into smaller particles.

The semi-liquid and semi-digested food is filtered through the bristles of combed plates, into lateral grooves below, whence it is carried into the ventral chamber of pyloric stomach through the cardiopyloric aperture. Here the digested and liquefied food is filtered again through the pyloric filtering apparatus. Thus, only the finest food particular enter through hepatopancreatic ducts into the large digestive gland where they are hydrolysed and absorbed.

The residual food, consisting of undigested and coarser particles, ascents up the dorsal pyloric chamber and from there enters the midgut for digestion and absorption. Undigested residual matter passes on to the hindgut. Here water is absorbed from it and the dry face thus formed is egested through the sphinctered anus.

Short Answer questions (2 Marks)

1. Define digestion?
2. What are the Omnivorous fishes? Give any two examples?
3. What are the surface feed fishes? Give any two examples?
4. Which enzymes are help in the digestion of Carbohydrates in fish?
5. Name the digestive glands of fish?
6. What is the main function of liver in fish?
7. What are the three main parts in Alimentary canal of prawn?
8. Name the common food of prawn?
9. What is the function of Hepatopancreas in prawn?
10. Where the food absorption is takes place in alimentary canal of prawn?

Long Answer Questions (6 Marks)

1. Describe the elementary canal of fish with neat labeled diagram?
2. Explain the digestion and absorption in fish?
3. Describe the digestive system of prawn with neat labelled diagram?
4. Explain the digestion and absorption in prawn?

Unit - 8

Respiratory and Circulatory Systems of Fish and Prawn.

Structure:

8.1 Introduction
8.2 Respiratory System of Fish
8.3 Circulatory System of Fish.
8.4 Respiratory System of Prawn
8.5 Circulatory System of Prawn

8.1 Introduction

Respiration is a catabolic process in which the respired oxygen is used in the oxidation of food resulting in the release of energy. This energy is utilized for all the vital activities. Carbohydrates are mainly concerned with release of energy. Oxygen required for this process is obtained from the surrounding medium. Carbon dioxide formed in this process of respiration is expressed follows

$C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2, + 6H_2O + \text{energy}.$

Respiration is the sign of life and index of all biochemical activities taking place in the body. The process of respiration involves the exchange of two gases, namely oxygen and carbon dioxide. Various organs required for the exchange of gases constitute the respiratory system.

On the basis of availability or non-availability of oxygen, respiration is differentiated into two kinds, namely (1) aerobic respiration (2) anaerobic respiration.

8.2 Respiratory System of Fish

The gaseous exchange of oxygen and carbon dioxide taking place between blood and water (or air) through the medium of respiratory organs are called the external respiration to distinguish it from the internal respiration which refers to the essential transfer of gases between blood and tissues or cells of the body and brings about release of energy.

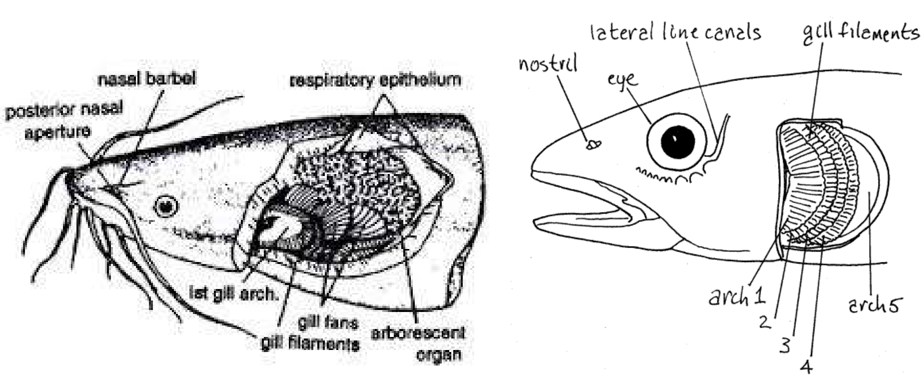


Fig.8.1. Respiratory region of Fishes

The main respiratory organs in a fish are the gills (fig 8.1). The lateral walls of the pharynx are perforated by means of a series of slit-like apertures, the first of which is called the spiracle, lying between the mandibular and the hyoid arches. The second or the hyoidean cleft lies between the hyoid arch and the first branchial arch, while the rest of the gill slits are situated between the proceeding branchial arches.

The anterior and the posterior wall of each gill slit are raised in the form of vascular filamentous outgrowths to form the gills where exchange of dissolved oxygen and carbon dioxide takes place. Besides the gills, other structures as the skin, air bladder and accessory organs also function as respiratory structures in some fishes.

Types of gills

Gills are two types—holobranch and pseudobranch.

Holobranch: A complete gills or a holobranch consists of a gill arch supported by cartilage or bone. Each arch bears gill rakers towards the inner side, and vascular plate-like filaments projecting towards the outside. Each row of these filaments forms a hemibranch or half gill. A holobranch carries two hemibranchs.

Pseudobranch: In many actinopterygians, a hyoidean pseudobranch consisting of a series of gill filaments are present anterior to the-first gill, as in *Catla catla.* The pseudobranch may be free or covered with a layer of mucous membrane. The pseudobranch may also be useful in the filling of gas bladder and in the regulation of intraocular pressure. Typically

Structure of a Teleostean Gill

Typically there are four pairs of gills in teleosts, each of which consists of a larger lower-limb and a shorter upper limb, supported by ceratobranchial and epibranchials respectively. Gill rakers are present in one or two rows on the inner margin of each gill arch. The gill rakers are developed in various degrees and may be soft, thin, thread-like or hard, flat and triangular, or even teeth-like, depending upon the food and feeding habits of the fish. Generally, they form a sieve to filter out the water, and protect the delicate gill filaments from solid particles. Each raker is lined externally by an epithelial layer containing taste buds and mucus-secreting cells. The taste buds help the fish in detecting the chemical nature of the water flowing through the gill slits.

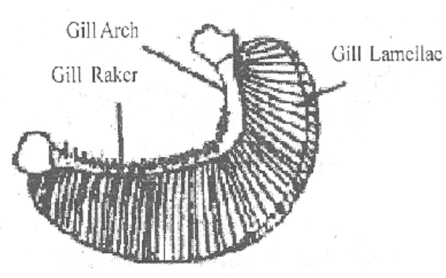


Fig: 8.2. Gill of *Cirrhinus*

Gill arch

Each gill arch encloses and afferent and an efferent branch of vessel and nerves. It is covered over externally by a thick or thin epithelium in which a large number of mucous glands, eosinophilic cells and taste buds are present. The number and distribution of mucous glands, taste buds etc. varies in fishes inhabiting different ecological habitats. Each gill arch has atleast one set of aboductor and a set of adductor muscles, which are responsible for the movement of the gill filaments (primary lamellae) during respiration. The abductor muscles are present on the outside of the gill arch connecting it with the proximal ends of the gill rays. The adductor muscles are present in the interbranchial septum and cross each other so as to become inserter on the opposite till rays.

Gill filaments or primary lamellae

Each gill arch bears two rows of gill filaments or primary gill lamellae (fig.8.4) towards the outside of the buccopharyngeal cavity. In most teleosts, the interbranchial septum between the two rows of lamellae is short so that the lamellae of the two rows are free at their distal ends.

The primary gill lamellae are supported by gill rays which are partly bony and partly cartilaginous and are connected with the gill arch and with each other by fibrous ligaments. Each gill ray is bifurcated at its proximal end to provide a passage for the different branchial vessel.

Secondary lamellae

Each primary lamella or gill filament bears a large number of secondary lamellae on both its sides. These flat, leaf-like structures are the main sites of gaseous exchange and vary in their shape dimension and density per unit length of the gill filament, in species living in different ecological habitats. Generally, the secondary lamellae are free from each other but may be fused at the distal ends of the primary lamellae. They vary from 10-40 on each side of the primary lamellae, being more numerous in active species. Each secondary lamella consists of a central vascular core composed of pillar cells covered by a basement membrane and an outer epithelium.

Gill Area

The relative number and size of the gill lamellae determines the respiratory area of the gill in the fish. The total gill area for a fish species is calculated as a product of the total length of the primary lamella, frequency of the secondary lamellae and the average bilateral lamellar area.

The total respiratory area varies with the habits of the fishes generally, fast swimming fishes have more gill area and a larger number of gill lamellae per mm of gill filament, than the sedentary species. Gill area in air breathing fishes is reported to be half of the area is directly proportional to the efficiency of the gill sieve. It increases with the increase in the body weight during the growth of the fish.

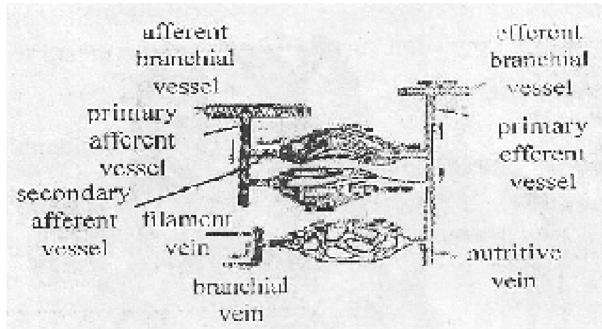


Fig. 8.3 Circulation of blood through gill lamella

Gill epithelium and branchial glands

The epithelium covering the lamellae is generally double layered but electron micrographs of gills of *Anabas* and *Clarias* have shown a multilayered epithelium varying from 5-18 mm in thickness. Amoebocytes and lymphocytes are commonly found in the epithelium of these fishes. Some of the cell are glandular and are specialized to perform various functions. Most common of these branchial glands are the mucous glands and chloride cells.

Vascular supply of a Teleost Gill

Generally only one afferent and one efferent branchial vessel is present in each gill arch in teleosts but in some species such as *L. rohita, C. batrachus, Anabas,* there are two efferent branchial vessels in each arch. Recent studies have shown that there are two vascular pathways in the gill: (i) Respiratory pathway and (ii) non-respiratory are nutritive pathway

The respiratory pathway is associated with respiration. Each afferent branchial vessel brings oxygen deficient blood into the gill. The oxygenated blood is collected by the efferent lamellar arterioles which carry the blood to the primary efferent vessel running along the margin of the primary gill lamella. The blood is finally carried to the main efferent branchial vessel of the gill arch.

The non-respiratory pathway consists of a complex arrangement of sinuses and veins that carry the blood direct to the hearth, by-passing the systemic circulation. Its function is believed to provide nutrition and oxygen to the filament tissue, and may also be associated with the circulation of hormones. This pathway consists of the efferent filament artery, nutritive blood channel, central venous sinus, venules and the branchial veins.

Respiratory process

Blood is oxygenated in teleosts by rhythmical inhalation and exhalation of water through the bucco-pharyngeal cavity. This is affected by suction of water into the cavity and its subsequent expulsion through the gill slits, during which the water bathes the highly vascular gill lamellae. The bucco-pharyngeal cavity therefore applies both suction and pressure to propel water through the gills.

For respiration, the mouth is opened and the buccal cavity is enlarged by lateral expansion of its walls. For this various muscles contract as well as the branchiostegal rays are spread and lowered. An increase of the buccal cavity creates negative water pressure in it so that water is sucked in.

When the oral cavity is filled with water, the mouth is closed and the operculum is abducted anteriorly to increase the opercular cavity, but the opercular opening is kept closed due to pressure of external water. A low pressure is thus created in the opecular cavity and water flows over the gills into it. Next the buccal and the opercular cavities are reduced so as to exercise pressure on the water inside it. The oral valves prevent the water from going out of the mouth. The opercula after reaching the maximum abduction are quickly brought towards the body. The water is expelled through the external brachial aperture, and is prevented from going back due to excess pressure in the buccal cavity as compared to the opercular cavity.

Other organs of respiration

In addition to the gills, the skin of many fishes helps in respiration. In periopthalmus tail is used for breathing. Some species possess larval gills which are filamentous outgrowth from the gills. In some species as Salmo and Misgurnus the gill lamellae are long, filiform structures and extend out of the gill slits in larval stages.

Polypterus larva also has pair of external gills which disappear in the adult. In some fishes, air bladder is modified as a lung for respiration. In *Amia* and *Lepidosteus,* the air bladder is highly vascular and sacculated internally and serves for respiration. In the *Dipnoi,* air bladder is completely modified as a lung. In other teleosts, air bladder may serve as reservoir of oxygen. Besides these structures, some species possess accessory respiratory organs to help in breathing.

Accessory respiratory organs

In some tropical fresh water fishes, special structures called the accessory air breathing organs are present in addition to the gills. Air breathing organs are generally found in fishes living in shallow stagnant, fresh water of tropical regions where deoxygenation of water occurs.

These organs may also develop in fishes inhabiting torrenting streams of the hills, that are liable to dry up during summer.

According respiratory organs found in few fishes and useful to live out side the water. for some time. Some of the accessory respiratory organs in fishes are skin *(Amphiphous, Periopthalmus, Baleopthalmus),* air sac *(Iteteropheustes)* and part of alimentary canal *(Misgurnus).*

Several types of accessory respiratory organs have been evolved in different species of fishes. In *Mastacembelus* however the unmodified gills secrete a large amount of mucus top keep them moist and facilitage gas diffiusion for some time when the fish is out of water.

Skin as a Respiratory Organ

Fishes like *Anguilla anguilla, Amphipnous cuchia, Periopthalmus* and *Boleopthalmus* species skin is highly vascular and serves for exchange of gases as in the frog when the fish is out of water. These fishes habitually leave the water and migrate from one place to another through damp vegetation. During this period, the moist skin serves as an important organ for respiration.

Since *Amphipnous* and *Mastacembelus* live in oxygen deficient stagnant waters, the skin is of little use of respiration but it plays an important role in extracting oxygen from air, when the fishes are exposed in drying up muddy ponds or when fish is moving out of water. The glandular secretions of the skin protect it from desiccation in air.

Buccopharyngeal epithelium

In some fishes the buccopharyngeal epithelium is supplied by a large number of capillaries to make it highly vascular. It may remain simple or may develop folds, pleats or tongues projecting into the buccal cavity and pharynx to make it an efficient respiratory organ. This is seen in Periopthalmus, *Boleopthalrnus, Amphipnous* and *Electrophorus.*

Phayngeal diverticulum

In *Channa marulius* and C. *striatus,* (fig.8.9) supra branchial cavities developed in the roof of the pharynx. These cavities freely open into the buccopharynx antero-ventrally, and into the opercular cavity postero-ventrally, and are lined with a highly vascular respiratory epithelium, that is raised into folds and tonues and has respiratory islets. In *Periopthalmus* also a small shallow pharyngeal diverticulum lined with respiratory epithelium is present on each side of the roof of the pharynx.

In the cuchia eel (*Amphipnouscuchia*) the gills are reduced and gill lamellae are present only on the second gill arch, while the third arch bears a fleshy vascular membrane (fig.8.10). The air breathing organs are in the form of a pair of sacs situated on the lateral sides of the head.

Opercular chamber modified for aerial respiration

In some species, the inhaled-air is passed though the gill slits into the opercular chamber where it is stored for some time. The opercular chamber becomes bulged out in the form of two little balloons in the hinder region of-the head and after sometime its walls collapse and the air is passed out through the small external branchial opening. The membrane lining the opercular chamber becomes thin and highly vascular to allow exchange of gases. This is seen in *Periopthalmus* and *Bolepthalmus.*

The following structural modifications are seen in *Periopthalmus:*

(i) The opercular bones have become thin and elastic.
(ii) The opercular chamber is enlarged and extends below the basibranchials and above the gill arches. Air pockets develop in the walls of the respiratory epithelium.
(iii) The branchiostegal apparatus of both sides develop a special type of safety valve movable by strips of muscles.
(iv) The epithelium lining the opercular chamber and the branchiostegal membranes becomes richly vascular.
(v) Intricate mechanism has been evolved for opening and closing the inhalant and exhalant apertures.

Heteropneustes fossilis

In this species the accessory respiratory organs are:

(i) The 'fans' or the expanded gill plates,
(ii) The air sac and
(iii) The respiratory membrane.

Four pairs of gills are present in this species as in other teleosts, but the gill lamellae are reduced in size. Four pairs of 'fans' develop on these gill arches.

***Anabas Testudineus*:** The air breathing organs consist of a spacious air chamber on either side of the skull lying between the first gill arch and the hyomandibular.

***Trichogaster Fasciatus*:** The accessory organs in this species consist of a supra branchial chamber, a labyrinthine organ and the respiratory membrane. The respiratory membrane lining the air chamber and covering the labyrinthine organs consists of vascular and non-vascular areas.

***Clarias Batrachus*:** The accessory air breathing organs of this fish consists of (i) the supra branchial chamber, (ii) the two beautiful 'rosettles' or air-trees, (iii) the 'fans' and (iv) the respiratory membrane.

The supra branchial chamber lies above the gills and is divided into two cup-like compartments and is lined by a highly vascular respiratory membrane.

Respiratory membrane

The respiratory epithelium covering the air breathing organs of various teleosts shows a complicated structure. It consists of vascular areas called the respiratory islets" and non-vascular areas called the "lanes". Exchange of gasses takes place in the islets which are highly vascular and show lamellar structure in *Heteropneustes* and *clarias,*

A part of the alimentary canal modified for aerial respiration

In few fishes, either the stomach or the intestine is specially modified to serve for aerial breathing. In these species, the inhaled air is swallowed and forced back into the alimentary canal and is stored for sometime in a special part of it. After respiratory exchange, the following modifications take place.

(a) The wall of the stomach or the intestine becomes thinned out considerably and is practically transparent due to great reduction of the muscle layers.
(b) Inner surface is lined by a single layer of epithelial cells. Mucus secreting cells or glands is absent and the epithelium is richly vascular.
(c) Circular muscle fibres are greatly reduced and the longitudinal muscle fibres form a very thin layer.

Air bladder modified as respiratory organ

The air bladder of some fishes is modified for aerial respiration. Thus in *Polypterus, Amia, Lepidosteus, Gymnarchus* and in the Dipnoi, the air bladder is most highly evolved acting as a lung in many of these fishes, the circulatory system is also modified so as to reseamble the urodele condition.

The swim bladder of *Notopterus* has a wide preumatic duct and acts as an accessory respiratory organ. The network of blood capillaries covered by a single layer of epithelium facilitates diffusion of gases between the blood and the air contained in the swim bladder.

Origin and significance of the air breathing organs

During development, the fifth gill arch does not develop gill lamellae, and its embryonic gill material forms rediments of the gill arch, and aggregates to form a structure called the 'gill mass'. The air breathing organs develop from this gill mass (Singh, 1993). Most of the fishes possessing air breathing organs are capable of living in highly deoxygenated water of the swamps and muddy ponds infested.

8.3 Circulatory System of Fish:

Blood

The blood of fishes is similar to that of any other vertebrates. It consists of plasma and cellular components. The cellular components are red blood cells (RBC), white blood cells (WBC) and thrombocytes. The plasma is liquid portion and consists of water. It acts as the solvent for a variety of solutes including proteins, dissolved gases, electrolytes, nutrients, waste material and regulatory substances. Lymph is the part of plasma that perfuses out of the capillaries to bathe the tissue. It also contains cellular components particularly more lymphocytes.

Plasma

The plasma composition is as follows

- Water
- Proteins (fibrinogen, globulin, albumin)
- Other solutes
- Small electrolytes (Na , K , Ca , Mg , Cl , HCO , PO and SO)
  Non protein nitrogen (NPN) substance (urea, uric acid, creatine, creatinine, ammonium salts).
- Nutrients (glucose, lipid, amino acid)
- Blood gases (oxygen, carbon dioxide, nitrogen)
- Regulatory substances (hormones, enzymes).

If the blood is collected in a vial containing an anticoagulant, the blood is collected in the vial without any anticoagulant, then the blood will coagulate and if this is centrifuged then the liquid portion is known as 'serum'. Actually the serum has lost the clotting factor prothrombin and fibrinogen but the plasma contains clotting factor proteins also.

Fish plasma contains albumin, the protein which control osmotic pressure. It also contains lipoprotein whose main function is to transport lipid. Ceruloplasmin, fibrinogen and iodurophorine are some important proteins of fish blood. Ceruloplasmin is a copper binding protein. The total plasma protein in fish ranges from 2 to 8 gdl. The thyroid binding proteins such as T3 and T4 is present in the blood circulation in free from. Thyroxine binds to vitellogenin in several Cyprinid species. Enzyme such as CPK, alkaline phosphatase (Alk Pase), SGOT, SGPT, LDH and their isoenzymes are reported in fish plasma.

There are three varieties of cells or corpuscles present in blood:

(a) Red blood corpuscles or Erythrocytes
(b) White Blood corpuscles or Leucocytes.
1. Agranulocytes
(a) Lymphocytes (b) Monocytes
2. Granulocytes
(a) Neutrophils (b) Eosinophils (c) Basophils (d)Thrombocytes.

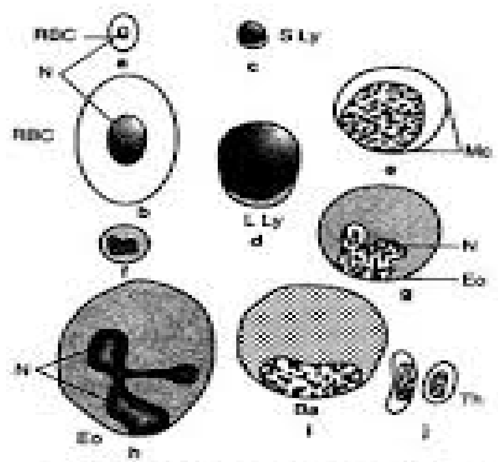


Fig: 8.4 Diagramatic sketch of the blood cells of Fishes

(a) Erythrocyte (RBC) of elasmobranch (larger). (b) Erythr (RBC) teleost (smaller). (c) Lymphocyte (small) (SLY). (d) Lymphocyte (large) (LLy). (e) Monocyte (Me). (f) Neutrophil (g) Eosinophil(Eo). (h) Eosinophil (Eo). (i)- Basophil (Ba). (j) Thromobocyte (th). N, nucleus; RBC, red blood cells.

Erythrocytes

The number of erythrocyte in blood varies according to the species as well as the age of the individual, season and environmental conditions. However, under similar conditions, a fairly constant umber of reticulocytes are present in species. The nucleus is centrally placed and round or oblong in shape. (Fig. 8.4 a,b)

The shape is generally cicular in *Clarias batrachus, Notopterus notopterus, Colisa fasciatus, Tor tor* but ellipsoid, oval or oblong in *Labeo rohita* and *Labeo calbasu.*

White blood cells or leucocytes

Although the fish white blood corpuscles have been well investigated, there is no unanimity regarding their classification. The fish leucocytes in peripheral blood are generally (i) Agranulocytes (ii) Granulocytes. The nomenclature is based on affinity of acid and basic dyes and depends upon human hematology. Plasma cells, basket and nuclear shades are also present.

Agranulocyles

They have no granules in the cytoplasm. The most important distinguishing character is unlobed nuclei. Thus they are distinguished from granulocytes, which possess specific segmented nucleus. A granulocytes have two varieties (a) Lymphocytes, (b) Monocytes.

Lymphocytes

They are most numerous types of leucocytes. The nucleus is round or oval in shape. They constitute 70 to 90% of the total leucocytes. They are rich in chromatin, although its structure is obscure, and is deep reddish violet in colour in preparation with Giemsa. Large and small lymphocytes are found in peripheral blood smears of teleosts, fresh and marine fishes similar to that of mammals. The cytoplasm is devoid of granules but cytoplasmic granules occasionary present, quantity of cytoplasm is evident and nucleus constitutes most of the cellular volume (Fig.8.4.c&d).

The main functions of fish lymphocytes are to produce immune mechanism by the production of antibody.

Monocytes

It consists of much less proportion of WBC population often absent in few fishes. It is suggested that they originate in the kidney and become apparent in the blood when foreign substances are present into the tissue or blood stream. The cytoplasm usually stain smoky bluish or pinkish purple. The nucleus of monocyte is fairly large and varied in shape (Fig.8.4,e). The function of monocyte is phagoeytic.

Macrophage

They are large size, the cytoplasm was occasionally finely or coarsely granulated. They belong to mononuclear phagocyte septum. They are abundant in renal lymphomyeloid tissue and spleen. Macrophages are present in various other tissues of fishes such as pronephros and olfactory mucosa etc. Macrophages system of the spleen, bone narrow and liver play a role in phagocytosis of RBC which undergoes degradation. Iron separated from haemoglobin molecule is removed by the liver.

Granulocytes

These cells possess specific granules in large numbers and they retain their nucleus. They are of three types (a) Neutrophils, (b) Eosnophils, (c) Basophils

Neutrophils

The neutrophils in fishes are most numerous of the white blood cells and constitute 5-9% of total leucocyte in *Solvelines fontinalis*. They are 25% of total leucocytes in brown trout.

They are named for their characteristic cytoplasmic staining. They can be easily identified by the multilobed shape of their nucleus and therefore they are

Segmented or multilobed but in some fishes neutrophils are bilobed.

Their cytoplasmic granules are pink, red or violet in peripheral blood smear. The nucleus often looks like the human kidney. In Giemsa stained smear the nucleus is reddish violet in colour and usually exhibits a reticular structure with heavy violet, colour.

Neutrophils show peroxidase and sudan black positive reaction. The neutrophil is an active phagocyte. It reaches to inflammation site and inflammation refers to local tissue response to injury.

Eosinophils

These cells are generally round and cytoplasm contains granules which have affinity to acidic dye and they take deep pinkish orange or orange red with purple orange background. The nucleus is lobed, takes deep orange purple or reddish purple stain. (Fig8.4.g and h).

Basopsils: The basophils are round or oval in outline. The cytoplasmic granules take deep bluish black stain. They are absent in anguilled and plaice.

Thrombocytes

Thrombocytes or spindle cells: These are round, oval or spindle shaped cells hence called thrombocytes but in mammal they are disc like and are called platelet (Fig.8.4).

They occupy as much as half of the total leucocytes in fish. It constitutes 82.2% of WBC in herring but only 0.7% in other teleosts. The cytoplasm is granular and deeply basophilic in centre and pale and homogenous on the periphery.

The cytoplasm takes pinkish or purplish colour. The thrombocytes help in clotting of blood.

Formation of blood cells (hemopoiesis)

The formation of cells and fluid of the blood is known as hemopoiesis. Both RBCs and WBCs are originated from lymphoid hemoblast or hemocytoblast usually mature after they enter the blood stream. In fishes apart from spleen and lymph nodes many more organs take part in the manufacture of the, blood cells.

Function of blood cells

The blood performs several functions. A few important functions are mentioned as follows

1. **Respiration:** An essential function is the transport of oxygen from dissolved water from the gills (respiratory modifications) to the tissue and carbondioxide from the tissue to the gills.
2. **Nutritive:** It carries nutrient material, glucose amino acids and fatty acids, vitamin, electrolytes and trace elements from alimentary canal to the tissue.
3. **Excretory:** It carries waste materials, the products of metabolism such as urea, uric acid, creatine etc. away from cell.
4. **Hemostasis:** of water and electrolyte concentration: The exchange of electrolyte and other molecules and their turn over is the function of blood. Blood glucose levels are often cited is being a sensitive physiological indicator of stress in fish and there is no unanimity about the blood glucose levels amongst fishes.
5. **Hormones** and humoral agents contain regulatory agent such as hormones and also contains cellular or humoral agent (antibodies). The concentration of various substances in the blood is regulated through-feed back loops that sense changes in concentration and triggers the synthesis of hormones and enzymes which initiate the synthesis of substances needed in various organs.

Fishes possess a closed circulatory system consisting of heart, arteries and veins

Heart

Heart consists of sinus vinous, atrium, ventricle and a well developed contractile conus arteriosus. The sinus-auricular and the atrio-ventricular openings are guarded by paired valves. In the conus, as many as six tiers of valves may be present.

Structure of the heart of a teleost

The heart lies within the pericardial sac interior to the septum transversum and consists of sinus venosus, auricle, ventricle and the bulbus arteriosus. The sinus is a fairly spacious chamber with smooth walls and receives blood through the paired ductus Cuvieri, paired hepatic veins, a posterior cardinal and an inferior jugular vein. The openings of these blood vessels are not guarded by valves. The sinus opens into the auricle through a sinus auricular aperture guarded by a pair of membranous semi-lunar valves, each having a longer limb that projects anteriorly into the auricle.

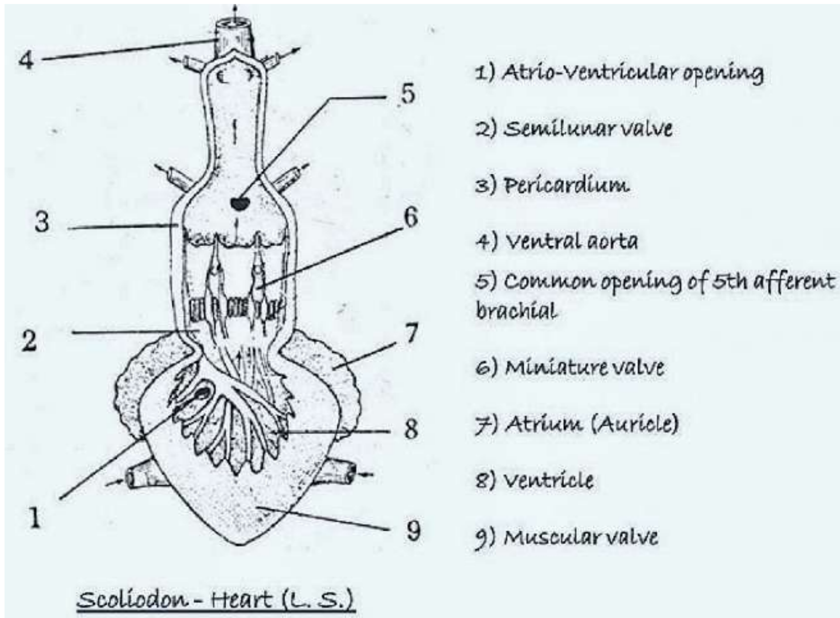


Fig: 8.5 Heart of Fish

The auricle covers the ventricle in dorsal view and is fairly large in size with an irregular outline. It is orange in colour, spongy in texture and has a narrow lumen extending up to the ventricle. The spongy wall of the auricle shows numerous spaces or cavities delimited on all the sides by muscular stands running in various directions. The valves of nearly equal size. Each of these valves has shorter limb attached to the wall of the auricle and a longer one adhering to the ventricular wall, while the convexities of the valves project into the auricle.

The ventricle is a highly muscular chamber with thick walls and a narrow lumen in between. The ventricle leads into the bulbus arteriosus through the ventriculo-bulbus opening guarded by a pair of semi-lunar valves. Each valve has a shorter limb attached to the wall of the ventricle and a longer one connected to the wall of the bulbus in such a way as to cross the limb of the other valve. The valves hang into the lumen of the ventricle. There is no conus, and the base of the ventral aorta is thickened to form the bulbus. The bulbus has thick walls and a narrow lumen, its cavity has a number of thin ribbon-like trabeculae running parallel to each other. The bulbus extends anteriorly into the ventral aorta.

Working of the heart

The venous blood flowing continuously towards the heart reaches the sinus and passes into the auricle by pushing apart the semilunar valves. During this, the pockets of the valves also become full of blood and the pressure due to the contraction of the auricle causes the valves to swell and adhere with each other, thus preventing the backward flow of the blood.

The blood now flows from the auricle into the ventricle by pushing apart the four auriculo-ventricular valves. As soon as the ventricular cavity is full, the valves also receive the blood, so that they bulge out and adhere with each other so as to effectively close the opening and thus, prevent the backward flow of the blood. The blood, now, pushes aside the ventriculo bulbar valves, to enter the bulbus. Here again, the increased pressure inside the bulbus causes the valves to swell and close the passage, preventing backward flow of the blood, which passes forward into the ventral aorta.

Cardio-vascular control: Fishes control their cardio-vascular systems by two methods:

(i) Aneural
(ii) Neural mechanisms.

Aneural cardio-vascular control is exercised by changes in blood volume, by direct responses of heart muscles to changes in temperature, and by secretions of various glands. Temperature acts as aneural regulator of circulation by direct action on the pace makers in the myocardium. Aneural control is also affected by the secretion of certain hormones. Thus, epinephrine stimulates heart rate, and experiments have shown that the level of circulating epinephrine and nor-epinerphrine rises with exercise in rainbow trout.

Neural control is effected though the tenth cranial nerve. The heart of all fishes are innervated by a branch of the vagus. Stimulation of vagus slows the heart rate in elasmobranchs and teleosts. In fishes a built-incapacity for circulatory adjustments in response to environmental or other changes.

Arterial system in a teleost

The ventral aorta runs forwards and gives off four pairs of afferent branchial vessels of which the third and the fourth have a common origin from the ventral which the third and the fourth have a common origin from the ventral aorta. These blood vessels enter into the respective holobranchs of the corresponding side and give off paired capillaries to the gill lamellae. After oxygenation in the gills the blood is collected by means of four pairs of efferent branchial arteries. Only one efferent is present in each gill arch and the first two of these emerge dorsally from the gills and join to form the first epibranchial vessel. The epibranchial of the two sides run posteriorly and meet to form the dorsal aorta. The third and fourth efferent branchial vessels also emerge from their respective holobranchs and join to form a short second epibranchial which opens into the dorsal aorta.

A short common carotid arises from the first efferent branchial vessel and divides almost immediately into an external carotid and an internal carotid artery. Near its base, the carotids receive an efferent pseudobranchial artery from the pseudobranch. A cerebral artery arises from the common carotid to supply the brain. The external cartid artery gives off a number of branch and supplies blood to the opercular and auditory regions and to the muscles of the jaw. The internal carotid artery supplies blood the snout and the optic region. A small branch of the internal carotid runs towards and middle line and joins its fellow of the opposite side to form the circulus cephalicus.

The dorsal aorta runs posteriorly below the vertebral column. The subclavian artery arises from the dorsal aorta, a little behind the second epibranchchial and supplies blood to the pectoral fins. The coeliaco-mesenteric artery arises from the dorsal aorta a little behind the subclavian and soon divides into coeliac and mesenteric arteries. The celiac artery supplies blood to the anterior part of the intestine while the mesenteric gives off branches to the liver, spleen, air bladder, gonads and to the rest of the alimentary canal.

The dorsal aorta runs through the substance of the kidneys and gives off several pairs of renal arteries to it, one of which continues into the pelvic fins also. The dorsal aorta then continues posteriorly as the caudal artery within the haemal canal and gives off several pairs of segmental arteries to the muscles during its course.

Venous system in a teleost

The blood from the head is collected by external and internal jugulars which unite to form an anterior vein on each side. The internal jugular vein receives blood from the premaxillary, nasal and optic regions while the external jugular collects blood from the maxillary and mandibular regions. The anterior cardinals also receive opercular vein and the subclavian vein before opening into the ductus Cuvieri. A single inferior jugular vein collects blood from the ventral surface of the pharynx and opens into the sinus venosus.

Only one posterior cardinal vein is present in this fish and runs through the substance of the right kidney. Renal veins from both the kidneys open into the posterior cardinal which, runs forwards and opens into the sinus venosus. The blood from the tail is collected by the caudal vein which after receiving several segmental veins, discharges into the kidney.

The hepatic portal vein collects blood from different regions of the alimentary canal, spleen, air bladder and the gonads and empties into the liver. From the liver, two hepatic veins arise and carry the blood to the sinus venosus.

8.4 Respiratory System of Prawn

I. Respiratory System

Respiratory system is well developed and consists of

(i) Lining of branchiostegites or gill covers,
(ii) There pairs of epipodites and
(iii) Eight pairs of gills or branchiae.

These are sheltered in two large and compressed gill-chambers, one on either side of thorax. Each gill-chamber is bounded internally by epimeron or lateral wall of thorax, and externally by the curving pleural side of carapace or brachiostegite. The gill-chambers open on the anterior, ventral and posterior sides.

1. **Lining of Branchiostegites:** Inner lining of branchiostegites or gill-covers is thin, membranous and highly vascular containing minute blood lacunae. These form large respiratory surfaces which absorb oxygen (O_2) dissolved in water and give out carbon dioxide (CO_2).

2. **Epipodites:** These are three pairs of simple foliaceous and highly vascular outgrowths of integument, given out from the coxal segments of 3 pairs of maxillipedes. They occupy the anterior part of gill-chambers beneath the scaphognathites of maxillae. Epipodites of first pair are bilobed and larger than others. Epipodites also serve as respiratory organs like primitive gills.
3. **Gills:** There are eight gills inside each gill-chamber. Only seven of them are exposed on removing the gill-cover as the 8^{th} gill lies concealed beneath the dorsal part of the second gill.

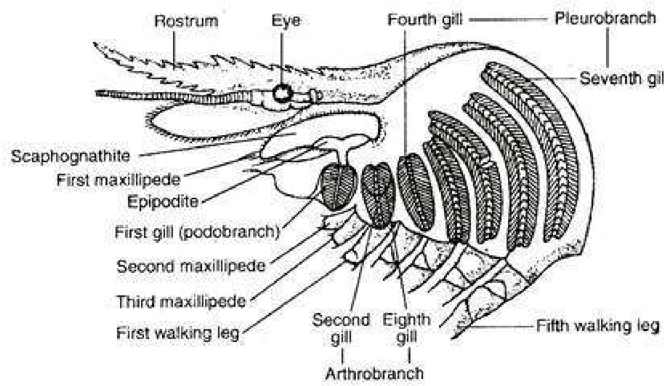


Fig.8.7 Gill-chamber exposed to show the gills of Prawn

(a) Types of gills: Gills are of three kinds according to their place of origin and attachment.

(i) **Podobranch or foot-gill:** It is attached to the coxa of an appendage. In Palaemon, one podobranch is carried by the coxa of each second maxillipede.

(ii) **Arthobranch or joint-gill:** It is attached to the arthrodial membrane joining a limb with the body. Each third maxillipede bears two arthrobranchs. Second arthrobranch is the smaller and remains concealed beneath the first arthobranch.

(iii) **Pleurobranch or Side Gill:** It is attached to the lateral wall of segment bearing the limb. Last five gills on each side are pleurobranchs, attached to the lateral wall of thoracic segments bearing the five walking legs.

(b) Branchail Formula: Number and disposition of respiratory organs of each gill chamber in prawn can be represented in the form of a branchial formula.

(c) Structure of Gills: Gills are more or less crescentic in shape. They gradually increase in size backwards, so that each gill is larger than the one in front of it. Each gill attached its middle to the wall of thorax by a small connection called the gill-root, through which nerves and blood channels enter and level the gill. All the gills of Palaemon are phyllobranchs, i.e., each them consists of two rows of leaf-like rhomboidal gill-plates arranged like leaves of a book, at right angles to the long narrow axis or base of gill. Gill-plates are largest in the middle but become gradually smaller towards the two ends. A deep median longitudinal groove runs between the two rows of diverging gill-plates.

(d) Blood Supply in a Gill: Three longitudinal blood channels run through the gill-base from one end of gill to the other. Two are lateral longitudinal channels running along the lateral margins, one on each side. The third is median longitudinal channel running through the apex of gill-base, beneath the outer median grove of gill. Lateral channels are connected together by a series of transverse connectives, forming a ladder-like structure. In each gill-plate the lateral channel of that side gives off a slender marginal channel which runs all along its margin and finally joins the median longitudinal channel.

(e) Blood circulation in a Gill: Deoxygenated blood from body is brought to the gill by an efferent branchial channel which enters the gill-root to open into a transverse connective lying just in front of it. Flowing first through the two lateral longitudinal channels, and then through the marginal channels it reaches the median longitudinal channel. During this journey the blood gets oxygenated. From median channel, blood is carried by an efferent branchial channel to the pericardium.

II. Mechanism of Respiration

The scaphognathite of each maxilla lies anteriorly inside the gill-chamber. Its constant vibrating movements, it bales out water from the anterior open end of gill chamber. Action of scaphognathites is supplemented by the expodities of maxillipedes. Fresh water enters the gill chamber from behind in the form of a current. This current of water flows over the lining of branchiostegites, gills and epipodites which are richly supplied with blood, so that exchange of gases takes place. The extremely delicate and thin gill-plates act as excellent permeabe membranes for the passage of gases to and fro by diffusion. Oxygen, dissolved in water, is taken in by blood and CO_2 from blood diffuses out in the water.

8.5 Circulatory System of Prawn

Blood: Blood is colourless, thin and watery fluid, containing floating amoeboid white corpuscles or leucocytes which are phygocytic. There are no red blood cells. The respiratory pigment is haemocyanin which is dissolved in plasma. It has the same function as haemoglobin of other animals, but its metallic base is copper instead of iron. Haemocyanin becomes blue when combined with oxygen.

i. Blood Vascular Organs

Unlike annelids which have a 'closed type' of blood vascular system, prawn has an 'open type' or lacunar type of blood vascular system. Strictly speaking, it is partly closed and partly open. This type of blood vascular system is characterized by the absence of capillaries so that blood flows through open spaces, the lacunae or sinuses, in body. Blood vascular system of prawn includes:

(i) Pericardium,
(ii) Heart
(iii) Arteries
(iv) Blood lacunae or sinuses
(v) Blood channels and
(vi) Blood.

There are no veins and capillaries as in vertabrates.

1. **Pericardium:** Heart lies dorsally in the posterior part of thorax, enclosed in a spacious haemocoelic chamber, the dorsal sinus or pericardium.
2. **Heart:** Heart is a muscular and somewhat triangular organ with its apex directed anteriorly and the broad base posteriorly. A median longitudinal cardiopyloric stand of fibrous tissue runs from its apex to the pyloric stomach. Two lateral stands extend from postero-lateral angels of heart to the body wall. The three stands keep the heart is perforated by five pairs of valvular, slit-like apertures, called Ostia. Blood from pericardial sinus enters the heart through ostia. Ostia are so distributed that the first pair lies dorsally, second pair ventrally, third pair posteriorly, fourth pair anterio-laterally and the fifth postero-laterally. In a section, cavity of heart appears spong-like filled with numerous interlacing muscle fibres with blood in the interspaces.

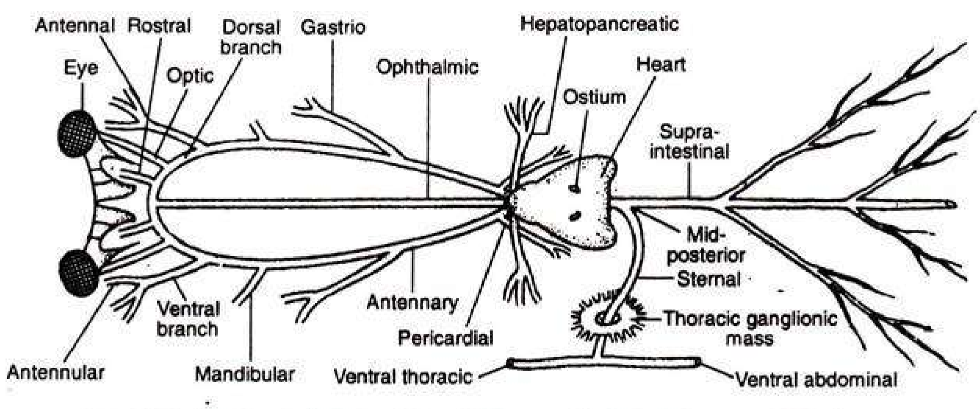


Fig: 8.8 Heart and principal arteries.

3. **Arteries:** Heart pumps blood to the body through narrow tube-like arteries which are provided with thick, strong and muscular wall. The principle arteries are as follows. Five of them arise from the anterior end and one from the posterior end of the heart. They are
   a. Median ophthalmic
   b. Antennary
   c. Hepatic
   d. Mid-posterior
4. **Blood Sinuses:** The heart and arteries comprise the closed portion of circulatory system. Arteries repeatedly branch in various organs of body. True capillaries and veins are absent. Minute arterial branches open freely into blood sinuses or lacunae of the haemocoel. All the sinus of body eventually meet into a pair of elongated and ill-defined ventral sinuses lying below hepatopancreas on the floor of thorax. The two sinuses communicate with each other at various places.
5. **Blood Channels:** The channels are lacunar tubes without proper walls. The sinuses and channels comprise the open portion of circulatory system. Six afferent branchial channels carry venous blood from each ventral sinus to the gills of that side, where it is aerated.

Course of Blood Circulation

The heart, by means of its rhythmic contractions, forces blood through the arteries to all the parts of body. Before being returned to the heart, the blood is distributed to the gills and blood sinuses. The course of circulation of blood in the body of prawn can be diagrammatically represented as shown in fig.

Short Answer questions (2 Marks)

1. Define respiration?
2. Name the accessory respiratory organs found in fish?
3. Write of any two scientific names of lung fishes?
4. Name the two types of gills present in fishes?
5. What are the cellular components of blood in fish?
6. Define 'hemopiesis'.
7. Why the fish heart is called as mono-circulatory heart?
8. What are the uses of gill-rackers in fish?
9. Define 'Aquatic Respiration'?
10. Write types of gills present in prawn?
11. What is open-type blood vascular systems?
12. Define pericardium.
13. Write any two names of arteries in prawn?
14. What is a blood sinus in prawn?

Long Answer Questions (6 Marks)

1. Discus the mechanism of respiration in fish?
2. Give an account on accessory respiratory organs in fishes?
3. Give an account on blood of fish?
4. Describe the structure and working mechanism of fish heart?
5. Describe the respiratory system of prawn?
6. Describe the circulatory system of prawn?

Unit-9

Excretory and Reproductive Systems of Fish and Prawn.

Structure

9.1 Excretory System of Fish

Various body parts which are concerned with the removal of metabolic wastes are included in the excretory system. Elimination of nitrogenous waste products from the body is a process called excretion. The excretory products are formed during the amino acid catabolism. The amino group (NH) is separated from the amino acid through the process of deamination. These excretory products are-harmful to the body, if they are accumulated.

The nitrogenous waste products include ammonia, urea and uric acid besides creation etc. Based on the excretory products animals are classified into three catagories.

1. **Ammonotelic animals:** Excrete nitrogenous wastes in the form of ammonia. eg.some bony fishes.
2. **Ureotelic animals:** Excrete nitrogenous wastes in the form of Urea. eg. Cartlaginous fishes, Amphibions and Mammales.
3. **Uricotelic animals:** Excrete nitrogenous wastes in the form of Uric acid. eg. Incets, Reptiles and Birds.

The excretory and reproductive organs are closely associated with each other in fish and these systems are together called urino-gential system. The excretory and genital systems work independently.

Excretion in fishes

The functions of excretion and osmoregulation are closely related and are performed by gills and kidneys in fishes. Although the gills are chiefly the respiratory organs, they are also important as excretory and osmoregulatory organs. Kidneys play the most important part in the excretion of nitrogenous wastes and in maintaining the water-salt balance (homeostasis). A kidney consists of a large number of the anterior region develop and become fuctional in early life and constitute the pronephors.

Those of the more posterior region develop and become functional in later life and form the mesonephors. The ancestral craniates probably had a complete set of segmental tubules in the trunk region forming an archinephros and opening into an archinephric duct.

The archinephors became differentiated into pro meso, and meta-nephros. A functional pronephros is found in fishes and is later replaced by mesonephric tubules. These open into the pronephric duct which therefore becomes the mesonephric duct. The tubules of the more anterior region of mesonephors have a tendency to become reduced and even degenerate becoming converted into a lymphoid organ. However the more posterior tubules take up the posterior tubules behind the pronephros, in fish and amphibian are also known as opisthonephros.

Structure of the kidney

The kidneys are paired; elongated structures placed above the alimentary canal and are close to the vertebral column. The teleostean kidney is generally divided into two portions, the head and the trunk kidney, but in many species these regions cannot be distinguished by external examination. Generally there are no conspicuous differences in shape between the two sexes. The marine teleostean kidney can be divided into five types.

1. The two kidneys are completely fused and there is no distinction between the trunk and head kidney as in clupeoideae.
2. The middle and posterior portions of the kidneys are fused. There is a clear distinction between the trunk and head kidney, as in the marine catfishes (piotosidae) and eels (Anguillidae).
3. Only the posterior portions of kidney are fused. The anterior portion is represented by two slender branches; head and trunk kidney are clearly distinguishable. eg: most marine fishes belonging to the Belonidae, Scopelida, Mugilidae, Scombridae, Carangidae, Cottidae and pleuronectide.
4. Only the extreme posterior portion of the kidney is fused. There is no distinction of head and trunk kidney, as in Syngnathidae (Sea horse and pipe fishes).
5. The two kidneys are completely separated as in Lophiidae.

The fresh water teleostean fishes possess kidneys of the first three types. Completely fused kidneys of type one is found in Salmonidae (salmon and trout). The cyprinidae (carps) have kidneys of type two, i.e., their middle and posterior portions are fused. Their anterior free lobes from the head kidney, while the fused portions constitute the trunk kidney. In many species, the trunk kidney is broad in the middle and gradually narrows in the ninder part (e.g. *Cirrhina, Labeo* and *Barbus).* Fishes belonging to Cyprinodontidae, Gasterosteidae and Cottidae posses kidneys of type three, in which only the posterior prtion is fused. In some species e.g., *Mystus, Amiurus, Dactylopterus* and *Anus,* the head kidney is completely separate from the remaining part.

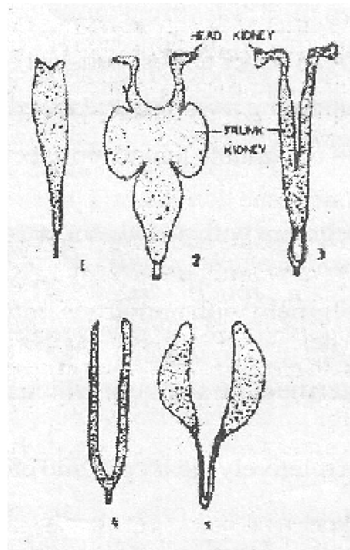


Fig: 9.1 Teleost kidneys:

Two mesonephric ducts are usual present and each runs along the outer border of the corresponding kidney. They are clearly visible in the middle and the posterior regions of the kidney. The two ducts always fuse to form the common duct. The fusion may occur at the posterior end of the kidney (e.g. *Mystus)* or at some point between the kidney and the urinary papilla. They remain separate till they open into the urinary bladder as *Labeo* and *Cirrhina.*

The urinary bladder may be a simple enlargement of the common mesonephric duct, or it may be a simple enlargemet of the common mesonephric duct, or it may be a distinct sac-like structure on one side of the common mesonephric duct *(Barbus* and *Mystus).*

The urinary bladder usually opens to the exterior by a common urinogenital aperture in the male fish and by a separate urinary pore in the female fish. The urinogenital aperture of the male may be situated on the external surface, but in some species a small integumentary cloaca is formed and the ducts open into it.

A pair of abdominal pores may also be present on either side of the gential pore of some species. The abdominal pores are special openings from coelom to the exterior and appear to be of no significance and are of doubtful function.

Nephron

A typical nephron of a fresh water teleost consists of the following parts:

(a) A renal corpuscle containing a well vascularised glomerulus.
(b) A ciliated neck region of variable length, connecting the renal corpuscle with the tubule.
(c) An initial proximal segment with prominent brush border and numerous prominent lysosomes.
(d) A second proximal segment with numerous mitochondria but less well developed brush border.
(e) A narrow ciliated intermediate segment which may be absent in some species.
(f) A distal segment with relatively clear cells and elongated mitochondria.

(g) A collecting duct system.

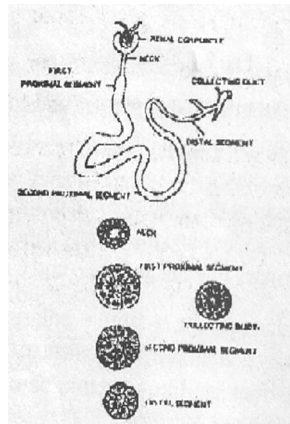


Fig.9.2 Nephron and its cross section of a teleost.

Oxmoregulators and osmoconjirmers:

Osmoregulators are those animals who can maintain the internal osmolarity different from the medium in which they live. The fishes are generally true osmoregulators maintaining the concentrations of body fluid. In these fishes which migrate between fresh and salt waters, the changing osmotic stress due to environmental changes is overcome with the help of endocrine mechanism.

Osmoconfirmers are those animals who are unable to control osmotic state of their body fluids but confirms to the osmolarity of the ambient medium. Majority of fishes either live in freshwater or in saltwater. But in fishes and aquatic animals their gills and roal membranes are permeable both to water and salts in marine environment salt is more in water against the salt inside the body fluid hence water moves out due to the process of 'osmosis'. The 'osmosis' may be defined as "if two solutions of different concentrations are separated by a semi permeable membrane, the solvent from the less concentrated part will move through the membrane into more concentrated solution. Hence to compensate the loss of water marine fishes drink water. The salt will enter the body due to concentration gradient and so salt will be more inside the body. On the other hand, in freshwater fishes, the salt will go out to the environment as the salt concentration will be more inside the body fluid. The water will move inside the body due to osmosis through partially permeable membrane. This means solvent will pass into more concentrated solution, but solute will also pass in the opposite direction. There will be however, a difference in the rate dependent upon the relative permeability for two types of molecules usually solvent pass rapidly.

Osmoregulation in freshwater fishes

The body fluid of freshwater fishes in generally hyperosmotic to their aqueous medium. Thus they are posed with two types of osmoregulatory problems.

1. Because of hyperosmotic body fluid they are subjected to swelling by movement of water into their body owing to osmotic gradient.

2. Since the surrounding medium has low salt concentration, they are faced with disappearance of their body salts by continual loss to the environment. Thus freshwater fishes must prevent net gain of water and net loss of salts. Net intake of water is prevented by kidney as it produces a dilute, more copious (i.e. plantifula hence dilute) urine.

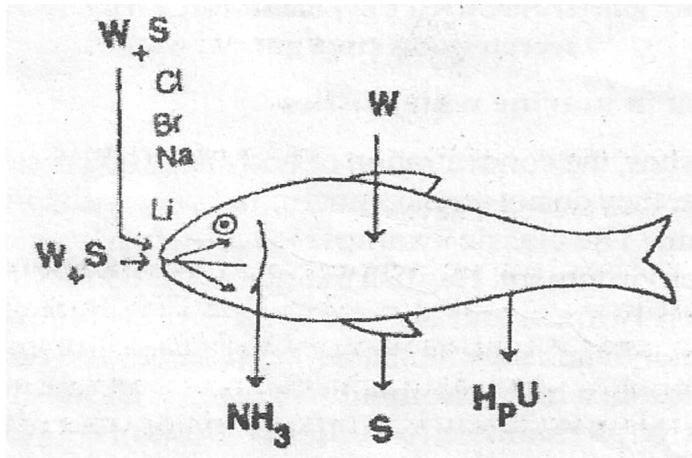


Fig.9.3 Osmoregulatory inflow and outflow of salts and wter in a fresh water fish. HpU, hypotonic uring, S, salt, W, water, W+W, water and salt.

The useful salts are largely retained by reabsorption into the blood in the tubules of kidney and dilute urine is excreted. Although some salts are also removed along with urine which creates torrential loss of some biologically important salts such as KCI, NaCl, $CaCI_2$ and $MgCI_2$, which are replaced in various parts. Freshwater fishes have remarkable capacity to excrete Na^+ and CL^- through their gills from surrounding water having less than 1mm/L NaC1, even though the plasma concentration of the salt exceeds 100mm/L NaCl. Thus NaC1 actively transported in the gills against a concentration gradient in excess of 100 times. In these fishes the salt loss and water uptake are reduced by the integument considerable with low permeability or impermeability to both water and salt also by not drinking the water.

Osmoregulation in marine water fishes

In marine fishes, the concentration of body fluid and marine water is almost similar. Therefore, they do not require much energy for maintenance of osmolarity of their body fluid. The classic-example is hagfish, Myxine whose plasma is isosmotic to the environment. Hagfish maintains the concentration of Ca^{++}, Mg^{++} and SO_4 significantly lower and Na^+ and Cl^- higher in comparison to seawater. Other marine water fishes such as sharks, rays, skates and primitive coelacanth (Latimria) have plasma which is isomotic to seawater. They differ from the hagfish in having capacity to maintain very lower electrolyte (i.e. inorganic ions) concentrations. They also have difference with organic osmolytes like urea and trimethylamine oxide. Kidneys of coelacanth and elasmobranchs excrete excess of inorganic salts such as NaCl. Also rectal gland located at the end of alimentary canal takes part in the excretion of NaCl.

Modern bony fishes (marine teleosts) have the body fluid hypotonic to seawater, so they have tendency to lose water to the surroundings particularly from gill via epithelium. The lost volume of water is replaced by drinking salt water. About 70-80% sea water containing NaCl and KCl enters the blood stream by absorption across the intestinal epithelium. However, most of the divalent cat ions like Ca^{++}, Mg^{++} and SO_4 which are left in the gut are finally excreted out. Excess salts absorbed along with sea water is ultimately removed from the blood with the help of gills by the active transport of Na^+, Cl^- sometimes K^+ and eliminated into the seawater. However, divalent ions are secreted into the kidney.

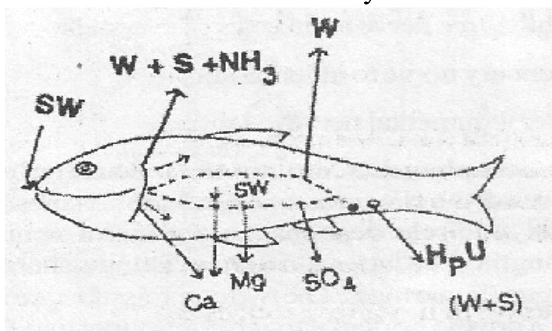


Fig:9.4. Osmotic regulation in marine bondy fishes. HpU, hypotonic urine: SW, sea water, W+S+NH_3, water, salt and ammonia, W. water.

Thus uring is isosmotic to the blood but rich in those salts, particularly Mg^{++}, Ca^{++} and SO_4 which are not secreted by the gills. Combined osmotic action of gills and kidney in marine teleosts resulted in the net retention of water that is hypotonic both to the ingested water and urine, By using similar mechanism some teleost species such as the salmon of pacific northwest maintain more or less constant plasma osmolarity inspite of being migratory between marine and freshwater environment.

Control of osmoregulation:

The concentration and dilution of urine is controlled by hormones, which affects the rate of renal filtration by changing the blood pressure and thus control the quantity of urine. Hormones also influence the rate of diffusion and absorption across the gill epithelium. Thyroid gland and suprarenal bodies secrete adrenocortical hormones which control osmoregulation if fishes.

9.2 Excretory System of Prawn

The excretory system of adult Palaemon consists of

(i) A pair of antennary or green glands

(ii) A pair of lateral ducts

(iii) An unpaired renal or nephroperitoneal sac and

(i) The integument.

True, nephridia do not occur.

1. **Antennary Glands**

Coxa of each antenna encloses an antennary gland which is opaque white in colour and as big as a pea-seed. It includes three parts

(a) End-sac
(b) Labyrinth or glandular plexus and
(c) Bladder

(a) End sac: The bean-shaped end-sac is the smallest part lying between bladder and labyrinth. Internally, it contains a large central bood-lacuna.

(b) Labyrinth: Labyrinth or glandular plesus is relatively larger than the end-sac and lies on its outer side. It consists of numerous narrow, branching and greatly coiled excretory tubules. Tubules are lined by a single layer of large excretory epithelial cells. They open by a single aperture into end-sac and by many apertures into bladder.

(c) Bladder: Bladder is the largest of all, lying on the inner side of end-sac. It s a thin-willed sac made of a single layer of excretory epithelial cells. Its inner wall is prolonged as a short excretory duct or ureter, which opens to outside through a small rounded renal pore, situated on a papilla on the inner surface of coxa of antenna.

2. **Lateral Ducts**

A narrow lateral duct runs posteriorly from the bladder of each anternnary gland. Ducts of both sides are connected by a transverse connective just in front of the brain. The two ducts run backwards along the oesophagus to open into the renal sac.

3. **Renal-sac:**

It is large thin-walled sac lying above the cardic stomach, stomach, just beneath the carapace and extending posteriorly up to the gonads. Its wall is made of a single layer of flattened excretory epithelial cells.

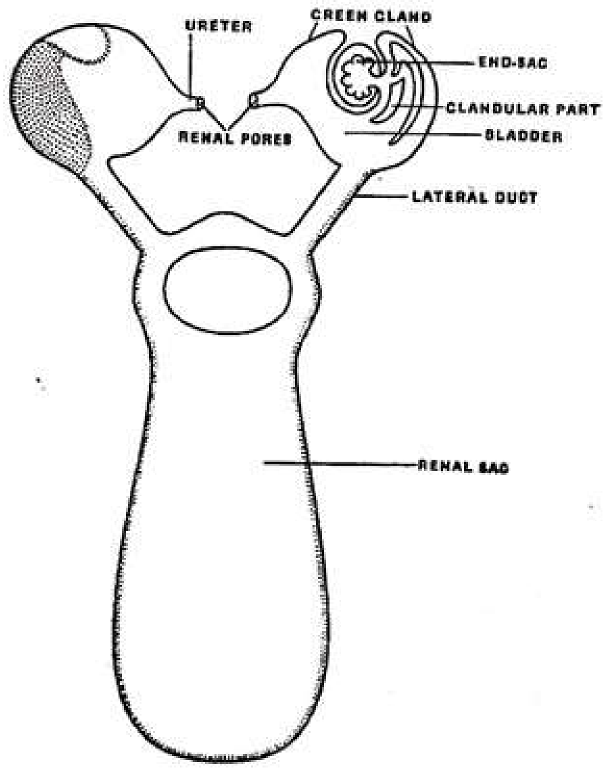


Fig. 9.6 Excretiory organs of prawn, dorsal view

Physiology of Excretion

The complex, nephridia-like antennary glands extract nitrogenous wastes and excess water (oxmeregulation) from blood in the same manner as the vertebrate kidneys. The end-sacs excrete mainly compounds of ammonia, but uric acid and other nitrogenous compounds are excreted by other parts. The excretory fluid from end sacs passes into labyrinths in which the useful materials are taken back by blood (Selective resorption). The remaining fluid (urine) passes into bladders and finally expelled out through the renal apertures.

9.3 Reproductive system of Fish

Reproduction is the process by which animals increase their population to continue their races in the nature. There are four types of reproduction monosexuals (bisexual, Hermophrodities and parthenogenetic). Reproductive system mainly consists of reproductive organs known as gonads, (testes and ovary), the gametes (sperms, ova). Fishes reproduce by several methods and are generally bisexual. Some species are hermaphrodite and even parthenogenetic reproduction occurs in a few cases. Some fishes are highly specialized for breeding and show interesting development of parental care comparable with higher animals. The sperms and he eggs develop in separate gonads except in some species of Sparidae and Serranidae, which are true hermaphrodites and the eggs and sperms, develop in the same gonad and self fertilization takes place. However, hermaphrodite gonads sometimes occur in other species also. Parthenogenetic development takes place in *Poecilia formosa,* in which the sperms simply induce the egg to develop, but take no part in fertilization.

Sexual dimorphism

The characteristics of sexual difference or sexual dimorphism that enables identification of the sexes are classed as primary and secondary. Primary sexual characters are concerned with reproductive organs, the testes in males and ovaries in females. The primary sexual characters often require dissection for their discrement, which makes the secondary sexual characters often more useful, although sometimes not so possitive.

Some species show well marked sexual dimorphism which may be of two kinds:

(i) Some species possess structural peculiarities directly related with fertilization of ova. These are in the form of copulatory organ in the male for introducing the milt into the body of the female, as the claspers in sharks. (ii) Some species possess structural peculiarities that are not connected with sexual union or fertilization, but are related with courtship, or fight among rival males.

In most fishes excepting the elasmobranches and a few teleosts, fertilization is external in water. In Chondricythyes the eggs are fertilized within the body of the female, and the males are provided with claspers or myxopterygia for transferring the sperms into the body of the female.

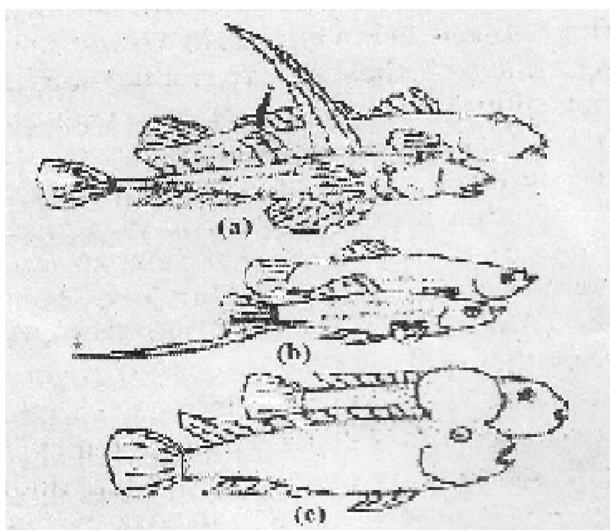


Fig 10.2 Sexual dimorphism in a. Dragonet b. Sword Fish c. Lion-head chichilid

Reproductive organs:

The gonads develop from the coelomic epithelium. The ovaries may be naked as in the Elasmobranches, Dipnoi, Chondrostei and Amia. This is called ‘gymnovarian’ condition and is primitive. Here, the ova are discharged into the coelomic cavity and pass out through the anteriorly placed oviducal funnel of the Mullerian duct. In Lepidosteus and teleports, the ovaries become enclosed in coelomic sacs and the lumen of the ovary is continued into the oviduct. This called the ‘cystovarian’ condition, and is secondary. In a few teleports belonging to the Salmonidae, Galaxidae. Hyodontidae, Notopteridae and Osteoglossidae the oviducts degenerate partly or completely and the ova are shed into the coelomic cavity and then pass out through pores or funnels. In the eels (Anguillidae) both male and female gonoducts degenerate losing all connection with the gonads.

Male reproductive organs

The male fish consist of a pair of testes which are elongated and flattened structures, situated on either side, ventral to the kidneys in the posterior region of the abdominal cavity. The testes remain attached to the body wall and the air bladder by means of mesorchia. They may or may not be equal in size. The two spem ducts join posteriorly to open into the urinogenital papilla. The testes may show indentations along their margin which become prominent during breeding season.

In a few species, the anterior three-fourth prt of each testis is functional and the pdosterior one-fourth is sterile as in *Mystus seenghala* and *Tor tor*. The posterior region of the testis in these species is structurally and functionally different from the anterior region. Various stages of germ cells are present in the anterior and middle part of the testis whose function is to produce sperms but the posterior region consists of sterile empty lamellae and probably serves for the storage of sperms during the breeding season. In some species, the entire testis is functional and serves to prodeuce sperms. Paired glandular sructures called the seminal vesicles are present as outgrowths of the hinder ends of the vasa deferentia in some teleports as *Clarias batrachus, C. lazera, Hereropneustes fossils.* However, insome other species *(Rita rita, Mystus vitattus)* the posterior part of the testis is glandular. The seminal vesicles are secretory in nature and show periodical changes in correlation with the testicular cycle. The function of the fluid secreted by the seminal vesicles is not known and it has been suggested that the fluid may serve to keep the sperms in an active but viable condition or it may help in nourishing the sperms.

Female reproductive organs

The ovaries are paired elongated sac-like structures lying in the abdominal cavity, ventral to the kidneys. They are attached t the body wall by means of the mesovarium. The anterior ends of the two ovaries are free but their caudal ends may become united into one. The hinder end of each ovary is continued posteriorly into a short oviduct. The two oviducts fuse ande open to the exterior by a separate genital aperture or by a common urinogential opening. Generally, both the ovaries are equal in size, but occasionally they are unequal also. They are thin, flaccid and translucent when immature, but on maturity, they become enlarged and lobulated, while the ripe ova are seen buling out. The wall of the ovary is fairly thick during the non-breeding season but becomes thin and highly vascular during the spawning period. It consists of three layers (i) an outer-most thin peritoneum, (ii) a thicker tunica albuginea made up of connective tissue, muscle fibres and blood capillaries, (iii) the innermost layer is the germinal epithelium which projects into the ovocoel in the form of lamellae. These ovierous lammellae are he seat for the development of oocytes. Which are visible in various stages of development. The germ cells or oogonia are found in clusters in the lamellae and probably originate from the germinal epithelium. An oogonium has a large nucleus, and a thin layer of ooplasm which is chromophobic. Each oogonium passes through a numer of maturation stages to become a ripe ovum. Several of these stages may be present at the same time in the ovary. As the oogonium increases in size, there is increase in the quantity of ooplasm which is stained with basic dyes.

Oocyte stages

The developing egg is known as an oocyte of which several stages can be recognized in the ovary. These are:

Oocyte - I.

This is larger than the oogonium, spherical in shape and with a central nucleus, having 2 or 3 nucleoli. The cytoplasm is basophilic

Oocyte - II

There is further increase in the size of the oocytes, number of nucleoli and basophilia of the cytoplasm. Several small nucleoli of various sizes are seen along the periphery of the nuclear membrane. Many oocytes present this stage; possess a yolk nucleus, lying close to the nuclear membrane in the cytoplasm. Later, the yolk nucleus moves away towards the periphery of the oocyte.

Oocyte - III

This is still larger in size, and is distinguished by the appearance of a thin layer of follicular cells around the cytoplasm; a few nucleoli pass out of the nuclear membrane, and are seen in the cytoplasm of the oocyte.

Oocyte - IV

There is further increase in the size of the oocyte and a large number of small, clear vacuoles called the yolk vesicles appear in the periphery of the ooplasm. The vesicles appear empty in the early stage and are not stainable. Many oocytes show an undulatred nuclear membrane, and the nucleoli enter into the pockets of the nuclear membrane and pass out into the ooplasm.

Oocyte - V

As the oocyte grows further, the yolk vesicles increase in number and fill the entire ooplasm. A vitelline membrane of zona radiate is also clearly visible, between the ooplasm and the follicular layer or the zona granulose. Nucleolar extrusion continues at this stage.

Oocyte - VI

This is characterized by the appearance of yolk in the form of minute granules in the extravesicular ooplasm. They appear first in the peripheral region and accumulate there in large numbers. The yolk granules then proceeds centripetally, till the whole-ooplasm becomes impregnated with them. The yolk granules fuse to form larger globules, and the oocyte is of considerable size. A thin layer of fibroblasts, known as theca is also distinguishable outside the follicular layer.

Oocyte - VII

There is heavy deposition of yolk globules which are fairly large in size. The yolk vesicles also fuse and become large. The nucleus migrates gradually towards the periphery. Some yolk vesicles are pushed towards the periphery of the egg and form cortical alveoli.

Ripe Egg

A ripe egg is largest in size, yellowish in colour and translucent. It is full of large amount of yolk globules and yolk vesicles may lie scattered in it. The nucleus is generally not visible in the ripe egg. An ovary contains several ripe eggs at a time during the spawning period. A mature egg is surrounded by an external layer of theca, followed by the follicular epithelium (zona granulose), and the innermost, zona radiate. The zona granulose is a syncytial layer having deeply staining nuclei. The theca is sometimes differentiable into theca extrena and theca interna. The function of the follicular epithelium in fish oocyte is controversial. The granulose cells are believed to be responsible for the deposition of yolk in the developing ovum and for its removal in ova which degenerate and become atretic. In addition to these, the granulose cells may also be responsible for the secretion of ovarian hormones.

Maturation and spawning

Both male and female gonads undergo marked cyclic morphological and histological changes before reaching full maturity and becoming ripe. This is called maturation of the gonads. Most of the fish's exhibit seasonal cycle in the production of gametes. The expulsion of gametes from the body into the surrounding water is called 'spawning resulting in fertilization. Fish spawns during a specified period which depends upon several factors. The period during which the gonads attain full maturity and spawning takes place in the population is called the breeding season of the species. After spawning, a new crop of germ cell is formed, which gradually mature to become ready for the next season.

In the viviparous teleports, fertilization generally takes place while egg is within the follicle. The egg may continue its development within the follicle (follicular gestation) or development takes place within the ovarian cavity (ovarian gestation).

Eggs

The number of eggs produced by a single female differs considerably and depends upon several factors like her age, size, condition and species. The egg is generally surrounded by a shell but when it leaves the ovary, it is enclosed in a vitelline membrane. Generally, the egg is spherical or oval in shape and has some amount of yolk in it. Eggs of bony fishes are of two main types pelagic eggs are buoyant and provided with a thin, non adhesive membrane, while demersal eggs are heavy and sink to the bottom, and are covered by a hard adhesive membrane. Sticky, demersal eggs become attached to the debris of the bottom and are prevented from being swept away along the current of water at the time of deposition. Marine fishes produce either pelagic or demersal eggs, but the eggs of freshwater fishes are generally demersal. Pelagic eggs are of small size and single large oil globule may be present on the surface of its yolk. The eggs of some species (somberisocidea, beloidae and exocoetide) have stickly threads for attachment with some object or with each other.

Development

The cleavage is incomplete and meroblastic, developments is direct.

Cleavage and the formation of blastula

The development of an egg begins soon after it is fertilized by sperm. The eggs of bony fishes have a relatively large amount of yolk, which is segregated from the active, cytoplasm. Cleavage is confined to the superficial layer of the cytoplasm and is incomplete (meroblastic). In the earlier stages cleavage planes are all vertical so that all the blastomeres lie in one plane only. The blastomeres are separated from each other by furrows but lie over the yolk. In the later stages, cleavages occur in the horizontal plane also, so that the blastomeres become arranged in more than one row. The marginal cells are in contact with the yolk. The disc of cells thus formed on the animal pole of the egg, is called the blastoderm. The central cells of the blastoderm divide to form a number of ‘free’ blastomeres which become arranged on the top of the yolk anterior end due to the presence of presumptive epidermis. But in Salmo the presumptive mesoderm area is present all round the margin of the blastoderm.

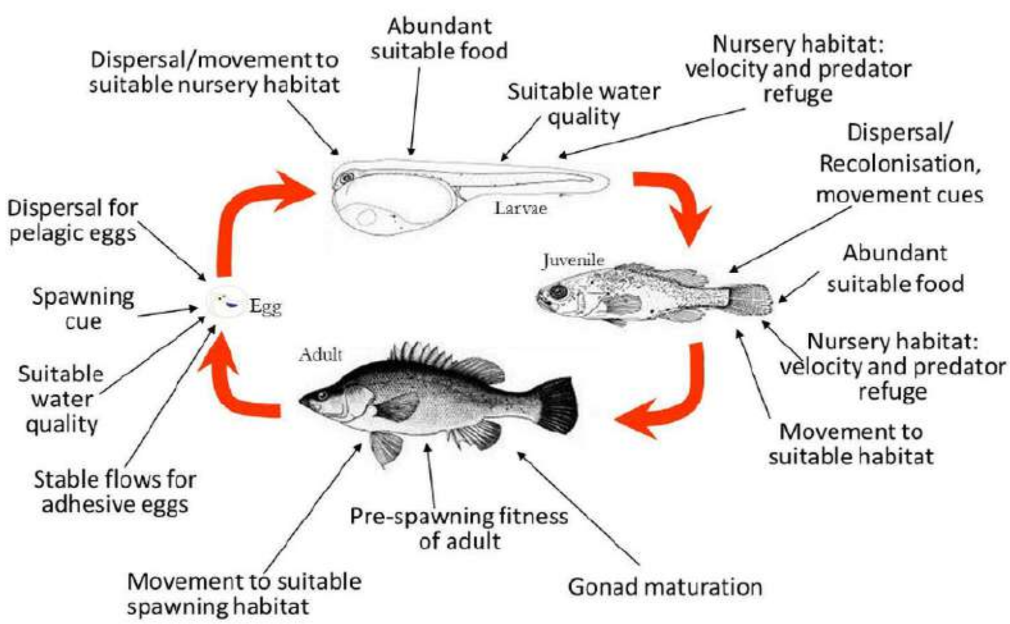


Fig: 10.3 Development stages of bony fish

Fate map of Blastula

It is possible to identify various regions of the blastula wall that are destined to give rise to specific organs in the embryo. Thus a fate map of the teleostean blastula can be constructed showing the presumptive ectoderm, mesoderm, notochord, neural plate etc. In the fish blastula, the areas which are destined to give rise to the organs of the dorsal region of the animal, are concentrated towards one side of the blastodise. This is the posterior end of the future embryo. At this end, along the margin of the blastoderm, lies the presumptive endoderm which is destined to form the gut. In front of this lies the presumptive notochord and still further forwards, towards the centre of the blastoderm lays the area of the nervous system. The presumptive mesoderm lies along the sides of the areas for endoderm, notochord and neural plate. The mesoderm area extends mainly along the margin of the blastoderm and in Fundulu is not continuous at the anterior end due to the presence of presumptive epidermis. But in Salmo the presumptive mesoderm area is present all round the margin of the blastoderm.

Gastrulation:

Gastrulation in bony fishes is accomplished by two processes invagination and epiboly. At the beginning of gastrulation, the presumptive endodermal and mesoderm cells at the posterior end of the blastoderm turn inward and migrate forwards under the blastoderm, so as to form the hypoblast. However there is no in pushing of the epithelial layer and no true archenteron is formed.

The presumptive endodermal cells lying along the posterior margin of the blastoderm, migrate inward along the surface of the yolk. As these cells move inwards, they are concentrated towards the midline of the blastoderm. The presumptive mesoderm cells also invaginate in a similar way and roll over the edge of the blastoderm. Although no true archenteron is formed the edge of the blastoderm may be compared with the dorsal lip of the blastopore of amphibians. The mesoderm cells, after invagination, also converge towards the midline, where the axial organs of the embryo are formed.

Hatching and post-embryonic development

After the completion of gastrulation, various organs of the body are formed resulting in a small embryo with more or less cylindrical and bilaterally symmetrical body. The body is raised up from the surface of the yolk. So that the embryo proper becomes distinct from the yolk sac. In this condition, the head of the embryo projects anteriorly from the yolk sac, the trunk lies over the yolk and the tail projects behind.

The board connection between the body and the yolk sac becomes constricted so as to form a stalk. Blood vessels develop in the wall of the yolk sac. Yolk is digested by the periblast and supplied to the body through blood vessels. The yolk sac is gradually reduced in size while the embryo grows. Finally, hatching takes place and the embryo becomes a free swimming larva.

Development of young ones

Young stages of fish, from the time of hatching till they become fully mature adult are known as hatching, fry and fingerling. The period of larval development varies considerably in different fishes. A newly hatched fish with a yolk sac is known as a sac-fry or hatching and after the yolk sac disappears, it is known as the advanced fry or spawn.

In some species the advanced fry resembles closely the adults except in size. This is called direct development and is seen in and many fishes. On the other hand an indirect development takes place in eels, where the larval form is leptocephalus or elever. In many fishes the fry undergoes metamorphosis during which the larval characters are lost and the adult features appear. A fry which loses the larval characters is like a miniature adult and is called fingerling. This enters an active feeding stage which results in the growth of the body and maturation of gonads to give rise to the adult. The females are usually larger in size than the males but the latter attain sexual maturity earlier.

The development of young one of a cyprinid fish described in the following stages.

Stage - I

This is called prolarva with fairly large sized yolk sac. The yolk sac is broad anteriorly, tapering towards the posterior end, and has a row of pigments on its upper part. It has a broad head, pigmented eyes, and a median continuous fold. The dorsal fin is demarcated but rays are not present in it. The caudal fin is truncate and 7-8 rudimentary rays are present in it. Anal fin is not dermarcated and the pelvic fin is not yet formed. The pectoral fin is represented by a membranous flap without any rays.

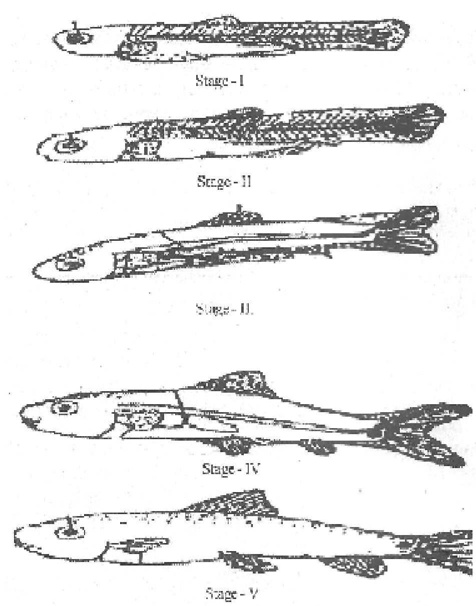


Fig.10.4 Development stages of Bony Fish

Stage - II

Yolk sac is slightly reduced, and chromatophores are present on the head. Dorsal fin is further demarcated and 7-8 rudimentary rays can be seen in it. Caudal fin consists of 15-16 rays. The anal fin is slightly demarcated but rays are not seen in it. The pectoral fin does not contain rays and is still in the form of a membranous flap. The air bladder is now visible.

State - III

The yolk sac is considerably reduced. The gape of the mouth extends backwards. The dorsal fin is almost complete with rays but is still connected with the caudal fin which is now deeply forked and contains 19 rays. The anal fin now has three rudimentary rays. A rudimentary pelvic fin cans the seen as a minute bud. Pectoral fin is still without rays. Alimentary canal is not visible and chromatophores are present on the head.

Stage - IV

Yolk is completely absorbed and it resembles the adult fish. The dorsal fin is fully developed and is not connected with the caudal fin. The anal fin contains 7 rays and is still connected with caudal. Pelvic fin is further developed. Pectoral fin is still without rays and a black spot is present on the caudal peduncle.

Stage - V

It larval is almost like the adult fish and all the fins are fully developed. Anal fin contains 9 rays and is separate from the caudal fin. Pectoral fins are well developed and contain 9-10 rays. Black spot on the caudal peduncle and the chromatophores on the back of the larva are more prominent.

9.4 Reproductive system of Prawn

I. Sexual dimorphism

The sexes are separating (dioecious) and sexual dimorphism is well marked:

1. Male is bigger in size than female.
2. The male possesses a narrower abdomen than female.
3. In male, bases of thoracic legs are more closely approximated than in female.
4. In male, second chelate legs are longer, stronger and too spiny than in female.
5. In male, each second pleopod bears an additional process, the appendix masculine, in between endopodite and appendix interna.
6. In male, epimera of abdominal segments are smaller than in female.
7. In male, paired gential openings lie on the coxae of 5^{th} pair of legs, while they lie on the coxae of 3^{rd} pair of legs in female.

A pair of gonads are similar in position, shape, size and general disposition in both the sexes. They lie in the posterior region of thorax, dorsally above the hepatopancreas and below pericardium. They lie in the posterior region of thorax, dorsally above the hepatopancreas and below pericardium. They extend anteriorly up to the renal sac and posteriorly up to the first abdominal segment.

II. Male Reproductive System

1. **Testes:** The two testes are soft, white and elongated bodies which fuse at their anterior ends to form a common lobe. They enclose between them a gap for the passage of the cardio-pyloric connecting heart to pyloric stomach.
2. **Vasa deferentia:** A long, coiled and narrow tube, the vas deferens arises from each testis near its posterior end. On emerging out the vas deferens of each side at once forms a much coiled mass and then runs vertically downwards between the abdominal flexor muscles on the inner side and thoracic wall on the outer side.

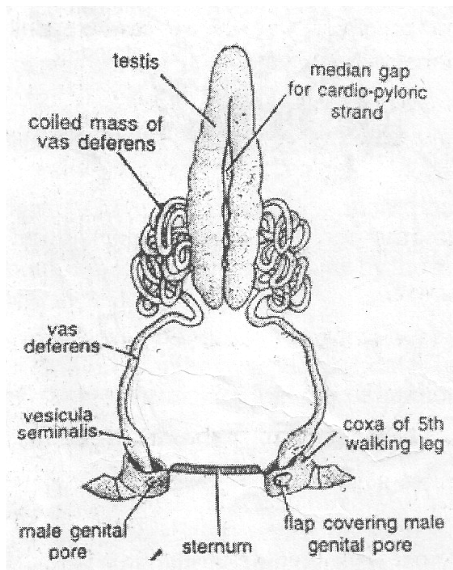


Fig: 9.5 Male reproductive organs of prawn

3. **Vesicula seminalis:** Each vasdeferens reaching ventrally near the base of fifth leg, swells to form a club-shaped vesicular seminalis. These store spermatozoa in the form of white compact, bodies, called spermatophores.

II. Female Reproductive System

1. **Ovaries:** The two ovaries are white, compact and sickle-shaped bodies touching each other at both the ends but leaving a gap in the middle for the passage of the cardiophyloric stand. The shape and size of ovaries vary with age and the season of year. Each ovary is enclosed within a membranous capsule and is made of numerous radial rows of ova in various stages of development. Immature ova lie towards the centre while mature ova towards the surface of ovary. Mature ova or eggs are large nucleated cells with plenty of yolk material (centro-lecithal).
2. **Oviducts:** A short, wide and thin walled tube, the oviduct, originates from the outer middle border of each ovary. It runs vertically downwards to

open through a female genital aperture on the inner side of the coxa of third walking leg of its side.

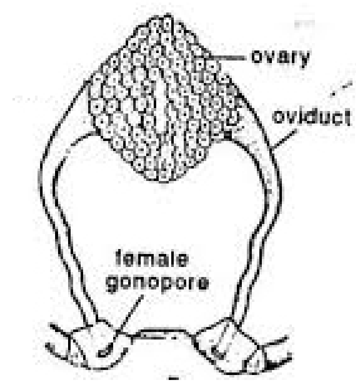


Fig.9.6 Female reproductive organs of prawn

Life Cycle and Development

1. **Fertilizartion:** *M. malcolmsonii* breeds during May, June and July. About two to three hundred mature eggs are laid by the female at one time in slimy strings. The male deposits sperms near the genital openings of the female and the eggs are fertilized as they come out. Thus, fertilization is external, or in situ. After fertilization, the eggs are fastened to the pleopods by the sticky secretion of certain tegumental glands. The eggs hanging from pleopods look like berries or bunches of grapes. During breeding season, a female carries hundreds of eggs in this way, until they hatch. She carries them wherever she goes and the eggs are kept aerated by the slow back and forth movement of pleopods. The female is now said to be 'in berry'.

2. **Development:** Development is direct as there is no free larval from involved. The off spring or juvenile hatching out of the egg resembles the adult except in size. The female bends down her abdomen to protect first the eggs, and later the young, which hatch in 5 to 6 weeks and cling to the pleopods for some time. Growth occurs in short periods between moulting and the adult form is reached after a series of moults. Prawns usually live for 3 to 5 years.

Summary

Fishes are generally bisexual and sexual dimorphism is exhibited by few fishes. Few fishes possess of copulatory organs (eg. sharks) and others possess structural peculiarities, but not connected with sexual union (eg. cichlids). A pair of testes and ovaries is reproductive organs in male and females respectively. Many seminiferous tubules are found in testis. Oocytes are developed inside the ovigerous lamellae of ovary. Seven oocyte stages are found in fishes. Ripe eggs are in largest in size and with large amount of yolk globules. Five maturity stages are found in males and females. Most of fishes are oviparous and external fertilization is found. Cleavage is incomplete and meroblastic development is direct except in Auguilla. The ductless glands are called as endocrine glands. Their secretions are known as hormones. The endocrine glands in

fishes are pituitary glands, interregnal tissue, chromaffin tissue, corpuscles of stannous, ultimobranchial glands, islets of Langerhans, thyroid gland, gastro intestinal glands, pineal glands and urophysis.

Short Answer questions (2 Marks)

1. Define Excretion?
2. What are the Anmonotelic animals, give an example?
3. What are ureotelic animals, give an examples?
4. What are uriocotelic animals give an example?
5. Name the excretory organ in fish?
6. What is the Osmoregulation?
7. Name the Name the excretory organs of prawn?
8. What is the main excretory product in prawn?
9. Define sexual dimorphysam, give one fish example?
10. Write names of development stages in fish seed?
11. What are claspers? Write the uses of claspers?
12. What is Eye-stalk ablation in prawn?
13. What is the life span of prawn in general?
14. What is the function of sinus gland in prawn?
15. Write the main deference's between male and female prawns?

Long Answer Questions (6 Marks)

1. Describe the excretory system of fishes?
2. Describe the excretory system and physiology of excretion in prawn?
3. Describe the reproductive organs in fishes?
4. Describe the reproductive organs in prawns?

Unit – 10

Nervous and Endocrine Systems of Fish and Prawn.

Structure

10.1 Introduction

Changes occur in the environment. Organisms detect such changes through receptor organs ad convey the message to specialized tissues for necessary adjustment. In higher animals the activities are coordinated by the nervous system. Nervous system regulates and controls the activities of different organs present in the body such as muscle contraction, glandular secretion, heart beat etc:

It connects various system of the body and coordinates all their activities and ensures the integrity of the organism. The stimuli are received by the nervous system through sense organs. Thus, the nervous system is responsible for receiving and responding various activities. Various organs of the body and activities of the organism are controlled and coordinated by the nervous system.

10.2 Nervous System of Fish

Nervous system is derived from ectoderm. The study of nervous system is known as neurology. The study of functioning of it is called neurophysiology and its diseases are known as neuropathology.

The nervous system is divisible into three parts

1. Central nervous system
2. Peripheral nervous system
3. Autonomous nervous system.

1. Central nervous system

The brain of a teleost is typically divisible into three regions fore brain, mid brain and hind brain.

Brain

Fore Brain (Prosencephalon)

The fore brain of telencephalon and the diencephalon. The telencephalon is the anteriror most part of the brain and is mainly concerned with the reception and conductin of smell. The telencephalon consists of a pair of solid olfactory lobes and two large cerebral hemispheres. Short oar, long olfactory bulbs at the base of olfactory rosette. Both these structures are present in species like *Puntius ticto* and are simple swellings of the olfactory tract.

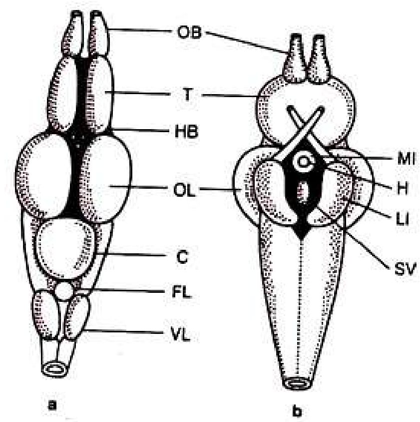
The cerebral hemispheres form the most important part of the telencephalon, these are in the form of solid masses, joined with each other in the mid-line and are covered over by a thin membranous pallium, which is non-nervous. The narrow space between the thin roof and the solid hemisphere may be considered to represent the first and second brain ventricles. A large bundle of fibres the anterior aommissure, connect it with the diencephalon.

Hence, these structures are probably concerned with other activities of the fish also besides being centres of smell reception. It is believed, that the telencephalon plays an important role in there productive behavior of fishes. Possibly it controls aggeression. Sexual ‘activity and parental behavior, maintaining the proper balance to ensure successful reproduction of the species.

The diencephalon is hardly visible from the dorsal side being represented by a median diamond shaped area between the cerebral hemispheres and the optic lobes. It is divisible into a dorsal empthalamus, a thalamus and a ventral hypothalamus. In the epithalamic region are present two ganglionic masses called the hebenulae that are almost equal in size.

From the roof of the diencephalon arises the pineal body as an evagination. Pineal body is not so well developed in bony fishes and has a doubtful function. It is suspected to be an endocrine gland. The diencephalon attains its maximum development on the ventral side in the form of hypothalamus and infundibulum.

The cavity of the diencephalon is the third ventricle of the brain.



: Diagram of brain of fishes. (a) Brain of *Puntius ticto* (dorsal view). (b) brain of *S. diaconthus*. C, cerebellum; FL, facial lobe; H, hypophysis; Hb, habenula; LI, inferior lobe; MI, median infundibulum; OB, olfactory bulb; OL, optic lobe; SV, saccus vasculosus; T. telencephalon; VL, vagal lobe.

Fig.10.1. Brain of *Puntius ticto*

The infundibulum is applied to the hypophysis in the mid-ventral line. The latter is an important endocrine gland and is attached to the brain by means of a stalk. The infundibulum is enlarged laterally to form a pair of bean-shaped ‘inferior lobes’, that lie ventral and opposite to the optic lobes. The inferior lobes are close to each other posterior but remain separate in their anterior regions, thus leaving a small area between their fore ends which projects as median infundibulum. A pair of stout optic nerves enters the brain in the antero-dorsal part of the inferior lobes.

They cross each other just in front of the diencephalon but do not fuse to form an optic chiasma in many species. The diencephalon has a large number of important nuclei and several fibre tracts, connecting it with different parts of the brain. It is an important correlation centre for afferent and efferent impulses. The hypothalamus influences the endocrine system of the fish through the pituitary gland. Neuro-secretory cells are also present in the hypothalamic nuclei and their secretions are conveyed to the hypophysis.

Mid brain (Mesencephalon)

The mesencephalon consists of dorsally placed optic tectum and the ventral tegmentum (fig.9.1). The tectum is seen in the form of two well developed optic lobes and is composed of at least five zones differing from each other in the shape and size of their cells. The fibres of the optic nerves end in the tectum and the image formed on the retina is projected on it. In all the higher bony fishes, the optic tectum projects into the optocoel in the form of a pair of torus longitudinalis, which connect it with the posterior commissure. The optocoel is nearly obliterated due to the presence of the valvula cerebel in it consisting of a granular layer and a molecular layer. The optic tectumin fishes are associated with the reception and elaboration of the visual sensations (sight) and correlates them with the muscular responses of the animal. It has also been associated with learning and is believed to perform functions similar to those of the cereberal cortex in mammals. However, the optic tectum differs in its degree of development in various species and is reduced in the blind fishes and cave fishes. The torus longitudinalis is also believed to be connected with vision but, may better be described as a correlation centre for photostatic and gravistatic centres of the brain.

Hind brain (Metencephalon)

The hind-brain consists of the cerebellum which develops as a large dorsal out-growth from the hind brain. It is only partly visible externally (as corpus cerebella) and its anterior part enters into the cavity of the optic lobes in the form of valvula cerebella. The corpus cerebella are composed of an outer molecular layer and an inner granular layer. These layers are reversed in position in the valvula cerebella. The cavity of the cerebellum is absent and its main function appears to be the maintenance of the body posture during swimming by coordinating muscular activities. In Mormyrids, the cerebellum is very well developed and is probably associated with reception of impulses from the electric organs of the fish.

The myelencephalon or the medulla oblongata is the last part of the brain. It is very well developed in all the teleosts and has a cavity called the fourth ventricle. It is broad in front and has one median facial lobe and two lateral vagal lobes that are variously developed in different species, depending upon the relative importance of various senses in them.

The vagal lobes are the gustatory centres of the medulla and are better developed in species that depend upon taste for feeding as in the carps *(Puntius ticto, Tor tor).* Facial lobes are prominent in species that search their food and explore the surrounding area with the help of long barbells as the siluroids *(Mystus seenghala).* Species having a better sense of hearing possess a well formed central acoustic lobe in the medulla oblongata. Fifth to tenth cranial nerves arise from this part of the brain which is therefore, associated with both sensory and motor impulses from different parts of the body.

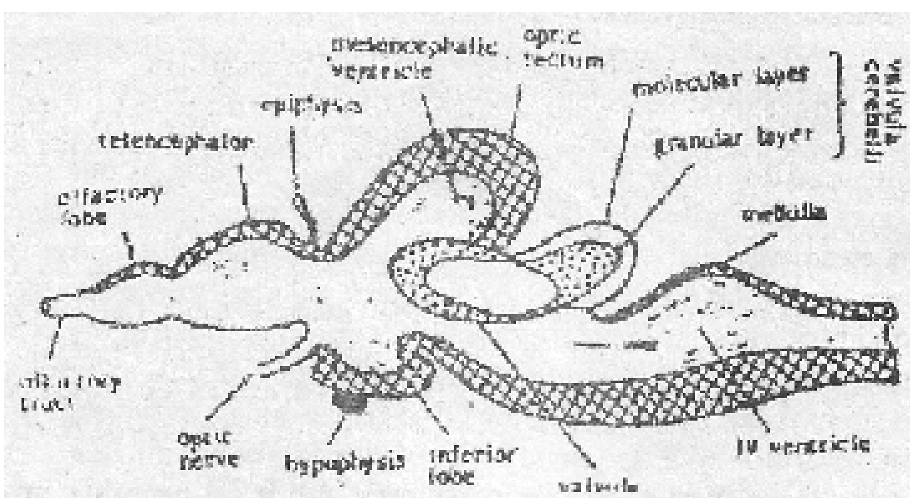


Fig:10.2 L.S. of fish brain

Spinal cord

The spinal cord is uniform in structure throughout its length and extends for the whole length of the body. In a cross section the spinal cord shows a central canal surrounded by gray matter consisting of nerve cells and external area of white substance consisting of nerve cells and an external area of white substance consisting of nerve cells and an external area of white substance consisting of nerve fibres. The gray matter has the appearance of the letter X with paired dorsal and ventral horns. The dorsal horns receive the somatic and visceral sensory fibres whereas the ventral horns contain motor nuclei.

Peripheral nervous system

It consists of two kinds of nerves, spinal and cranial. The former take their origin form the spinal cord and are metamerically arranged i.e., their number corresponds with that of the vertebrae. Cranial nerves arise from the brain and ten pairs of them are typically present in a teleost.

Cranial nerves

1. There are ten pairs of cranial nerves in fishes. The Olfactory nerve takes its origin from the olfactory lobes or the front end of the cerebral hemispheres and runs forwards to end in the olfactory rosette. It is a special sensory nerve conveying smell impulses to the brain.
2. The Optic nerve arises from the optic tectum of the mid-brain and emerges from its ventral side. The two optic nerves cross each other in front of the diencephalon, and each nerve then enters the orbit through the optic foramen and supplies the retina of the eye. It is a special sensory nerve carrying visal impulses.
3. The Occulomotor nerve arises from the ventral side of the mid-brain and enters the orbit through the optic foramen to supply to the superior, inferior, anterior rectus and the inferior oblique muscles of the eye ball. It is a somatic motor nerve and innervates four of the six striated muscles of the eye ball.
4. The Trochlear nerve arises from the dorso-lateral side of the brain between the optic lobes and the cerebellum and enters the orbit through a foramen in the orbito sphenoid. It supplies the superior oblique muscle of the eye ball.
5. The Trigeminal nerve arises from ‘the lateral side of the medulla oblongata and supplies the snout and upper and lower jaws. It a mixed nerve and is divided into three important branches- the ophthalmic, maxillary and mandibular. In the common fresh water fish, *Wallago attu,* the trigeminal and the facial nerves, join immediately after their origin to form the trigemino-facial complex.
6. The Abducens nerve arises from the ventral side of the medulla oblongata, a little behind the trigeminal nerve. It also enters the orbit and supplies the posterior rectus muscle that moves the eye ball.
7. Facial nerve has independent origin from the side of the medulla oblongata behind the trigerninal, but soon joins the latter to form the trigemino-facial complex which divides into three trunks, the supraorbital, infrobital and the hyomandibular.

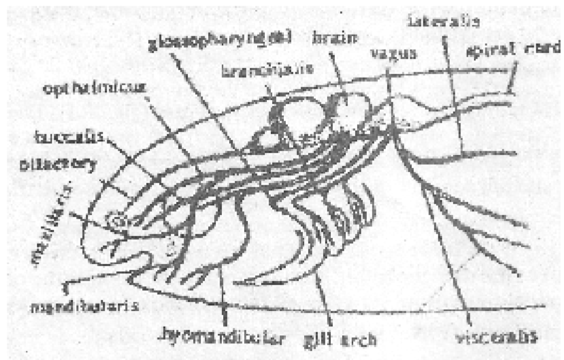


Fig:10.3. Cranial Nerves *Labeo*

8. Auditory nerve arises from the side of the medulla oblongata behind the facial, and divides into two branches: a vestibular branch to supply the utriculus and the ampullae of the inner car, and (b) a saccular branch, to supply the sacculus and the lagena.
9. Glossopharyngeal nerve arises from the ventro-lateral aspect of the medulla oblongata behind the auditory and enters the first gill slit. It is mixed nerve and supplies a part of the lateral fine system, taste buds in the pharynx and the muscles of the first gill slit.
10. Vagus nerve arises behind the glossopharyngeal and has an extensive distribution. It divides into a lateralis branch and a branchio-visceral trunk. The lateralis is a stout nerve that runs up to the end of the tail along the lateral line canal and innervates it by several branches.

    The branchio-visceral trunk divides into four branchialis nerves and a visceralis branchi. Each branchial branch gives off a slender branch to the pharynx and then divides into a pretrematic and a post-trematic branch to supply the muscles of the gills. The visceralis branch supplies various organs of the viscera.

10.3 Nervous system of prawn

The nervous system of prawn is of the annelidan type. However, it is somewhat larger and has more fusion of ganglia. It consists of

(i) The central nervous system including brain connected with a ventral ganglionated nerve cord through a pair of circum-oesophageal commissures
(ii) The peripheral nervous system including nerves, and
(iii) The sympathetic nervous system.

1. **Brain or supra-oesophageal ganglia:** Brain lies at the base of rostrum, anterior to oesophagus and surrounded by a thick mass of fat. It is a bilobed structure derived from the fusion of several ganglia. On each side of the brain gives off
   (i) An antenulary nerve to atennule, into which it sends a statocystic branch to the statocyst branch to the statocyst,
   (ii) A stout optic nerve to compound eye
   (iii) An ophthalmic nerve to muscles of eye-stalk
   (i) An antennary nerve to antenna and
   (i) A slender tegumetal nerve to labrum.

2. **Circum-oesphageal Commissures:** Posteriorly, the Brain gives off a pair of stout nerves or the circumoesophageal commisures. These run backwards and downwards, encircle oesophagus and unite ventrially with the suboesophageal ganglia. The latter form an indistinguishable anterior part of the ventral thoracic ganglionic mass. The two commissures are cross over, just behind oesophagus, by a double bridge of tough connective tissue, called endostemite. Each commissure bears a small commissural ganglion near its anterior end, seconds a small mandibular nerve to mandible of its side. Both oexophageal commissures are connected together by a slender transverse commissure near their posterior ends.
3. **Ventral Thoracic Ganglionic Mass:** Like segments, the segmental nerve ganglia of cephalothorax also become fused to form an elongated ventral thoracic ganglionic mass, lying mid-ventrally on the floor of cephalothorax. It represents fusion of 11 pairs of ganglia and gives off laterally 11 pairs of nerves. First 3 pairs are the cephalic nerves, supplying the mandibles, maxillulae and maxillae, respectively. Last eight pairs are the thoracic nerves, of which first three pairs supply the 3 pairs of maxillipedes, and the remaining five pairs supply the five pairs of walking legs. Each nerve to a leg becomes bifurcated before entering the legs.
4. **Ventral nerve cord:** Ventral thoracic ganglionic mass gives off from its hind end a stout ventral or abdominal nerve cord. It runs along the mid-ventral line of abdomen. In each abdominal segment, it enlarges to form an abdominal ganglion. Each of the first five abdominal ganglia gives off three pairs of nerves.

(ii) One pair of pedal nerves to pleopods
(ii) One pair of nerves to extensor muscles and
(i) One pair of nerves to flexor muscles of succeeding segment.

The last, stellate or sixth abdominal ganglion is the largest composed of several fused ganglia. It supplies two pairs of nerves to flexor muscles, two pairs to uropods, two pairs to telson and a single median nerve to hindgut.

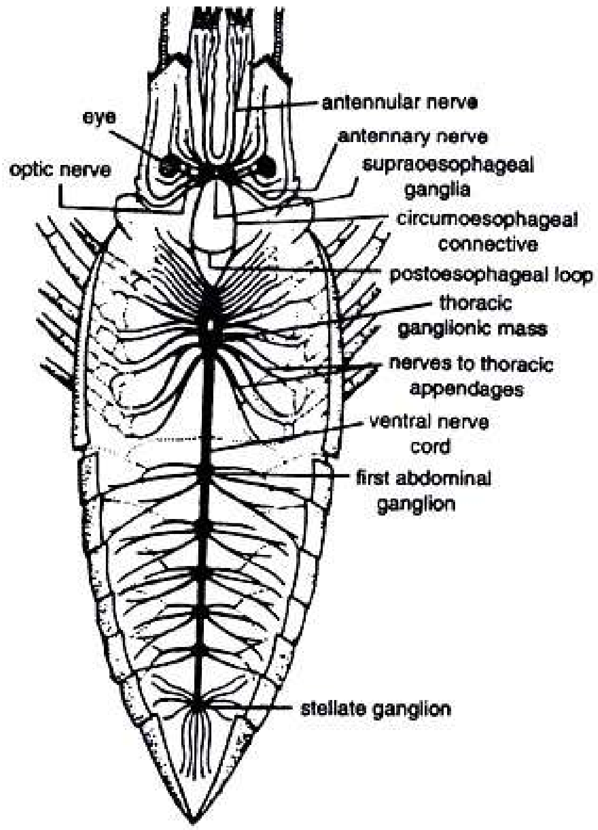


Fig:10.4 Nervous system in dorsal view

5. Sympathetic nervous system: Sympathetic, visceral or autonomic nervous system comprises a few ganglia and nerves. A small nerve, arising mid-posteriorly from brain, bears two visceral ganglia laying one behind the other. First ganglion is joined with the two commissural ganglia by connectives. Second ganglion gives off two pairs of nerves to the walls of oesophagus and cardiac stomach.

10.5 Endocrime system of prawn

Palaemon, like other crustaceans, produces a large number of hormones. It is believed that the sinus gland, located at the base of eyestalk, many hormones. They are believed to regulate.

(i) The spread of pigment in chromotophores of epidermis and in compound eye.
(ii) Deposition of lime salts in the exoskeleton, and
(iii) Moulting.

Recent investigations have shown that the hormones that regulate moulting are of two types. The moulting-inhibiting hormones are secreted by X organ in the eye stlalk and moulting-accelerating hormone by the Y organ beneath the adductor also induces tetamorphosis.

Secretion of male sex hormones (androgens) has been reported by H.Charlaux-Cottong (1954) from androgenic glands located between, muscles of coxal segments of the last pair of walking legs. These hormones control the male sex characters.

Short Answer questions (2 Marks)

1. Define Neurology?
2. What are the main divisions of nervous system of fish?
3. Name the parts of fish brain?
4. How many pairs of cranial nervous formed in fishes?
5. How the brain is formed in prawns?
6. What are the main divisions of prawn nervous system?
7. Name the nervous generate form brain of fish?
8. Define endocrinology?
9. Differentiate between exocrine and endocrine glands with examples in fish?
10. Write the names of different parts of pituitary gland in fishes?
11. Write any two hormones secreted form pituitary gland in fish?
12. Define 'hormone'?
13. Name the endocrine part of pancreas in fish?
14. What is the use of eye-stalk ablation in prawn?
15. What are the hormones secretes by thyroid gland in fish?

Long Answer Questions (6 Marks)

1. Explain the structure of fish brain?
2. Explain the cranial nervous in fish?
3. Describe the nervous system of prawn?
4. Describe the pituitary gland and its hormones in fishes?
5. Write about the thyroid gland in fishes?
6. Describe the endocrine system in prawn?

FISHERIES

Paper - II

PRINCIPLES OF FISHERIES & AQUA CULTURE

INDEX

Unit-1

INTRODUCTION OF AQUACULTURE

Structure

1. Introduction of Aquaculture:

History:

Aquaculture is having a long history on fish culture in Asia, ancient Egypt and central Europe. The book "Classic of Fish Culture" written by Fan Lei around 500 BC, a Chinese Politician and a fish- culturist, is considered as a proof for the commercial fish culture practiced in China. In 2500 BC Egyptians farmed Tilapia in ponds. Earliest fish that was used for farming is Common Carp (*Cyprinus* carpio) which was introduced by Chinese immigrants into several Asian countries. Common carp lost its importance from 6th century AD because of the Tang Dynasty Emperor 'Lee', as common carp is called as 'Lee' in Chinese.

Due to practical difficulty of separating the larvae of different species collected from wild paved the way polyculture (culture of different species together). Pen and cage culture of catfish have originated in Cambodia. Java Island is the origin for earliest brackish-water farming in South East Asia in the 15th century AD. (Pillay, T.V.R).

In India Kautilya, described how fish could be poisonous in tanks during war in his book "Artha Shastra" written around 300 B.C. King Someswara son of King Vikramaditya VI was the first to record the common sport fishes of India and group them into marine and freshwater forms in his book Manasoltara compiled in 1127AD.

Scope:

The word 'aquaculture' is used to denote all kinds of culture of aquatic animals and plants in fresh, brackish and marine environments. In India freshwater fish culture aquaculture is confined to three Indian Major Carps (IMC), viz., Rohu (*Labeo rohita*), Catla

(*Catla* catla) and Mrigala (*Cirrhinus mrigala*) and three exotic species namely Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon idella*), and Common Carp (*Cyprinus carpio*). Among the catfishes, magur (*Clarias batrachus*) is most preferred in India because of their high market value. In recent years framing of *Pangasius sp.* witnessed increasing interest especially in Kolleru lake region of Andhra Pradesh due to its higher growth potential and ready market.

Among the crustaceans Giant Freshwater Prawn, *Macrobrachium rosenbergii* has been the principal species, being culture in both under monoculture and under mixed farming systems in freshwater. However, its culture is very much reduced due to disease and growth related problems. Other than *M. rosenbergii, M. malcomsonii* and *M. gangeticum* are potential species for aquaculture but commercial culture is not yet started in bigway.

In brackishwater sector, the aquaculture development was mostly contributed by shrimp, *Penaeus monodon* culture in the beginning. The other shrimp species like *P. indicus*, *P. merguiensis*, *P. pencillatus*, *P. japonicas* and *P. semisulcatus* are other potential species though commercial culture is not yet started. Recently *Litopenaeus vannamei* culture is started on a very big way. At present more than 90% of shrimp production from aquaculture is contributed by *L. vannamei.* The finfish species like the Asian Seabass (*Lates calcarifer*) and Grouper (*Epinephelus* sp.), Grey Mullet (*Mugil cephalus*), Pearl Spot (*Etroplus suratensis*), Milk Fish (*Chanos chanos*) are the commercially important brackishwater species in India.

Present Status of Fisheries & Aquaculture:

World:

Global total capture fishery production in 2014 was 93.4 million tonnes, of which 81.5 million tonnes from marine waters and 11.9 million tonnes from inland waters. For marine fisheries production, China major producer followed by Indonesia, the United States of America and the Russian Federation. Other major producers were India, Vietnam, Bangladesh and Egypt.

Global aquaculture production amounted to 73.8 million tonnes, consisting of 49.8 million tonnes of finfish, 16.1 million tonnes of molluscs, 6.9 million tonnes of crustaceans, and 7.3 million tonnes of other aquatic animals including frogs in 2014. China occupied first position in aquaculture production with 58.79 million tonnes followed by Indonesia 14.33 million tonnes and India is with 4.88 million tonnes.

India:

India stood 3rd in fisheries and aquaculture among world. It is having the longest coastal line comprising of 8129 km, 2.02 million sq.km Exclusive Economic Zone, 0.5 million sq.km Continental shelf area, 3.15 million ha of reservoir area, 2.35 million ha of ponds and tanks, 1.24 million ha of Brackish water area and Estuaries 0.29 million ha. (NFDB).

India is having a diverse resource ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species. The country has shown continuous and sustained increments in fish production since independence. It constitutes about 6.3% of the global fish production; the sector contributes to 1.1% of the Gross Domestic Product (GDP) and 5.15% of the agricultural GDP. Present total fish production of India is 10.07 million metric tonnes from this nearly 65% contribution from the inland sector and nearly the same from culture fisheries.

Fish Farmer's Development Agencies (FFDAs) and 39 Brackish water Fish Farmer's Development Agencies (BFDAs) for promoting freshwater and coastal aquaculture. India is having more than 2.4 lakh fishing crafts operating in the coast, six major fishing harbours, 62 minor fishing harbours and 1511 landing centers are functioning to cater to the needs of over 3.9 million fisher folk.

Fish and fishery products have presently emerged as the largest group in agricultural exports of India, with 10.51 lakh tonnes in terms of quantity and Rs.33,442 crores in value. This accounts for around 10% of the total exports of the country and nearly 20% of the agricultural exports. More than 50 different types of fish and shellfish products are exported to 75 countries around the world.

Andhra Pradesh:

Andhra Pradesh ranks 1st in total fish and prawn production and producing about 70% of culture shrimp in the country. Fish and Prawn production increased from 8.14 lakh tonnes with a value of Rs. 6,358 crore during the year 2005-06 to 19.78 lakh tonnes with a value of Rs. 22,707 crore during the year 2014-15. The average growth rate per annum is about 10.12% on production and 11.79% on value over a period of one decade.

During the year 2015-16, A.P produced 23.52 lakh tonnes of fish and prawn which accounts value of Rs. 30,099 crore with a growth rate of 18.89% on production and 32.78% on value was achieved. Seafood exports value from AP increased from Rs. 2,100 crore with 20% share in the country during the year 2009-10 to Rs.15,000 crore with 45% share in the country during the year 2014-15. The average growth rate on exports for a period of 5 years from 2010-11 to 2014-15 is 71% Fisheries sector contribution to Gross State Domestic Product (GSDP) during 2014-15 is 5.40%.

Short Answer Type Questions:

1. What is aquaculture
2. Write about brief history of aquaculture
3. Write a short note on the scope of aquaculture
4. Write about the status of aquaculture in Andhra Pradesh

Long Answer Type Questions:

1. Write an essay on history and scope of aquaculture
2. Describe the present scenario of aquaculture in the world, India and Andhra Pradesh.

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Unit-2

TYPES OF AQUACULTURE

Structure

Aquaculture can be defined as culture of aquatic organisms. The term can also be used for defining production of aquatic organisms for food, aquariums, sport fishing, lake stockings, biological supply house, chemicals and pharmaceuticals etc. Aquaculture fish production can be done in various types of systems based on different factors. Some of those systems are fresh water, marine water, tanks, ponds, raceways, recirculating systems, cages etc.

Types of Aquaculture Based on type of source of water:			
I.	Fresh water	:	Aquaculture is done in freshwater having a salinity of < 0.5 ppt. Most of the inland aquaculture systems fall under this category. Eg. Freshwater Ponds
II.	Marine (Mariculture)	:	Culture is done in marine environment. Average salinity of seawater is ≥ 35 ppt. Eg. Open sea cages
III.	Brackish water	:	Aquaculture done in brackish water having salinity between 0.5 and 35 ppt. Eg. Shrimp ponds.

Freshwater aquaculture:

Culture of aquatic organisms under inland water bodies which includes freshwater bodies like rivers, canals, streams, lakes, flood plain wetlands or bheels, reservoirs, ponds, tanks and other derelict water bodies. The tanks and reservoirs are mainly constructed for irrigation purpose and fish culture in these systems is secondary. All the freshwater fishes and prawns are cultured in this environment.

In India freshwater aquaculture is being take up in 2.36 million ha area of ponds. Freshwater aquaculture contributes nearly 55% of the total fish production. However, only 40% of the available area is being used. In addition to ponds, freshwater aquaculture is also being undertaken in lakes, irrigation canals, reservoirs and paddy fields. Freshwater aquaculture is often combined with the culture of shrimps in low-saline water ponds. Though the freshwater aquaculture has increased a lot, the three Indian major carps, viz., catla, rohu and mrigal have been continued to be major species and contribute most of the production. The exotic silver carp, grass carp and common carp are given second preference due to the low market demand. In Andhra Pradesh the average production under carp farming is 5-6 tonnes/ha/year. Several progressive fish farmers have achieved 8-12tonnes/ha/year production. Apart from ponds it is also possible to expand the freshwater aquaculture.

It is possible to install cages/rafts in rivers: In India there are five major riverine systems:-

1. The Ganga river system
2. The Brahmaputra river system
3. Godavari river system
4. Krishna river system
5. Cauvery river system

Lacustrine Resources: Reservoir is an artificial water body which was created by obstructing the water flow by a barrier. On the basis of area reservoirs are classified into large, medium and small.

Large reservoirs – more than 5000 ha water spread area

Medium reservoirs – between 1000 – 5000 ha water spread area

Small reservoirs – lesser than 1000 ha water spread area.

Brackish water Aquaculture

The brackish water occurs where sea and inland waters meet and salinity ranges between 0.5 to 35 ppt. among the fin fishes Sea bass, groupers, mullets, milk fish and silver pompano and in shellfish shrimps and crabs are being cultured in this waters.

In India brackish water framing is an age-old practice confined mainly to the bheries (manmade impoundments in coastal wetlands) of West Bengal and Pokkali (salt resistant deep water paddy) fields along the Kerala coast. Without any additional input, except that of trapping the naturally bred juvenile fish and shrimp seed. The importance of brackish water aquaculture was recognized only after the initiation of an All India Coordinated Research Project, (AICRP) on 'Brackish water Fish Farming' by ICAR in 1973.

Area under shrimp farming got increased during 1990-1994 due to the development of more commercial hatcheries and the formation of Brackish water Fish Farmers Development Agencies (BFDA) in the maritime states of India. Studies on maturation and the breeding of shrimps were initiated by the Central Marine Fisheries Research Institute (CMFRI) in the early 1970s. In late 1980s MPEDA established the Andhra Pradesh Shrimp Seed Production and Research center (TASPARC) and Andhra Pradesh and Orissa Shrimp Seed Production and Research center (OSPARC) based in Orissa which provided assistance for the establishment of number of private hatcheries.

During recent years, culture of Vannamei Shrimp (*Litopenaeus vannamei*) has been taken up on a very large scale. Coastal Aquaculture Authority (CAA) is regulating the aquaculture and seed production in costal and brackish water regions.

Mariculture

Mariculture can be defined as culture of fishes and other organisms in open sea, marine back waters and shallow bays in different aquaculture methods. Culture of mussels, oysters and seaweeds is taken up under mariculture. Mariculture is being undertaken in Maharashtra, Gujarat, Kerala, Andhra Pradesh, West Bengal and Tamil Nadu states on low levels. Cage culture of Seabass and Cobia species is picking up in the recent times. Though marine aquaculture in open sea is very less practiced, inland and coastal production of shrimps is more common.

Marine fishery resources of India include Arabian sea on the West coast and Bay of Bengal on the east coast.

Marine fisheries can be broadly divided into two categories

1. Coastal fisheries or inshore fisheries
2. Offshore and deep- sea fisheries

Coastal fisheries or inshore fisheries: India is having the longest coastal line comprising of 8129 km, 2.02 million sq.km Exclusive Economic Zone, 0.5 million sq.km Continental shelf area.

Offshore and deep- sea fisheries: Water lies after the continental slope are come under the deep sea or offshore waters regions. They are less productive than the inshore waters.

Short Answer Type Questions:

1. Define aquaculture?
2. Based on type of water, what are the types of aquaculture?
3. Write a short note on Riverine Fisheries?
4. Write a short note on lacustrine resources?
5. Write a short note on Brackish water Aquaculture?

Long Answer Type Questions:

1. Write an essay on Freshwater Aquaculture?
2. Write an essay on Brackish water Aquaculture?
3. Write an essay on Mariculture?
4. Describe the present scenario of aquaculture in the world, India and Andhra Pradesh?

Unit-3

CULTURE SYSTEMS

Structure:

Introduction

Aquaculture can be practiced in various types of culture systems. These systems are based on the traditional ideas that have been used for years, but some encompass new and sometimes radical concepts that make them unique. There are mainly three culture systems i.e. open, semi-closed and closed culture systems. Each system has its own characteristics, advantages and disadvantages. Section of the systems depends upon the type of fish to be reared and the resources available and finally idea of the farmer.

Open Systems:

Open aquaculture system refers to the rearing of aquatic species, within enclosures in natural open waters. There is continuous exchange of water between the culture system and the environment. Since there is a continuous and uncontrolled exchange of water, the water quality parameters cannot be managed as per our requirement.

Open systems are being implemented in a wide range of environments including freshwater rivers, brackish estuaries and coastal marine regions. Floating mesh cages are anchored to the seafloor and vary in size depending on the scale of operation and the species cultured.

These are the oldest systems among the all practices by using the environment as the fish farm. Natural water bodies like seas, lakes, estuaries are used and organisms to be cultured are stocked in these waters. In comparison with other systems open systems needs lesser management so that capital investments are low. The main advantage of these systems is conditions are more natural and uncrowded in the culture environment; less time is required in monitoring the condition of the culture organisms in open systems. The disadvantages like predation and poaching are common. The growth rate and uniformity of the product are un predictable in this system. Some of the examples of these systems include Cages, long lines, floats, rafts, trays and clam beds etc.

Water spread area in inland, marine, estuarine and coastal waters is likely to be unbounded with irregular shape and the height of water column is uneven due to undulating bottom. The open water bodies can be differentiated into perennial long seasonal tanks depends upon the period of water retention. In open water bodies parameters like Height of the water column, water turbidity, and temperature cannot be controlled while physico-chemical parameters like dissolved oxygen, carbon dioxide, pH, cannot be managed due to their huge size. There is no scope for fertilization, manure due to waters are continuously let-out for agriculture.

Reservoirs: Reservoir can be defined as a large waterbody created by putting across a stream or river an earthen, stone masonry or concrete bundh or dam. Reservoirs are mainly constructed for irrigation, generation of power, flood control, recreation, fishery development etc. In India there about 19134 small, 180 medium and 56 large reservoirs.

Examples of the open systems include Cage, Pen and Raft.

Cage culture: Cage is a meshed enclosure having bottom in which the seed of cultivable organisms released. Artificial feeding is done and the organisms are harvested when they reach marketable size.

Types:

There are basically three kinds of cages they are floating cages, submerged cages, fully submerged cages (sinking)

1. Floating cages – occupy the upper surface of the water column and have framework supported on floats with moving systems and anchorage for keeping the cage system in a particular position. Suitable for fish culture in shallow water (3-5 meters depth)
2. Submerged cages – They are anchored in the mid-depth of water column. Buoyancy will be maintained floats.
3. Fully submerged cages – They rest at the bottom

Pen culture

A Pen is defined as "a fixed enclosure in which the bottom is the bed of the water body". Pen is different from the Cage which in turn is defined as "an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged." The word 'pen' here is also used synonymous with 'enclosure' as it is used in enclosure culture.

Pen culture originated in the inland sea area of Japan in the early 1920s. It was adopted by Peoples Republic of China in the early 1950s. Lake bottom forms the bottom of the encloser. Pen enclosures are bigger in size ranging from 0.1 to 1000 ha. The shape of the pen may be of square, rectangular, oval or elongated horseshoe shaped. Shape of the pen depends upon the nature of shore, land and water depth.

Raft culture

Rafts are the floating structures made of bamboo poles or metal rods with buoys at the top for floating in the water. Depth required for keeping of the raft is more than 5 meters. These systems are used for the culture of oysters, mussels and sea weeds in open seas.

Semi Closed Systems

In this kind of systems water is directed from natural sources or ground water into specially designed ponds and race ways and released into the environment once the culture is over. Therefore there is a controlled water exchange between the culture system and the environment. This system provides greater control over the growing conditions than the other systems. Yield per unit area is more and uniform sized organisms can be harvested. We can easily eradicate the predators by filtering the water. Diseases can be identified and treated in semi closed systems. The main disadvantages of semi closed system areneed of more complex management and it is expensive too.

A. **Ponds**

In world majority of the culture is being practiced in ponds. They are made of earthen ponds, reinforced concrete ponds which are used for culturing of all kinds of aquatic organisms in both freshwater and marine water as well as brackish waters. Ponds can be classified into two types based on operation

1. Grow in ponds

These ponds are small in size and they are used for nursery and rearing of fish seed nursery ponds and rearing ponds are the examples for this type of ponds.

a) Nursery ponds - size of the nursery ponds ranging from 50×50×3 or 4 and are used for keeping spawn or fry.
b) Rearing ponds - size of the rearing ponds ranging between 90×30×4. and they are used for the rearing of advanced fry or early fingerlings (25 mm to 50 mm) for a period of 30 to 60 days.

2. Grow out ponds

They are definite size and shape, smaller in dimension in order to manage efficiently. The minimum size of the pond may be 0.4 Ha and maximum size upto 40-51 Ha. They are used for stocking ponds.

3. **Stocking ponds**- they are larger in size with a depth about 6 feet and they are used for growing fingerlings to table size fish.

Closed systems

These systems are practiced where the water availability is limited or poor quality. Water required for the culture is taken in from the source, it is treated and used in the culture. During the culture and sometimes after the culture also, the water is treated and reused again. Hence no water is exchanged in this type of systems. Super intensive culture is done in these systems. All the physicochemical parameters can be regulated parasites and predators are not found. Application of feed and any other chemical is more efficient and easy. Uniformity of the cultured organisms and faster growth can be achieved. Recirculatory systems are the good examples for this kind of systems

Recirculatory systems

These are highly useful for the areas where water is scarce. Water is conserved throughout most or all of the growing season by circulating in the culture tanks after purifying it through biological filters closed type of recirculation systems is used primarily for experimental work and for rearing of larval organisms. These systems consists of four components culture chambers, primarily settling chamber, a biological filter and clarifier or secondary settling chamber for purification of water for reuse.

Raceway culture

These systems are designed to provide a flow through system to enable rearing of higher stocking densities of animals. An abundant flow of good quality, well- oxygenated water is essential to provide respiratory requirements and to flush out metabolic wastes, particularly ammonia. They are smaller in size than ponds and occupy less space. The majority of the raceways used is made of reinforced concrete or cement blocks.

Short Answer Type Question:

1. Write a short note on Cage culture?
2. Write a short note on Pen culture?
3. Write a short note on Raft Culture?
4. Write a short note on Grow-in Ponds?
5. Write a short note on Grow-out Ponds?
6. Write a short note on Recirculatory Aquaculture System?
7. Write a short note on Raceway Culture?

Long Answer type of questions:

1. Write an essay on Open Type of Aquaculture Systems?
2. Describe Semi-closed Aquaculture Systems in detail?
3. Give a detailed account of Closed Aquaculture System?

Unit-4

CULTIVABLE FAUNA IN AQUACULTURE

Structure:

Introduction:

In India large number of native finfish and shellfish are available and they are cultured on commercial scale. Other than these, exotic species are also being cultured. Some of the cultured fish feeds only on plant origin food, so they are called as herbivorous while other feeds on insects and its larvae are called insectivorous. Some other fish feed on only fish, they are called carnivorous and while some other fish feed anything in the pond ecosystem they are called omnivores. Herbivorous and omnivorous fishes are easily cultured together and these are mainly from crap family Cyprinidae.

Criteria for selection of fish:

The culture value of the fish depends on several factors such as their growth, size and adaptability.

Biological characteristics

- A major factor that decides the suitability of a species for aquaculture is the rate of growth and production under culture conditions. Fishes with high growth rate are most suitable for culture. However some of the slow growing fishes are also being cultured because of their high commercial value.
- The size and age at first maturity is one of the criteria. It is preferable to have late mature fishes so that they can attain marketable size before their maturity.
- Preferably cultured species could be bred easily under captive conditions. This will make adequate quantities of seed. For hatchery high fecundity species is preferable.
- Species with shorter incubation period and larval cycle often contribute to lower mortality of larvae and grater survival in hatcheries.
- Larvae that would accept artificial feeds would be easier to rear in hatcheries.
- Herbivorous and omnivorous species have been preferred as they feed on natural food organisms in water.
- Hardy species that can tolerate unfavorable conditions will be preferable.

Economic and market considerations:

These are more important than biological factors in the selection of species to be cultured

- Species must have good acceptance in the market
- There should be enough availability of markets for the species which we chosen.
- Production cost must be less
- Species with high growth with less feed will be economical.

Cultivable fishes:

Carps form the largest fish family in the world. Their body is fully covered with scales and they are toothless. Several species of carps are available in the Indian rivers among which catla, rohu and mrigal are the commonly recommended Indian major carps for commercial culture.

1. Catla

Catla catla commonly known as catla has a big head and deep body, large upturned mouth and non-fringed lips. Dorsal fin has 14-16 branched rays. It is a surface feeder and feeds mainly on zooplankton using large gill rakers.

Catla catla

The young ones of catla 15-20 mm size prefer to feed on zooplankton as well as phytoplankton. It is surface feeder. Catla is the fastest growing fish among the Indian major carps it can attain a maximum size of 1.8 m or 45 kg. Catla gets matured in the third year of its life cycle and is a riverine breeder which breeds during rainy season. The eggs of catla are non-adhesive and float in water.

2. Rohu

Labeo rohita commonly known as rohu has a small and pointed head. Mouth position of the rohu is terminal and has fringed lower lip. Body is covered with 12-13 branched rays and body remains covered with dull reddish scales. It is a column feeder, feeds on phytoplankton, plant debris or decaying debris of aquatic plants.

The young ones of this species feed on zooplankton and is known to be fairly fast growing species attaining a maximum size of 1m. Rohu matures in the second year and breeds naturally in rivers during monsoon season. Rohu eggs also non- adhesive and float in water.

Labeo rohita

3. Mrigal

Cirrhinus mrigal is commonly called as mrigal and has a linear body, small head with blunt snout. Lips are non-fringed and mouth is sub-terminal. Dorsal fin has 12-13 branched rays. Its body is bright silvery with golden tinge. It is bottom feeder feeding on vegetable debris and decaying organic matter but young ones are zooplankton feeders. Mrigal can reach size upto 0.9 m size and matures in the second year. It breeds naturally in riverine conditions during rainy season. Eggs are non-adhesive float in the water.

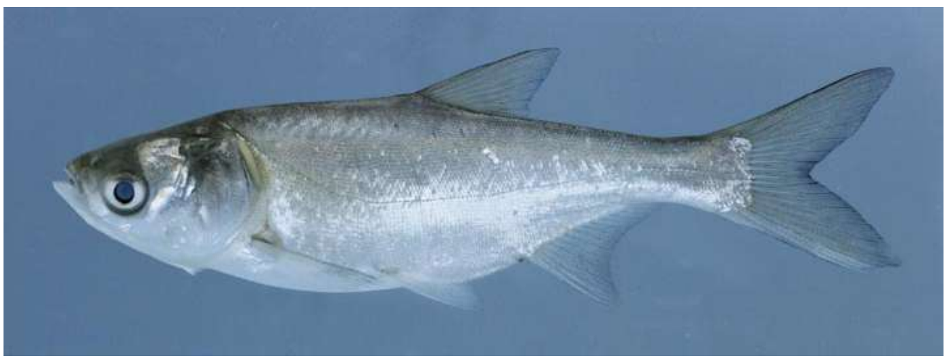
Cirrhinus mrigal

Exotic Carps

These fishes are not native of India but were introduced from other countries for various purposes. Three exotic carps that are most commonly cultured in India are silver carp, grass carp and common carp, all of these three species have same feeding habits like major carps catla, rohu and mrigal.

1. Silver carp

Sliver carp (*Hypophthalmicthys molitrix*) is a native of China introduced to India from Japan in 1959 and is now a well-established fish among the fish farmers. Body is flat with round mouth opening upward, slightly protruding lower jaws, small eyes. It is having comparatively smaller scales which are white in color.

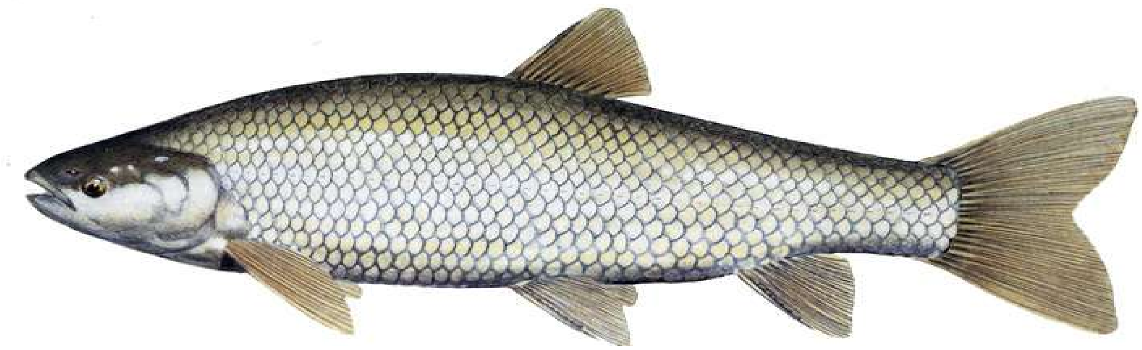


Hypophthalmicthys molitrix

Silver carp is a surface feeder gathers food from the top layers of water column and hence like catla. Young ones feed mainly on the micro fauna but in later part of their life they mostly feed on micro and small plants. They have the capacity to grow up to 5.5 kg per year under composite growing conditions.

2. Grass carp

Grass carp (*Ctenopharyngodon idella*) was originally found in the big rivers of China and Russia. This fish was introduced in India in 1959 from Honkong and Japan. The body is elongated with broad head and rounded snout. The upper jaw is slightly longer and the body covered with moderately sized scales having light greenish tinge. It feeds on aquatic weeds and terrestrial grass. If plants are not available it can also feed on fish fry.



Ctenopharyngodon idella

It can consume feed about double of its body weight per day and fifty percent of the feed consumed is defecated in semi digested condition which forms organic manure. The newly hatched grass carp feed on zooplankton including mosquito larvae but after attaining a length of 2-3 cm it becomes herbivore. It can grow up to a maximum size of 1.5 m. the sexual maturity takes place in the second or third year.

3. Common Carp

Cyprinus carpio is commonly known as common carp. There are three varities available namely *Cyprinus carpio communis* (Scale carp) which has small scales; *Cyprinus carpio specularis* (mirror carp) having shiny and scattered scales and the *Cyprinus carpio nudus* (leather carp) which has leathery appearance due to absence of scales on the body. The body of common carp is deep with shot head.

Cyprinus carpio

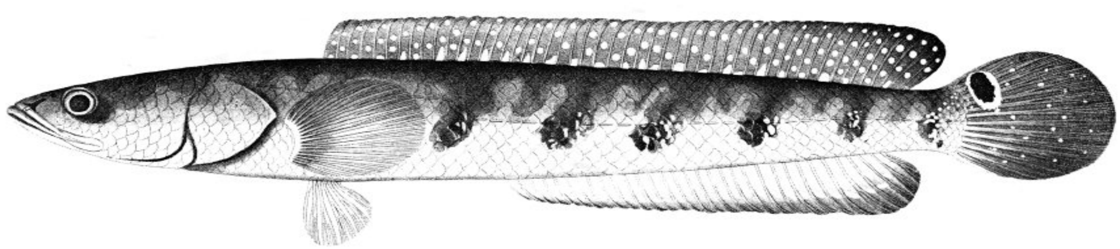
The scale carp and mirror carp thrive in plains but leather carp is mostly limited to cold upland waters. Common carp is omnivore and bottom feeder feeding on larvae of insects, worms, molluscs, stalks and leaves of submerged plants and occasionally on zooplankton. It is a fast growing and quite harder can attain a maximum size of 75 cm. all the varieties of common carp can breed freely in ponds. Common carp eggs are adhesive and adhered to the submerged vegetation.

Murrels

These fishes are air-breathing fishes and have an elongated cylindrical body. The head is depressed and mouth is large and protractile. These species are suitable for culture in the irrigation wells and shallow derelict swamps. The peak breeding of these fishes is associated with pre-monsoon months.

Channa marulius

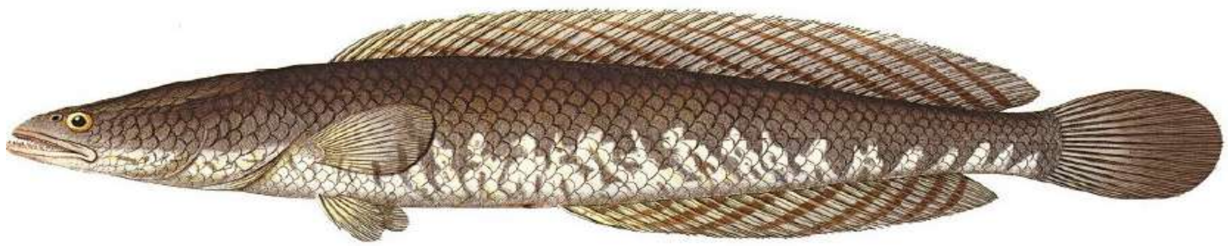
It is commonly called as giant snakehead fish. They are in greyish in back side: abdomen is orange and black bands on lateral line. Spots are present on posterior parts of the body. Dorsal and anal fins are long and without spines. It is suitable for culture in ponds along with tilapia. The young ones of tilapia serve as food for this species. It can reach a maximum size of 1.2 m.



Channa marulius

Channa striatus

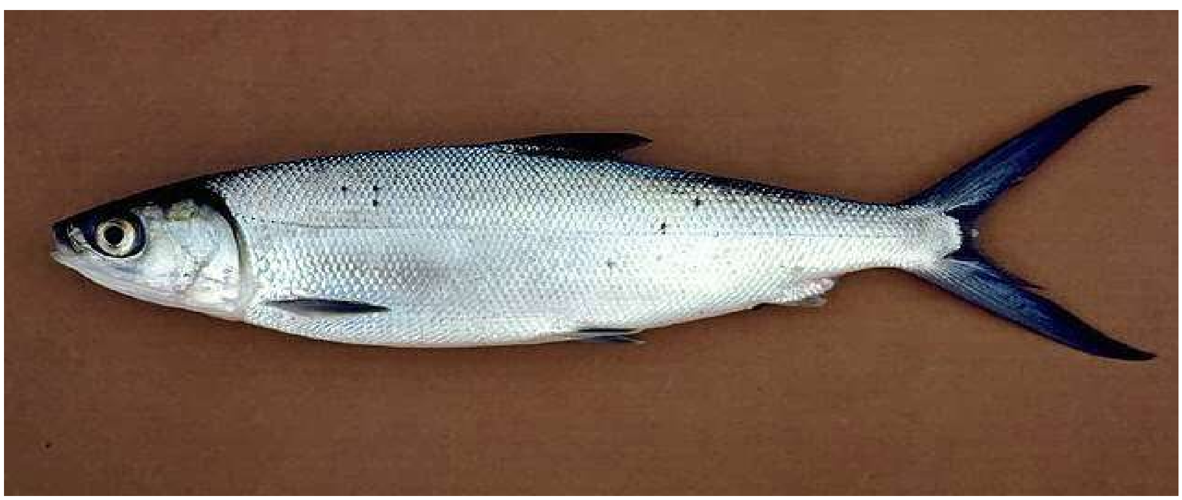
It is commonly known as stripped snakehead. There are stripes present on the body. The lower jaw is longer. The colour of back is dusky or brown and dirty white on sides and beneath. The dorsal and anal fins are long and without spines. It can grow maximum upto 90 cm.



Channa striatus

Chanos chanos

It is marine euryhaline fish and can be culture in low salinities also. It is extensively cultivated in Philippines. It can grow upto four feet length. In India fry of chanos collected and stocked. The chanos is plankton feeder and feeds on mainly on filamentous green algae. Abundant fry are caught in tidal creeks with peak period of availability in April, May and June. The chanos grows quicker in fresh water than brackish water. It is having highest lifespan.



Chanos chanos

Mugil cephalus

It is commonly called as mullet. It is widely distributed brackish waters. It is greenish color of the body with shrimp culture becoming popular. Mullets feed on filamentous and planktonic algae, vegetable debris and mud at the bottom in shallow waters. It can grow upto three feet in length.

Cat Fishes

These are air breathing fishes because they can directly breathe in atmospheric air. Due to this ability they can live for a long time without water and can be transported live and in fresh condition over long distances safely. The body of catfishes is not covered with scales and jaws possess two pairs of long barbels in the lower and upper jaws. An adipose fin on the dorsal surface may or may not be present.

Clarias batrachus

It is locally known as magur. Adipose fin is absent and dorsal fin is elongated, the anal fin is long and the caudal fin rounded. It feeds on animals, algae, higher plants of the bottom and it is suitable for culture in swampy areas. It can attain a maximum size of 40 cm. Matures at the age of one yare and deposits eggs in the burrows made in the pond.

Clarias batrachus

Heteropneustes fossilis

It is commonly known as singhi. Dorsal side of the fish is almost straight but ventral is slightly convex. Jaws are equal in length. Lips are continuous; dorsal fin is short and spineless without adipose fin. Caudal fin is rounded; pectoral spine is strong, osseous and pointed. Feeds on animals, algae, higher plants of the bottom etc. suitable for culture in swampy areas.

Heteropneustes fossilis

Cultivable Shellfish

Fresh Water Prawns

Macrobrachium rosenbergii

It is commonly called as Giant Freshwater Prawn and its commercial name is Scampi. Morphologically scampi can be distinguished from other species by the following morphological features.

- It has a very long rostrum, with 11-14 dorsal teeth and 8-10 ventral teeth
- The tip of its telson reaches distinctly beyond the posterior spines of the telson
- The adult male has very long second chelipeds in which all segments are elongate and have blunt spines;
- Scampi is the largest Macrobrachium species among the all known species with total body length upto 33 cm, and adult females of up to 29 cm.

Macrobrachium rosenbergii

Macrobrachium malcomsonii

It is commonly called as Godavari River Prawn. *M. malcolmsonii* is widely distributed throughout the Indian subcontinent, especially in the rivers draining into the Bay of Bengal. This species has a tremendous potential for culture in freshwater ponds and tanks. This second-largest, fast-growing prawn commonly occurs in the rivers of Bangladesh, India, and Pakistan, including the Ganges/Padma, Mahanadi, Hooghly, and Brahmaputra River systems. It is highly migratory species found in Chilaka Lake. In Andhra it is found in Godavari River. It can grow upto 15 cm size.

Marine Shrimps:

Penaeus monodon

It is commonly known as Tiger Shrimp and commercially called as Black Tiger. It grows very fast to a size of 40 to 60 grams in cultured ponds within 4-5 months. In marine environment, it can grows to a size of 350 mm with a weight of 250 grams. In pond environment they move on the bottom and feed on detritus, insect larvae and lab-lab. Generally they mature and spawn in the sea away from shore, where the larvae also develop metamorphose into post larvae. Then post larvae drifts towards the coast into the backwaters and estuaries. The adult shrimp migrate back into the sea for reproductive development i.e. gonadal maturation and spawning. Only male can mature in the brackish water environment females do not attain maturity in brackish waters.

Male:

- ✓ Presence of petasma in the first pleopod. Petasma is formed by the fusion of endopodites of first pleopod along their inner margin.
- ✓ Presence of appendix masculina in the second pleopod
- ✓ Gonopore is located at the base of fifth walking leg.
- ✓ Smaller in size than female.

Penaeus monodon

Female:

- ✓ Petasma, appendix masculina is absent
- ✓ Thelycum is present in the thoracic sterna between pereopods 4th and 5th
- ✓ It is used for storing spermatophore.
- ✓ Gonopore is located at the base of 3rd walking leg.
- ✓ Larger than male of the same age group.

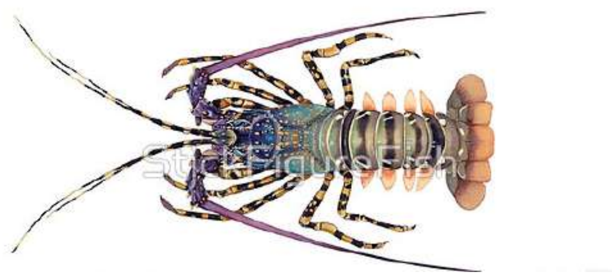
Penaeus indicus

Commonly known as Indian White Shrimp. It grows to a size to 20 to 40 grams in about 4 months in cultured ponds in the open sea grows to a size of 150 to 200 grams. They feed on detritus, insect larvae, lab-lab as they move to the bottom of the pond.

Cultivable lobsters

Among the various tropical spiny lobster species in the Indo-Western Pacific region, *Panulirus ornatus* and *P. homarus* are emerging as the favored species for aquaculture. Because of their various factors some of those factors including market demand and pricing, availability of naturally settling seed (for on-growing), development of hatchery technology, suitability for captive grow-out and adaptability to a variety of production systems. Production to date is based only on naturally settled pueruli, which in some areas of Vietnam and Indonesia are particularly abundant and easily caught.

Both *P. ornatus* and *P. homarus* are reef dwelling species, most abundant on coral and coastal fringing rocky reefs and the areas surrounding them. Both are less commonly found in inshore areas of a sedimentary nature, indicating their broad environmental tolerances that make them suitable for aquaculture. They are found in depths of 1 to 50 m. The juvenile and adult stages of both species are omnivorous, grazing primarily on small crustaceans, molluscs, worms and algae. They are generally nocturnal, most active from dusk through to dawn. Both are highly social, preferring to congregate in groups in hollows, caves and crevices within and beneath the reef structures. This social nature also confers a distinct advantage for aquaculture.



Panulirus ornatus

Cultivable Crabs

Crabs are among the most common marine invertebrates, and most common introduced and invasive species. Presently there are several species occur in one or more of the Nordic countries, and several more introduced species may be spreading from neighboring countries. The feasibility of culturing crabs has received attention in some countries because of high market demand and decreasing availability. While coming to the problems of intensive farming of crabs, which exhibit pronounced cannibalism during the larval and adult stages, some of the early attempts at propagating the economically important species were for the purpose of stocking open waters with larvae.

A more profitable operation that has been in existence for over two centuries in the USA is the production of soft-shell crabs popularly known as ‘shedding crabs’ on a commercial scale. Pre-moult blue crabs (*Callinectes sapidus*) captured from wild stocks are held until they moult once they moults crabs are sold as soft-shell crabs, which grabs higher prices in the markets.

Edible crabs of commercial importance are *Scylla tranquebarica, Scylla serrata*. These are commonly called as mud crabs. They are basically marine crabs but migrate to brackish water for growth while they are juvenile and the adults migrate from brackish water to the ocean for breeding and spawning.

Scylla serrata

Scylla tranquebarica is the largest species and it can grow maximum size upto 220 mm (carapace width) weighing 2.5 kg whereas *S. serrata* is smaller, it can attain a size of 140 mm (carapace width) and 0.5 kg to 0.72 kg weight. *S. tranquebarica* are found in open waters. *S. serrata* are found in burrows in the intertidal and subtidal regions of mangrove, estuaries and creeks. In India, crabs are formed as secondary crop along with shrimp in traditional tide fed farm of Pokkali fields of Kerala, Bheries of West Bengal and Khazan lands of Karnataka.

Male:

Abdominal flap is slender and triangular, claws are comparatively larger than the females.

Female:

Abdominal flap is broad and triangular or semicircular shape in berried females. Claws are smaller than the male.

Cultivable molluscans

Introduction

Molluscans contributed 30.4% of the global aquaculture production of fin fishes and shell fishes in the year 1999. Cultures of these organisms were done even from the era of Romans. Bivalves such as oysters, mussels, clams, scallops and a few other gastropods such as abalones (*Haliotes rufescens*), top shells (*Trochus cornatus*) are extensively cultured in mainly in subtropical and temperate countries like USA, Japan, Korea, France, Spain, Netherlands, Italy etc. Till recent years seed for culture was taken from natural spawning grounds. During recent years technology has been developed for the seed production of these organisms in controlled conditions and number of commercial hatcheries has been established in several countries.

Oysters

Oysters are the main species in contribution of maximum production among both finfish and shell fish. In the year 1999, one species of oyster *Crassostrea gigas* (pacific oyster) alone contributed 10% of the total production cultivable oysters are belonging two genera as *Crassostrea* (cupped oysters) and *Ostrea* (flat oysters). In India *Crassostrea madrasensis* is the common species found. Pearl oysters are extensively farmed by Japanese for production of pearl. All pearl oysters are protandrous hermaphrodites, being first male later changing to female. In *Crassostrea* males and females release the gametes in to the water where fertilization takes place. But in flat oysters males release sperms in to the water which enters in to the pallial cavity of female along with inhalant water and fertilization takes place in the water.

Mussels

Many countries like Thailand, New Zealand and Philippines promoting the mussel culture in the coastal areas. In India, Kerala coast is considered as the mussel fishery zone. About 555 ha of green mussel bed with an estimated potential of 15887 tons and brown mussel bed with a standing stock of 1586 tons reported to exist in Kerala.

Perna viridis

Perna indica

There are three species of mussels of the genus Perna such as *Perna viridis* or green mussel, *Perna perna* and *Perna canaliculus* (green-lipped mussel), along the Indian coasts *P. viridis* and *P. indica* (brown mussel) have been reported. *P. indica* is being a ciliary-mucoid filter feeder it feeds on phytoplankton, zooplankton and detritus of upto 0.46 mm diameter and hence is considered a highly suitable candidate for culture in coastal arears because of its feeding nature by utilizing the primary producers. It is having high protein content upto 67g/100g dry weight. Regular seed supply is an important factor in the expansion of this bivalve culture. Natural spat collection is not enough to fulfill the need. Recently hatchery roared spat is made available for mussel culture.

Short Answer type Questions:

1. Write about biological characters as a criteria for selection of fish for aquaculture?
2. Economic and market considerations economic and market considerations for selection of fish for aquaculture?
3. Write a short not on Indian major carps?
4. Write a short note on exotic carps?
5. Write a short note on murrels?
6. Write a short note on brackish water fish?
7. Write a short note on catfishes?
8. Write a short note on freshwater prawns?
9. Write a short note on marine shrimps?
10. Write a short note on cultivable lobsters?
11. Write a short note on cultivable crabs?
12. Write a short note on cultivable molluscans?

Long answer type questions:

1. Write an essay on criteria for selection of fish for aquaculture?
2. Write an essay on cultivable fin fishes?
3. Write an essay on cultivable shell fishes?

Unit-5

CULTIVABLE FLORA IN AQUACULTURE

Structure:

Introduction

Though aquaculture as practiced today is largely based on vertebrate and invertebrate animal species, plants contribute a substantial proportion of world production through aquatic farming. In 1999, estimated seaweed production is 9.5 million tons which was about 22% of that year's overall production. Major producers were China, Philippines, Korean republic, Vietnam, Malaysia. In these countries seaweeds are cultured mainly for human consumption. Seaweeds can also be used as fodder and in the manufacture of agar, carrageenan, alginates, mannitol and iodine. It was originated from Japan three centuries ago with the culture of 'nori' or the laver (*Porphyra*), which continuous to be the most important species cultivated for human consumption. There are mainly three groups of cultivated seaweeds for human consumption.

- Red algae (Rhodophyceae)
- Brown algae (Phaeophyceae)
- Green algae (Chlrophyceae)

All are typically marine species, but they differ from each other by tolerance to the salinity and temperature. Many of them cannot withstand exposure to wide variations in salinity; they require low temperature between 10 and 20^0 C. They are largely limited to the intertidal and sub-tidal regions; vertical distribution is governed by the availability of sunlight. Reproduction can be both sexual and asexual. Some species of red algae exhibit a biphasic (gametophyte, carposporophyte) type of alteration of generation, while others are triphasic (gametophyte, carposporophyte, tetrasporophyte). Asexual reproduction by means of asexual (neutral) spores occurs in the rather young stage of the leafy plants and this often accounts for the heavy settlement on collectors in culture operations. (Pillay, T.V.R. and Kutty, M.N.)

There are about 900 species of green seaweed, 4000 red species and 1500 brown species found in nature. The greatest variety of red seaweeds is found in subtropical and tropical waters, while brown seaweeds are more common in cooler, temperate waters. Economic importance Some 221 species of seaweed are utilized commercially. Of these, about 145 species are used for food and 110 species for phycocolloid production.Natural seaweed stocks have become inadequate to meet the industrial requirements and hence cultivation of these important resources has become necessary. Asia stands as the world leader in seaweed cultivation and more than 80% is contributed by China, Korea and Japan.

Seaweed resources in India

In India seaweed culture mainly practiced in two coastal states and islands. Seaweeds grow abundantly along the Tamil Nadu and Gujarat coasts and around Lakshadweep and Andaman and Nicobar islands. There are also rich seaweed beds around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu and Chilka in Orissa. Out of approximately 700 species of marine algae found in both inter-tidal and deep water regions of the Indian coast, nearly 60 species are commercially important. Agar yielding red seaweeds such as *Gelidiella acerosa* and *Gracilaria sp*. are collected throughout the year while algin yielding brown algae such as *Sargassum* and *Turbinaria* are collected seasonally from August to January on Southern coast.

Chlrophyta

Commonly green algae are found in both freshwater and marine water. Some species are terrestrial, growing on soil, or rocks. They are unicellular, multicellular, and colonial (living as a loose aggregation of cells) or coenocytic (composed of one large cell without cross-walls). They have membrane-bound chloroplasts and nuclei. Some are symbiotic with fungi giving lichens. Others are symbiotic with animals; e.g. the freshwater coelenterate Hydra has a symbiotic species of Chlorella as does *Paramecium bursaria*, a protozoan.

Ulva lactuca

A numberof fresh water green algae (Charophytes, Desmids and Spirogyra) are now included in the Charophyta, a phylum of predominantly freshwater and terrestrial algae, which are more closely related to the higher plants than the marine green algae belonging to the Chlrophyta (known as chlorophytes). Asexual reproduction may be fission (splitting), budding, fragmentation or by zoospores (motile spores). Sexual reproduction is very common and may be by isogamous (gametes both motile and same size) anisogamous (both motile and different sizes – female bigger) or oogamous (female on-motile and egg like; male motile). Many green algae have an alteration of haploid and diploid phases. The haploid phase form gametengia (sexual reproductive organs) and the diploid phases form zoospores by reduction division (meiosis). Examples Chlorella, Chlamydomonas, Spirogyra, Ulva.

Commercial use

Beta-carotene is produced from the hypersaline green algae *Dunaliella salina*. Carotene is found to prevent preventing certain type of cancers, including lung cancer. Caulerpa, a marine tropical to warm-temperate genus, is very popular in aquaria.

Chlorella is a genus of unicellular green algae lives in freshwater and terrestrial about 100 species, is grown like yeast in bioreactors, where it has a very rapid life history. It can improve the nutritional quality of daily diet. It can be added to the foods like pasta or cookies.

Ulva is an algae looks like a bright green sheets and live primarily in marine environments. They are also found in brackish waters, especially estuaries. They live in the middle to low intertidal zone by attaching to the rocks and as deep as 10 meters in calm, protected areas. Ulva is usually found as dense groups, commonly known as the sea lettuce or the green laver. It can be used as substitute to nori and eaten in soups and salads. There are ten species of Ulva exist worldwide.

Rhodophyta: Red algae

These are red in color because of the pigments called phycoerythrin and phycocyanin; this masks the other pigments, chlorophyll-A, beta-carotene and a number of unique xanthophylls. The main reserves are typically floridean starch, and floridoside; true starch like that of higher plants and green algae is absent. The wall of the algae is made of cellulose and agars and carrageenans, both long-chained polysaccharide in widespread commercial use. There are some unicellular representatives of diverse origin, more complex thalli are built up of filaments.

Kappaphycus sps.

Coralline algae is an important group of red algae, which secrete calcium carbonate onto the surface of their cells. Some of these corallines are articulated with flexible erect branches; others are crustose. These are used in bone-replacement therapies, vermifuges. Several red algae like dulse (*Palmaria palmata*) and Carageen moss (*Chondrus crispus* and *Mastocarpus stellatus*). Most important source of carrageenan is *Kappaphycus* and *betaphycus*. These are commonly used in food, especially yoghurts, chocolate milk and repared puddings.*Gracillaria*, *Gelidium*, *Pterocladia* and other red algae are used in manufacture of all important agar, which can be used as growth medium for microorganisms and biotechnological applications.

Azolla

Azolla is a free floating heterophorous free-floating freshwater fern that live symbiotically with anabaena azollae, a nitrogen fixing blue-green algae. Botanists are having more interest on it because of their association with blue –green algae and their rapid growth in nitrogen deficient habitats. There are six species under the genus of *Azolla* distributed widely throughout temperate, sub-tropical and tropical regions of the world.

Azolla *sp*. consists of a main stem growing at the surface of the water, with alternate leaves and adventitious roots at regular intervals along the stem. From the axil of certain leaves secondary stems develop. Fronds of the Azolla are triangular, polygonal and float on water surface individually or in mats.

Habit and Habitat: It is a free-floating aquatic fern belonging to the family Azolaceae. It is hetero sporous fern, which means having two kinds of spores (i.e. male and female gametophytic generations in the plant). This family contains seven living and twenty extinct species. Based on the morphology of reproductive organs, the living species are grouped into two sub-genera. They are Euazolla and Azolla.

Culture: There are basically two methods for development of Azolla, one is by means of vegetative propagation and other is sexual reproduction, which occurs during temporary adverse environmental conditions with the production of both microsporocarp and megasporocarp.

Azolla sps

Significance of Azolla: Azolla is capable of absorbing nitrogen from its environment but in association of Anabaena known as "Azolla. Anabaena association" meets the entire nitrogen requirement.

Physico-chemical parameters required for culture: A developed Azolla mat can fix averagely 1.0 to 2.6 kgs per hectare per day. When it compared with the industrial production of nitrogenous fertilizer carried out by nitrogenous operates with maximum efficiency at 300 ^{o}C and 200-1000 atm. The normal doubling time of Azolla plant is three days and for one kilogram of phosphorus applied result in 4-5 kilograms of nitrogen through Azolla i.e., 1.5 to 2.0 tons of fresh biomass. It can survive in a wider range of pH of 3.5 to 10.0 with an optimum of pH of 4.5 – 7.0 and it tolerate salinities up to 10 ppt.

Culture method of Azolla: Azolla is grown as a green manure before paddy transplantation or dual crop in agriculture. While coming to the aquaculture Azolla has to be cultured separately and it can be applied as a green manure. Azolla can be cultured in puddles, drainage and shallow water stretches at the outlets of ponds and tanks. There is no need using prime agriculture land for this. Culture of Azolla a number of earthen raceways are formed continuously, each with a size of 10.0 × 1.5 × 0.3 meters with a facilities for water supply and drainage. In order to avoid crab menace, shallow earthen bunds are raised to retain the water. For raceways initial inoculation of Azolla about 6 kilograms, phosphate fertilizer about 50 grams of single super phosphate and pesticide of carbo furon dip for inoculum at 1-2 ppm. Depth required for this culture is 5-10 cm. Then allow to grow about a week time. It grows to 18-24 kgs. Then remove the superficial earth layers with organic accumulations and apply to fish pond.

Uses:

- ✓ Because of its high decomposition rates it can be used as a substrate for enriching the detritus food chain. It is useful in aqua farming as a nitrogenous bio fertilizer.
- ✓ It can be used as ingredient of supplementary feed and forage for grass carp fish.
- ✓ A studies on bio fertilization of Azolla have shown that the nutrient requirements of composite fish culture could be reached by the application of Azolla
- ✓ It is used for microbial processing such as composting prior to application in ponds/tanks.
- ✓ Azolla can alone at the rate of 40 tonnes per hectare providing over 100kgs of nitrogen, 25 kgs of Phosphorous and 90kgs of Potassium in addition to about 1500 kgs of organic manure.
- ✓ It is paying a good role in environmental upkeep by substituting the chemical fertilizers.

Spirulina

Spirulina (*Arthrospira platensis*) is a naturally occurring blue-green micro-algae which grows and thrives in warm water alkaline lakes. It is a single celled organism that turns sunlight into micronutrient life energy. It is one of early life forms originating more than 3.6 billion years ago, and its spiral shape is what gives it the common name of spirulina.

Spirulina was discovered in South America and Africa in natural alkaline lakes. It is highly notorious micro salt water plant. Algae is having a long history as a part of our diet for many communities. Since the 1970's, Spirulina has been known and widely used as a dietary supplement in some countries. Spirulina contains rich vegetable protein 60-63%, (that is 3-4 times higher than fish or beef), multi vitamins (vitamin B12 is 3-4 times higher than animal livers) which is lacking in a vegetarian diet. It contains a wide range mineral, high volume of Beta-carotene.

Culture: Commercial production of spirulina is not possible in cold or temperate areas. Spirulina need high temperature constantly if temperature falls below 25°C it will not grow and under 20^0C it stops reproduction and die in a short time. It absorbs the sunshine and creates a reaction in it and starts the production of nutrients in the cell. Spirulina grows in alkaline saline waters. It can easily absorb the nutrients from water, if any pollution occurs in the waters like heavy metals it will absorb that metals and concentration of metals will be increased in the spirulina based on the intensity of the pollution. There are four requirements for culture of spirulina. They are

1. Tropical water
2. Strong sunshine
3. Pure water source
4. Pollution free environment

Spirulina sps

Uses: Spirulina contains more than 60% of vegetable protein, which is much higher than fish, pork, or beef. As animal protein is much bigger molecule than the vegetable protein, it is hard to digest. Vegetable protein is water soluble; it is simply discharged by our system as waste and not stored as fat.

Benefits of taking 5-10 grams of spirulina every day

- ❖ Increases the CD4 count – Strengthens the immune system (particularly useful for HIV/ AIDS patients.

- Increases RNA (Ribonucleic acid) in the brain for more energy
- The beta carotene (contains 10 times more that of carrots) is an excellent source of disease fighting antioxidants, and is also good for healthy eyes and vision.
- Contains vegetable protein and amino acids to build muscle

Spirulina powder and tablets

- High concentration of B Vitamins, which not only break down carbohydrate and lipids but also maintain cardiovascular health.
- It is also an excellent anti-inflammatory, which is an essential benefit to arthritis patients and prevents heart disease.
- It contains anti-aging properties.
- It improves digestive health. It contains easy to absorb iron supplements ideal for women and children.
- It reduces cancer with antioxidant protection

Short answer type questions:

1. Write a short note on seaweed resources in India?
2. Write a short note on Chlorophyta?
3. Write a short note on Rhodophyta?
4. Write a short note on Azolla?
5. Write a short note on Spirulina?

Long answer type questions:

1. Write an essay on commercially important seaweeds in India?
2. Write an essay on chlorophyta and rhodophyta?
3. Write an essay on culture methods and commercial uses of Azolla?

Unit-6

FISH BIOTECHNOLOGY

Structure:

Introduction:

The fisheries and aquaculture industries in Asia contribute about 45 percent of world fish production. These industries are significant contributors to the food supply, livelihood, foreign exchange earnings and socio-economic stability in rural areas of several Asian countries. At the global level fish production is stagnant, at around 100 million tonnes, or has even slightly declined in recent years. Overharvesting of the world's oceans is recognized as a global threat. To avoid this threat, the production of cultured fish must be accelerated. The ability to produce transgenic fish and shellfish in culture, which grow faster and larger with more efficient utilization of nutrients is of particular value to developing countries, not only as a source of food, but also as export products.

India is having a diverse resource ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species. The country has shown continuous and sustained increments in fish production since independence. It constitutes about 6.3% of the global fish production. The sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP. Present total fish production of India is 10.07 million metric tonnes from this nearly 65% contribution from the inland sector and nearly the same from culture fisheries. Biotechnology allows scientists to identify and combine traits in fish and shellfish to increase productivity and quality of the product. Scientists are investigating the genes that will increase the production of natural fish growth factors.

The rapid growth of aquaculture has significantly benefited from both conventional technologies and biotechnologies and it is expected that advanced biotechnologies will further help the sector in meeting the global demand for aquatic food in the coming decades. While biotechnologies are being applied in fisheries management, their use is very limited compared with aquaculture.

The four main areas where biotechnologies have been used in aquaculture and fisheries include

- Genetic improvement and control of reproduction
- Biosecurity and disease control
- Environmental management and bioremediation
- Biodiversity conservation and fisheries management

Biotechnology in fish breeding

Best biotechnological tool for the induced breeding of fish is Gonadotropin releasing hormone (GnRH). It is the key regulator and central initiator of reproductive system in all vertebrates. GnRH is a decapeptide and was first isolated from pig which is having an ability to induce pituitary release of leutinising hormone (LH) and follicle stimulating hormone (FSH) (Schally.,1973). Based on the structural variant and their biological activities, number of chemical analogues have been prepared and of them is salmon GnRH. It is widely used and commercially available in the name of Ovaprim throughout the world.

Cryopreservation of Gametes

Preservation of living cells, tissues, organs, embryos, larvae for an indefinite period by storing the same at very low temperature, usually at -196^{0}C this technique is called as cryopreservation. Application of this technique on semen storage for artificial insemination of live stock has made dramatic improvements in animal husbandry practices. In fisheries several attempts have been carried out to cryopreserve the spermatozoa and ova from various species and to use the same for seed production. Though this technique applied on several cultured, vulnerable and endangered species are successful. Cryopreservation of ova is difficult because of their large size, complex structure, existence of several membranes with variable permeability is considered as the main obstacles in preservation of teleost ova. For successful application of cryopreservation protocol knowledge on the milt composition and sperm quality is essential.

Principles of cryopreservation

There are three essential steps in cryopreservation.

1. Freezing
2. Storing
3. Thawing

If cryopreservation is done without proper necessary precautions results in death of sperms by cryo-injuries. These are may be due to the formation of ice crystals during freezing and thawing or due to osmotic changes. While application of this technique rate of freezing and rate of thawing are critical in preserving the vitality and viability of the spermatozoa. If cooling rate is too low, the cells get sufficient time to loose water so that it will maintain osmotic equilibrium with extra cellular solution. If it happens dehydration cells takes place resulting in death of the cells. If the cooling rate is very high, the time for water to diffuse out of the cell to the extra cellular ice crystals is very less and so little or no water escapes from the cell.

In such cases, the cells equilibrate by intercellular freezing either by homogenous heterogonous nucleation. When the freezing rate is moderate or optimum only part of the water leaves the cells, and a part of the water vitrifies or form small ice crystals which are tolerable if thawing is fast enough to avoid recrystallization. Soon after thawing, the sperm remain viable for fertilization. Use of cryoprotectants increase the post-thaw survival.

Transgenic fish

Transgenesis or transgenics may be defined as introduction of exogenous gene/DNA into host genome resulting in its stable maintenance, transmission and expression. The technology offers an excellent opportunity for modifying or improving the genetic traits of commercially important fishes, mollusks and crustaceans for aquaculture. Transgenic animals idea was most popular when Palmitter first produced transgenic mouse by introducing metallothione in human growth hormone fusion gene (mT-hGH) into mouse egg, resulting in significant increment in growth.

First transgenic fish production was done by Zhu in China. Now this technology successfully applied to number of fish species. Dramatic growth enhancement has been shown using this technique especially in salmonids. Selective breeding of rohu has been initiated for the first time in India by CIFA in collaboration with Institute of Aquaculture Research, Norway to genetically improve rohu for higher growth. It has shown genetic gain of 18% per generation for growth trait after nine generations of selective breeding. Improved rohu was tested in different agro-climatic regions of India i.e., Punjab, Andhra Pradesh and West Bengal. In the all the field testing centers improved rohu showed superior growth efficiency over control and local hatchery stocks. The improved rohu is popularly known as "Jayanti" as it was first released in the 50 years of India's independence.

To realize the full potential of the transgenic fish technology in aquaculture, several important scientific breakthroughs are required they are:

- More efficient technologies for gene transfer
- Suitable promotors to direct the expression of transgenics at optimum level during the desired developmental stages
- Targeted gene transfer tools like embryonic stem cell gene transfer
- Identified genes of desirable traits for aquaculture and other applications
- Information on the physiological, nutritional, immunological and environmental factors that increase the performance of the transgenic animals
- Safety and environmental impacts of transgenic fish.

Hybridization

Hybridization is a simplest way to improve the genetic status. By combining the haploid genome of two different parent species belonging to either same genus (inter–specific) or two different genera (inter-generic) and sometimes even between two strains of the same species (intra-specific) hybrids can be produced. Some scientists hold the view that hybridization in nature is facilitated when there is scarcity of one species and dominance of an allied species in close proximity. In bundh breeding, occurrence of natural hybrids due to congestion in the spawning ground. Due to limited space, there is a great chance for ova of one species getting accidentally fertilized by the sperm of another species.

Inter Specific Hybrids

These are obtained by crossing individuals of same genus but different species. Most of the inter- specific hybrids of Indian major carps show intermediate characters to their parental species. Examples of this kind of hybrids are *Labeo rohita* × *L. calbasu* (female rohu with male calbasu); *L. calbasu* × *L. rohita* (female calbasu with male rohu). These hybrids show high percentage of fertilization and hatchability. Offspring of both crosses are highly viable and their growth rates was superior to one of the parent i.e. slow growing *L. Calbasu.* Hybrids of both crosses are found to be fertile and attained maturity within two years.

Inter Generic Hybrids

A hybrid obtained by crossing of individuals from two different genera is called as inter-generic hybrids. In all the cases hybrids are observed to be better than one of the slow growing parents. These hybrids also showing some intermediate characters to their parents. Example: out of 13 inter-generic hybrids only four crosses i.e. Rohu × Catla, Mrigal × Catla, Rohu × Mrigal, Fimbriatus × Catla have been found to possess useful traits in terms of growth.

Impact of Hybridization

Adaptability of any hybrid to the environment is determined by genetic introgression i.e. flow of genes from one species pool to another species. If it is $< 0.1\%$ it may help in increasing capability of adaptation against natural selection. Reduction of genetic diversity also takes place because of indiscriminate hybridization.

Short answer type questions:

1. Write a short note on the main areas of biotechnology in aquaculture and fisheries?
2. Write a short note on principles of cryopreservation of gametes?
3. Write a short note on transgenic fish?
4. Write a short note on inter specific hybridization of fish with examples?
5. Write a short note on inter generic hybridization of fish with examples?
6. Write a short note on impact of hybridization?

Long answer type questions:

1. Write about application of biotechnology in fish breeding?
2. Write an essay on hybridization of fishes?

Unit-7

AQUARIUM

Structure:

Introduction

An aquarium is a tank of water made of glass either fixed in a frame or all glass fixed by silicon gel/glue which is transparent and through which fishes can be seen. Thickness of sheet glass varies with the size of fish aquaria. Aquarium fishes are also called as mute pets as they cannot make any problems to the owners like dog etc. An aquarium will help you rest, relax, find tranqubility and harmony, it will reduce your stress and improve your health. Watching aquarium can reduce your stress, lower blood pressure and makes people healthy.

Definition

Aquarium is also called as vivarium consisting of at least one transparent side in which water dwelling plants or animals are kept. The term came from Latin word which means aqua-water, with suffix –arium- "a place for relating to". An aquarium typically constructed of glass or high strength acrylic plastic which is attached by silicone glue. Size can range from a small glass bowl to immense public aquaria.

Fabrication of Aquarium

For making of an aquarium, the glass pieces should be cut into correct desired sizes. Five pieces of glass required for making of one aquarium. In those five glasses, one is for front, one for back, two for sides and bottom (base). The glasses for front, back and bottom should be equal in size. After getting the all five glasses, the edges of each glass should be filed evenly with grain sand paper or stone. It is good to rub the edges in one direction only.

Place the base glass on a flat surface and pieces of adhesive tapes are put on all the four sides. Then silicon glue adhesive is put on edge preferably on the side, which will hold the back glass pane. Take back glass pane and put its edge on to the glue line of the base glass. Stick the flying adhesive tapes on to it and provide support of a weight from outer side. Now stick adhesive tape pieces to the sides of this glass pane and make a line of glue on edge of one side and continue towards base glass. Likewise fix the second side glass pane. The front glass pane should be joined in the last.

Making of aquarium

Support of weight and adhesive tape makes good bonding between glass panes. The silicon glue dries up within a few minutes; excess glue can be removed by using a razor blade. Then leave as it is for a week and then tested for water leakage by filling it with water and leaving for overnight. If no leakage is found, then our tank is ready for fish keeping.

For making of large size tanks, plastic or metal corners should be guide using silicon glue. They will increase the strength of aquarium ultimately durability also. Aquarium should be kept on a stand or table having a height of 90 cm. The filled aquarium should never be lifted.

Decoration

A newly constructed aquarium should be washed with common salt solution followed by fresh water. Washing with soap and powder is not recommended. The aquarium should be kept at a place where direct sunlight does not reach.

- ❖ After selecting a suitable place, put a layer of washed chips or coarse sand (3-6 mm) upto a thickness of 2 inches. Usually for one square foot needs about 5 kg of chips or coarse sand is needed.
- ❖ In order to make aquarium more beautiful attractive caves or hiding places may be made inside, which is very useful for shelter seeking or timid fishes.
- ❖ After providing bedding, plant some rooting aquatic plants like *Hydrilla*, *Valisneria*, *Myriophyllum*, *Cabomba* and *Ceratophylum*. Keep the taller plants backside and smaller plants at the front.
- ❖ Accessories like filter, aeration devices, thermometer, feeding cups, toys, etc. must be placed after bed laying.
- ❖ While releasing of fishes hang the bag in which fish are carried into the aquarium water for about 10 minutes. Then open the bag and allow some water to enter the bag and get mixed then release the fish into the tank water.

Maintenance of Aquarium

The water used for filling of aquarium should be of good quality. Aquarium water generally get polluted by fecal matter, uneaten food and broken pieces of aquatic plants. The fish will suffer due to lack of adequate oxygen as it is depleted due to waste that is accumulated in the tank. This can be overcome by providing aeration and regular removing of extra fed and faces by siphoning. The quantity of feed should be kept such that the fish consume it immediately. Feeding should be at fixed schedule. Feeding should be strictly as per demand. Aquarium water to be siphoned every fortnightly or monthly for removing accumulated waste. The quantity of water siphoned must be replaced with fresh water.

Study of Aquarium Fishes and Breeding

A few fishes of small size that are suitable for introduction into aquarium are as follows:

1. *Poecilia reticulata* (Guppy)
2. *Betta splendens* (Siamese fighter fish)

3. *Mollinensia letipinna* (Molly)
4. *Carassius auratus* (Gold fish)
5. *Xiphophorous maculatus* (Platy)
6. *Puntius conchonius* (Rosy barb)
7. *Mollinensia scanopos* (Black molly)
8. *Astronotus oscillatus* (Oscar)
9. *Trichogaster liri* (Pearl gourami)
10. *Helostoma temmincki* (Kissing gourami)
11. *Xiphophorous hellari* (Sword tail)

Betta splendens is commonly called as Siamese fighter fish. It is brilliantly coloured and most attractive. However male becomes highly excited during the breeding season and fights with other male in the aquarium, causing severe injury and even killing the other male.

Siamese Fighter fish *(Betta splendens)*

The Angel fish (*Pterophyllum scalare)* is laterally flattened, disc-like and has greenish body with four vertical bands. It is available in various colours like black, silvery or even white with dark bands and red spots on the head and it has elongated paired fins that make some attractive look.

Angel fish (*Pterophyllum scalare)*

The kissing gourami *Helostoma temmincki* is amative of Thailand. It looks beautiful by having a yellow silvery colour. A pair is often seen with lips close to each other, looking like kissing the other, hence the name. It needs large swimming space so aquarium also must be large for rearing of this species.

Kissing gourami (*Helostoma temmincki)*

Lebistes (guppy) *Gambusia, Mollinensia* (Molly) are live bearers. They are small sized fishes and give the birth to youngness. Guppy is one of the most popular fish for the aquarium, and is seen in several colour combinations.

Guppy (*Poecilia reticulata*)

Gold fish is a popular fish among the world; it will be in golden colour. Different varieties of gold fish were available like lion head, peacock tail, oranada, etc. *Danio* and *Esomus*are good indigenous species having one or more horizontal bands from head to tail, and are larvivorous.

Gold fish (*Carassius auratus*)

Breeding of ornamental fishes

Gold fish:

Gold fish (*Carassius auratus*) is the most important aquarium fish because of its high commercial preference due to its graceful appearance. It is reported to grow upto 20-30cm.

Common gold fish is metallic orange red in colour, dorsal fin is having long base but caudal fin is only slightly forked and rounded.

Sexual dimorphism

During breeding season, tubercles appear on head, operculum and sometimes on pectoral fins and other fins of males. While females do not exhibit any breeding turbcles. Belly line between the lowest point of belly to base of tail is observed from above, it is in circular in outline of female but a slight curve in male. Belly of the female may be bulged slightly to one side. Genital opening is round and protruded in females and long and oval in case of males.

Courtship, Spawning and Larval Rearing

Fishes of 8-15 months old ranging in size from 40-100 grams can be used as brood stock. During breeding season, male and female move in pair, male taking a position below the posterior region of female by using its snout nearer to the vent of the female and trunk below the caudal fin. Sometimes courtship may continue for several days also. Then female release the eggs which are fertilized by milt produced by male simultaneously. Gold fish eggs are adhesive in nature. So various types of water plants are used for collection as they stick to these plants. Parent fish has the habit of eating its own eggs, it is advisable to separate the egg collectors containing eggs into a different containers. Each female release about 2500-3000 eggs. Fertilized eggs are transparent in the beginning as the development proceeds, transparency also decreases. Unfertilized and dead eggs are cloudy. Generally under ideal conditions eggs hatch out in 72 hours.

Angel Fish (*Pterophyllum scalare*)

It is one of the attractive fishes among the aquarium fishes because of its graceful moment and shape; breeders have developed different strains of fish exhibiting different colour patterns by this time. Though it is a native of amazon basin, it is distributed all over the world as it is in high demand. It grows upto 5 inches. Strains with silvery body with black vertical bars, pure black strains, strains with silvery colour; gold coloured, albino coloured etc. have been developed.

For breeding mature pair into an aquarium provided with enough of aquatic plants. The pair selects usually stiff plant stalk or leaf and after cleaning they attach the eggs in rows to the surface. The egged are fanned by the parents and incubation period is 4 days. Hatchlings are attached to the leafs of the plants by a sticky thread attached to its head. Yolk sac is absorbed within 3-4 days and by this time threads also disappears. Then the fry dropped to the bottom it is better to remove fry in order to avoid loss of fry due to cannibalistic nature of the parents.

Diseases

Fishes are also subject to disease like other animals living on the earth. Most serious disease among them is infections as these can wipe out a great many fishes. Congenital diseases are deformities with which the fish is born; usually they are genetically caused. Example: Absence of operculum, fins or twisted backbones. Some diseases are produced by injuries caused during handling they are called traumatic disease.

White Spot Disease:

It is a protozoan disease caused by *Ichthyophthirius multifilis*. This disease can kill the fish if we are not aware of its presence. They occur when the temperature of the water drops in the aquarium during this time resistance of the fish becomes reduced and the vitality of parasite increased.

Symptoms

- It causes itching sensation in infected fishes and fishes may attempt to rub or scratch themselves against objects in the aquarium.
- White spots are present on the fish body.

Treatment

- Raise the temperature of the aquarium water upto 28^0C.
- By using a 5% aqueous solution of Methylene blue (Notes).

Velvet:

It is a common disease among the aquarium fishes. Infected fishes having a golden dust like spots on their skin, as if sprayed with golden powder. If not properly treated means condition of the fish deteriorates and a series of circular crusts develop and even kills the young fishes before the disease is suspected.

Symptoms

Fishes will rub their bodies to the walls of the aquarium and objects present in the aquarium. Gills become infected and swollen. Fins eaten away by other fishes, vitality will be lowered, become inactive and finally die.

Treatment

- Infected fish must be removed from the tank and treated with Methylene blue for 10 days in a separate aquarium.
- Plants should be disinfected with potassium permanganate solution.
- Gravels should be washed and kept in hot boiling water for 10 minutes.
- Aquarium must be cleaned with a weak solution of disinfectant detergent before washing with fresh water (Notes).

Short answer type questions:

1. Define Aquarium?
2. Write a short note on decoration of aquarium?
3. Write a short note on maintenance of aquarium?
4. Write a short note on white spot disease in ornamental fishes?
5. Write a short note on velvet disease in ornamental fishes?

Long answer type questions:

1. Write in detail about fabrication of aquarium?
2. Write an essay on the breeding of ornamental fish?
3. Describe diseases in ornamental fishes in detail?

Unit-8

FISHING CRAFT AND GEAR

Structure:

Introduction

There are several methods and means employed by mankind to catch the fish for food from ancient times. Any instrument or object or device to catch the fish is called “Gear”. The platform which is used for carry fisherman and the gear to fishing grounds is called as

"Craft". In olden days, crafts and gears used throughout the country were mostly primitive and non-mechanized. However modernization and mechanization has taken place in the past three decades. The fishing gear along with the craft, accessory equipment's required for fishing, and the men, forming a "fishing unit". Quantity of the yield per single unit is depends upon its efficiency and the productivity of the fishing area.

Types of Crafts

The fishing vessels can be classified on the basis of different criteria like depth of operation, duration of voyage, size of vessel, materials used in the construction, type of propelling system and in accordance with the actual operations.

Classification based on the depth of operation:

1. Inshore vessels– vessels operating up to 10 fathoms depth
2. Offshore vessels – vessels operating in the depth range of 10-40 fathoms
3. Deep sea vessels – vessels operating beyond 40 fathoms depth

Based on the size of the vessel and duration of voyage:

1. Near water vessels – length up to 12 m which mostly make daily trips or trips of short duration
2. Middle water vessels – length between 12 - 30 m having an endurance of 7 days or more but not exceeding 25 days
3. Distant waters vessels – size over 30 m length with endurance exceeding 25 days

Based on the materials used in the construction:

1. Wooden
2. Steel
3. Fiber glass
4. Ferrocement
5. Aluminum
6. Composite

Based on the propelling system used:

1. With oars
2. With sail
3. Engine driven
4. Intermediate

Based on type of water in which they are used:

1. Fresh water fishing vessels – mainly operated in inland waters
2. Sea water fishing vessels – mainly operated in sea

Trawlers

A vessel which operates the trawl nets for fishing is called as trawler. There are several type of trawlers are available based on their operation and construction.

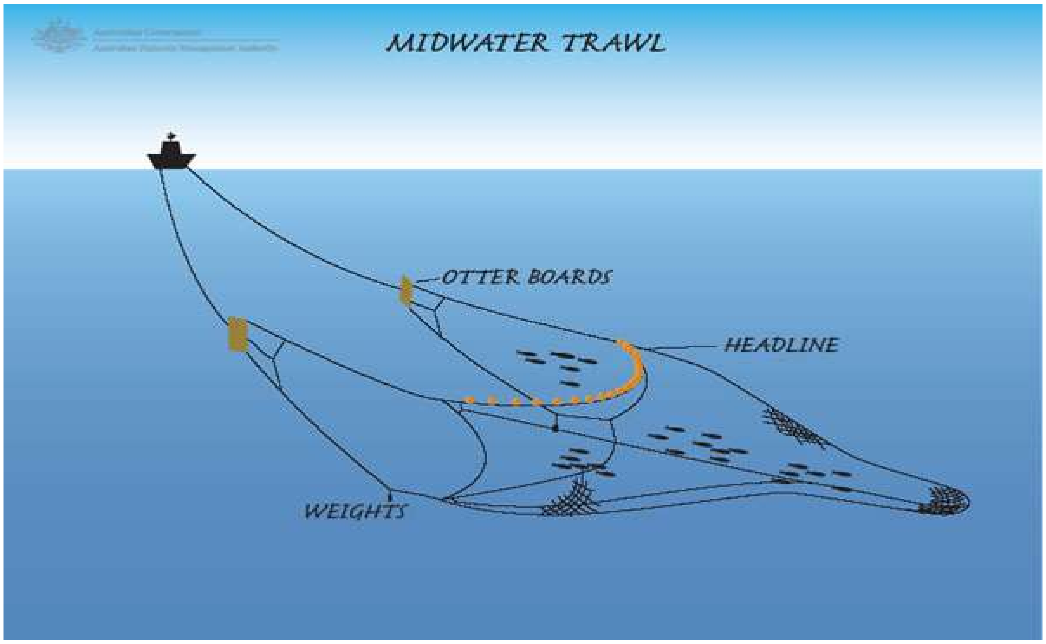
Side trawl: Trawler in which the trawl is set over the side and warps pass through blocks hanging from two gallows, one forward and one aft.

Stern trawl: In this method, the gear is set and hauled over the stern. The wraps are led from the trawl which through various lead blocks over to the stern.

Wet fish trawler: The fish is kept in the fresh/ wet condition in a wet fish trawler.

Freezer trawler: A trawler which is which is equipped with refrigerating plant and freezing equipment and in which fish is preserved by freezing.

Factory vessels: a trawler equipped with processing plant mechanical gutting and filleting equipment with freezing installation, fish oil, fish-meals and sometimes canning plants. The number of persons working (crew) in such a vessels is large (Latha Shenoy).

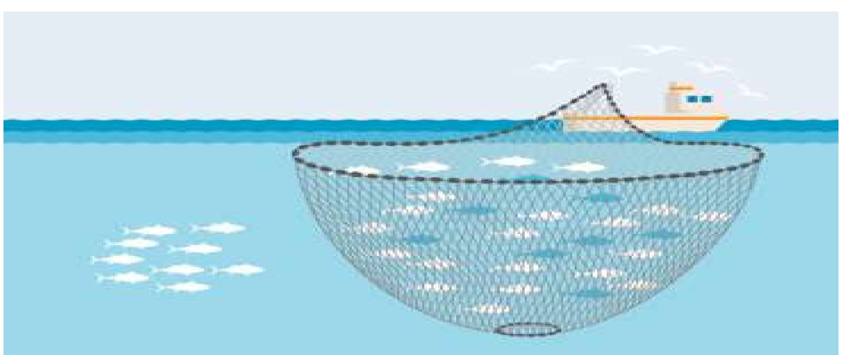


A mid water trawl

Seiners

These are the vessels which operates the surrounding gear or seine nets. More number of crew is needed for operating this kind of nets.

1. Purse seines – vessels which operate purse seine and which are equipped with pursing gallows and pursing winches for hauling of purse lines.



Purse seine

Dredgers

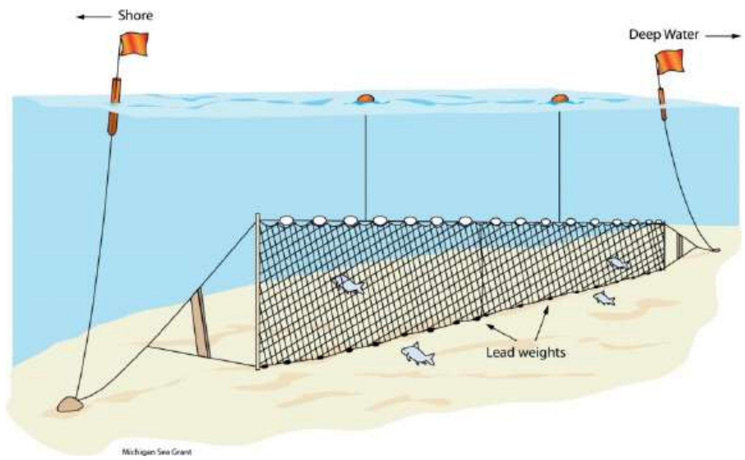
Vessels which use dredges for collecting molluscs from the bottom. They need more power to drag the gear.

Lift netters

These are the vessels operating large lift nets which are raised and lowered by means of out riggers.

Gill netters

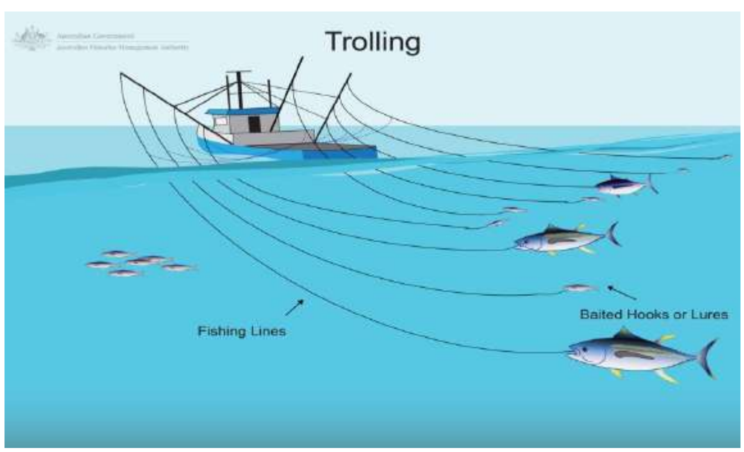
Gill nets operated either set or drift and the larger vessels often equipped with net haulers or net drums.



Gill net

Liners

These are vessels use lines and hooks with or without bait or lure. Operation of lines is called as trolling.



Trolling

Non fishing vessels

Mother ships- Vessels which provide fishing vessels at sea with supplies of fuel, freshwater, provisions and other consumable goods, transfer the catch from the vessels, process and preserve them fresh, render medical and social services to the crew.

Fish carriers- These are used for transporting the fish in refrigerated condition by using fish holds.

Hospital ships- These render medical services to the crew of fishing vessels operating offshore.

Fishery protection vessels- These are engaged in protection of fishing grounds and surveillance of fishing vessels operating in a country's territorial waters and in the EEZ areas.

Fishery research vessels- These are engaged in fish stock assessment, experimental fishing using various gear and in fish handling.

Types of Gears:

A fishing gear is a device or any object used to catch the fish, prawns and crab. Various types of devices are used since prehistoric times and depend upon the species to be caught, condition of the river or seabed and depth of operation etc.

Spear and Harpoon

Fishes of large size are wounded with the help of spear, lance or harpoons. Hunting of fish by using spear is an ancient practice, is called as "Konch". One or more metallic conical points are attached at the end of a 2 m long bamboo shaft to form a spear or trishul. This is thrown at a large fish by man standing on a boat. Harpoon is also called as 'Ek-Katiya' and has been barbed iron point attached to a 3 m long bamboo shaft. A spear is also used to spear a fish through holes in the ice. A rope is fastened to every spear, so that it is recovered for reuse, after being thrown at a fish.

Hook and line

In this type fish is caught by offering a baited hook and the gear is operated by hand. In a "hand line" one or more hooks are attached at the end of a cotton line (dori) whose other end is tied to a long bamboo stick. Generally hooks are made of well-tempered steel to prevent rusting, and also made of bone, tortoise shell, mother of pearl, etc. a hook consists of a head or eye, shank, bend, and point. They are different types of hooks are available based on shape and size, double or treble, with or without barbs, designed to catch a particular species. Long line consists of main line and several pendent branch lines.

Fish Traps

Fishermen use various methods to trap the fish.

Two hemispherical baskets, each having an opening at the narrow end are joined together at their broad ends. The narrow openings are guarded by curved bamboo sticks with their free ends facing towards the inner side. Suitable bait is kept inside the basket, to lure the fish into the trap from where they are unable to get out.

Basket trap is used to catch fish like *Heteropneustes*, *Clarias* and *Channa* that live in shallow muddy water. The basket trap is made of split bamboo having a opening about a meter in diameter at one end and a small opening 12-15 cm in different at the top. The basket is dropped into the water and the wide opening pressed into the mud where fish and prawn are expected.

Basket trap

Nets

There are various types of nets used all over the world and are prepared to suit the conditions of the fishing ground, weather and the species of fish to be caught. The efficiency of nets are depends on its design, size of the mesh and “tension” on the webbing. Twines used for making of nets are made of cotton, silk, hemp fiber, or from synthetic material as the nylon, decron, vinylon etc. Nets made of synthetic fibers are better, being transparent and resistant to rotting.

Types of nets

There are several types of nets are available based on their construction, type of operation and fish to be caught etc. they are mainly of following types

1. Dip or Lift net- It consists of a piece of net set on a frame with handle, and is lowered into water and lifted out in a scooping style. It is of triangular or rectangular or square in shape. The smaller nets are operated by hand from a boat.

2. Cast net- It is looking like an umbrella, with a strong rope attached to the apex. A number of weights of iron or lead are attached along the margin. Efficiency of net is depends upon the skill of the fisherman. Net gradually sinks to the bottom due to sinkers attached to the margin. Small fish and prawn are entangled in it.

3. Purse net- It is looking like a purse; migratory fish like *Hilsa* are caught by rectangular "Kharki jal" and the "Shangla jal" are two varieties of the purse net. The net is suspended from the boat by ropes while the mouth is kept open, and the boat is moving downstream, fish which is migrating upstream enter the mouth and are easily caught.

4. Gill net- It is a large wall of net set in water and is passively operated, as it is not moved by fisherman to catch the fish. It consists of two ropes one is head ropes to which floaters are attached and other is foot rope to which sinkers are attached in order to maintain buoyancy of net.it can made by using cotton or hemp in various colours so that it is not visible to the fish. Mesh size is depends on the species to be caught. It is normally set across the river, or transverse to the path of migrating fish. The fish is caught in the net behind the operculum hence these nets are named as "Gill nets".

5. Seines- These are large in size used for active fishing. A large area of water is first surrounded by a net wall, which is then hauled and the fish are filtered and brought to the shore. It may be of three types: 1. Boat seine, 2. Drag seine and 3. Shore seine.

6. Trawl or Drag net- These are conical or bag shaped, work on the principle of filtering water to catch fish. It is usually operated in mid water or bottom so it is very efficient for the fish and prawn living at the bottom or in mid water. Upper lip of the net is having a head rope with a number of floaters while lower lip has a foot rope with a number of wooden or metallic bobbins. Size of the mesh will decrease from top belly to codend (terminal part).

Gear materials

Efficiency of fishing gear is dependent to very great extent on the materials used for its construction. In olden days natural materials were mainly used in fishing gears. Subsequently, synthetic fibres have come to existence. The use of synthetic fibres is one of the most significant technological revolution which enhanced the efficiency and productivity of fishing gears. Natural fibres get decomposed by cellulose digesting bacteria on a continuous usage in water and hence their life is lesser than synthetic fibres. Synthetic fibres are having so many advantages over the natural fibres, they do not absorb water, there is no need for using any preservatives, and above all their catching efficiency is better.

Fibres

These are the materials used for construction of fishing gear. A fibre can be defined as “a unit of matter of hair like demission whose length is at least 200 times greater than its width”. Based on the source frown which they obtained, they classified as natural fibres and manmade fibres. Natural fibres obtained either from animal or plant sources.

Natural Fibres:

Vegetable fibres contain cellulose base and prone to rotting in water as they are attacked by cellulose digesting micro-organisms. Vegetable fibres are derived from leaves, stalk, seeds and fruits. These fibres are again divided into seed fibres, bast fibres, leaf fibres and fruit fibres.

Cotton fibres are the examples of the fruit fibres which grow in seed pods of the cotton plant. Before the introduction of synthetic fibres cotton fibre is the most commonly used net material. They are having a length of 25-50 mm and diameter 0.01 to 0.04 mm. they are extremely fine with dull white in colour.

Bast fibres are derived from the components of the bast tissues of stems. Ramie, hemp, linen are the examples of this kind of fibres. They are also called as soft fibres, length of ramie fibres (China grass) ranging from 8-25 cm with a 0.024-0.070mm diameter. Hemp is derived from the bast of the *Cannabis sativa* (Italian hemp) with yellow to brown colour.

Pulpy tissues of long leaves are the sources of leaf fibres; they are called as hard fibres sisal and manila are the examples. Manila is taken from the Abaca plant, as they are having large diameter used in cordage and heavy netting. Length of the manila fibres ranging from 150-300cm with a 0.01-0.025mm diameter. Animal fibres have a protein base, silk, wool and hair are the examples of this animal fibers. Among these only silk has been used in fishing gears to acertain extent.

Synthetic Fibres:

These are the manmade fibres manufactured by chemical synthesis from simple substances like phenol, benzene, acetylene, prussic acid etc. Deepening on the type of polymerization four groups of can be identified.

Polycondensation: In this water is eliminated examples: Polyamide (PA) and Polyester (PES). They are traded as Nylon, amilian, perlon, kapron, etc. those of polyester are terylene, dacron, etc.

Polymeric compounds: In this method water is not eliminated during the chemical process. Polyvinyl alcohol (PVAA) and Polyvinyl chloride (PVC) comes under this group. PVC was the first synthetic fibre to be produced on an industrial scale and first synthetic material used for fishing gear.

Mixed polymers: These are formed by co-polymerization of mixture of vinylidene and vinyl alcohol. Polyvinylidine chloride (PVD) is the examples for this kind of polymers.

Polyadditive compounds: Monomers polymerize in a simple additive manner to form polymer. Polyethylene (PE) are comes under this family.

Fabrication of fishing gears

A net consists of number of meshes of fixed dimensions. Normally a mesh has four sides which are otherwise called as bars of equal length. The webbing can be either machine made or hand-made. The process of making webbing by hand is called as braiding.

Net braiding:

Braiding is initiated by laying a foundation line between the two hooks. Clove hitches are made on this line. The number clove hitches made is one extra over and above required number of meshes. The initial row of clove hitches is called as setting up row. Baiting, creasing, fly meshing are the methods used for shaping of the net.

Maintenance of gears:

All kinds of fishing gears either natural or synthetic need proper treatment, preservation and storage for longer life expectancy and better catching efficiency. There are several causes affecting the netting materials durability and efficiency. There are several causes affecting the efficiency and durability of the materials. They are

1. Rotting
2. Weathering
3. Abrasion
4. Mechanical destruction by animals
5. Fouling
6. Rusting

Besides this materials have to be treated with some preservatives to increase their stiffness, avoid knot slippage and coloring for improving their catching efficiency.

Preservation against rotting

There are different methods are available to preserve the netting materials according to varying situations.

Washing and sunlight disinfection: In this method, nets are washed in freshwater and dried in sunlight. It is the simplest way.

Tanning:

Tannin is extract of barks, roots, leaves, seed coats, fruits etc. which is poisonous to micro-organisms. In tannings a thin coat of tannin is given to the netting. Fixation can be done either by copper sulphate or potassium dichromate.

Short answer type questions:

1. Define fishing craft?
2. Define fishing gear?
3. How do you classify fishing crafts based on the depth of operation?
4. How do you classify fishing crafts based on the duration of voyage?
5. How do you classify fishing crafts based on the material used for construction?
6. Write a short note on spear and harpoon?
7. Write a short note on Fish traps?
8. Write a short note on natural fibres?
9. Write a short note on synthetic fibres?
10. What is poly condensation?

Long answer type questions:

1. Write an essay on classification of fishing gears?
2. Give a detailed account on trawlers?
3. Describe non fishing vessels in detail?
4. Give a detailed account of types of gears used for fishing?
5. Write an essay on gear materials, fabrication and preservation of gears?

Unit-9

FISHING METHODS

Structure:

Introduction

In earlier days, very simple methods were used for catching fish. Over the years, these simple gears have been replaced by more efficient ones capable of catching fish in bulk quantities. Initially hand picking was practiced along the shore of lakes, rivers and seas to catch sedentary, stranded and stupefied fish. Fishes are stupefied either mechanically, chemically or electrically. To extend the range of human arm kind of spear was developed. To prevent the fish escaping from the thrown gear, method like harpooning is developed which is having an advantage over spear to retrieving the catch.

Fishing technology is a discipline which deals with techniques used for fish capture. It covers both direct means of capture such as fishing gears, vessels as well as methods employed to use them, and the indirect method applied to facilitate capture such as fish locating technology and technique involved in the application of fisheries oceanography and limnology, fishing technology is subject of enormous complexity.

Electric fishing

It is a technique covering a number of very different methods, which all have in common the use of an electric current flowing through the water to impress the on fish within the space, affected a common pattern of reaction, leading to their capture. This method is having an advantage over the other fishing methods by means of collecting fish that they do not require preliminary preparation of the site, with consequent delay and disturbance of the fish to be investigated, and that the requirements in terms of manpower and exertion is also low. While coming to the disadvantage it is having a high risk of physical danger to both fish and operators, though these disadvantages can be removed by experienced management and people.

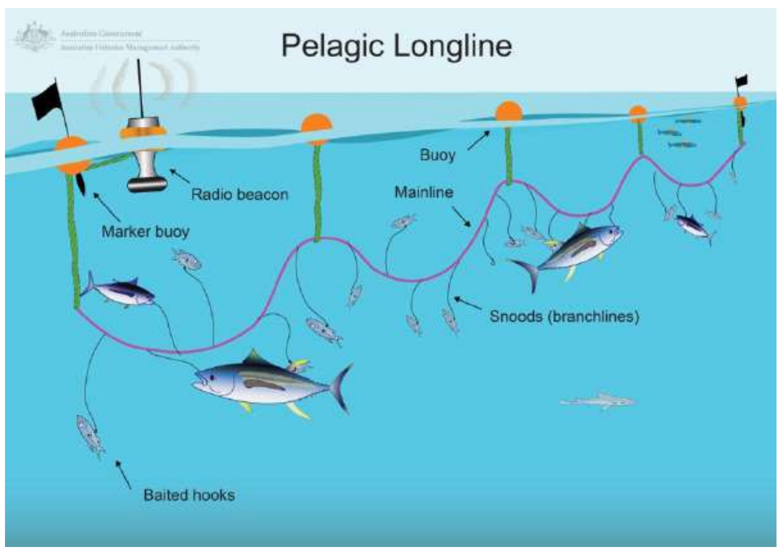
The extent of fishing diameter varies with the power available, the water conductivity-which may change abruptly in a stream where a drain enter, the temperature, and the efficiency of the type of electric current as stimulator. While comparing the currents to be used an inefficient type, such as smooth direct current, shows great variations of effectiveness for slight variation in physical factors; alternating current is less sensitive, and if selected current is properly pulsed means it has an almost uniform action. It is impossible to decide the efficiency of electric fishing in advance, but only in retrospect. The behavior and motivation of the fish vary with numbers and changing physiology to produce abrupt alterations in the results.

Line fishing

Line fishing is a technique in which fish is offered bait for luring and once it is taken, it is difficult for the fish to escape and fish is caught. It is a passive fishing method used for widely scattered large pelagic and demersal carnivorous fishes having high individual value. To ensure the effective capture, gorges or hooks are used. The materials shapes and designs of hooks have improved over the years for better catch. There are several types of line fishing that are used for capture of fishes like tuna, mackeral, squids, cod, snappers etc.

Classification of lines

a. Without hooks: No hooks are used in this method and instead attractive bait is attached to a line of adequate length. This is used for catching crabs, snails, octopus etc. which hold on to the bait until the line is pulled out of water.
b. With rip hooks: in this method hooks without baits will be used. Fish gets attracted by sparking bait and is then caught by snapping on it. Sometimes, it hooks spears or rips up the fish coming in its range.
c. With gorges hooks: These are provided with baits. Gorge is a straight stick pointed at both ends, tied at the middle and inserted length wise into a bait parallel to the twine. When the fish swallows it, the bait takes a vertical position. However when either the line is pulled or the fish tries to swim away, the gorge takes up a transverse position in the mouth of the fish there by preventing its escape. Modern hooks are more effective than these older ones they are directly penetrate into mouth of the fish.



Trolling operation

Trawling

Trawl is a dragged gear towed through the water either in the bottom or subsurface waters. In world it accounts for more than 20% of world marine catch. In India, trawl nets are operated by more than 65% of the mechanised boats contributing substantially to the marine catch.

Description of trawl

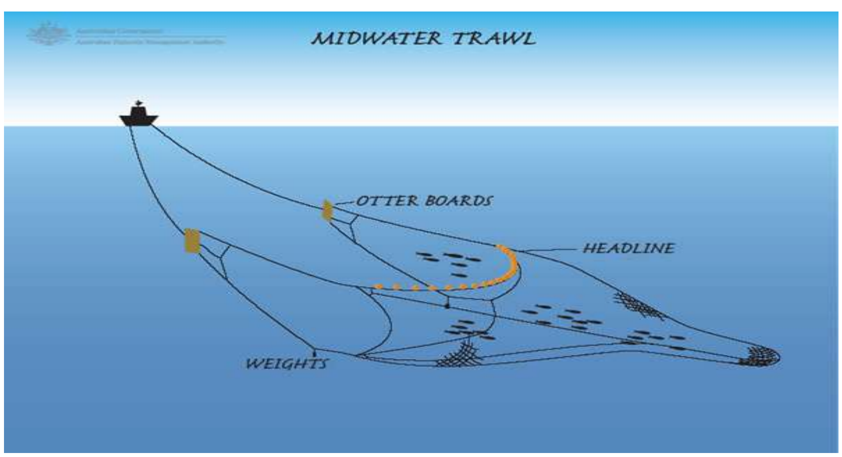
It is a conical shaped net with two panels upper and lower one each consists of codend, throat, belly, square and two wings. The main part of the net is made of knot is called as “webbing”. The upper edge of the trawl net is attached to the head rope carrying the floats. The belly is wide at the mouth and narrows towards the cod end. The upper belly is also called as baiting and it is laced together with lower belly. The cod end is the terminal part of the net with small and narrow meshes and it is made of thicker twine which finally holds the fish.

Classification of the trawl

There are several types of trawls are there based on their fabrication, fish catching mechanism and other similar features.

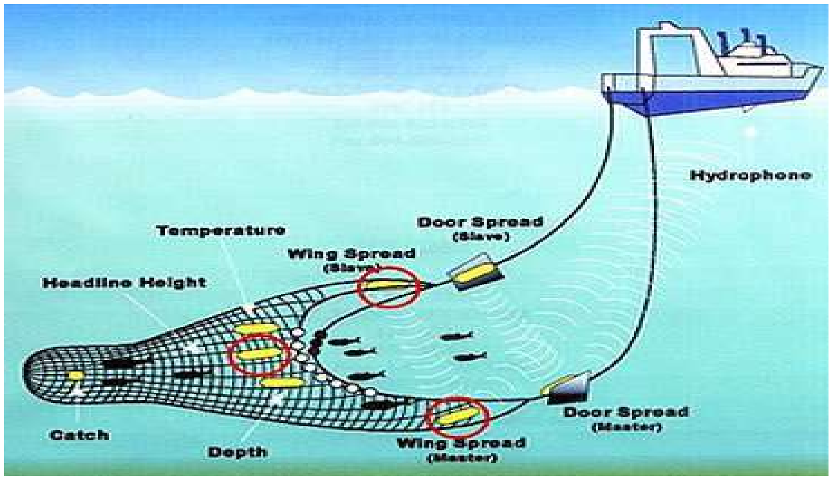
1. According to the mouth opening:
   a. Beam trawl: The net mouth is held open by a beam.
   b. Otter trawl: The net mouth is kept open horizontally by otter boards
   c. Bull trawl: The net is kept open by two boats pulling apart.

2. According to the depth of operation:
   a. Mid water trawl: Trawl is operated anywhere in the column or subsurface waters



Mid water trawl

   b. Bottom trawl: Trawl net operated or dragged over the bottom

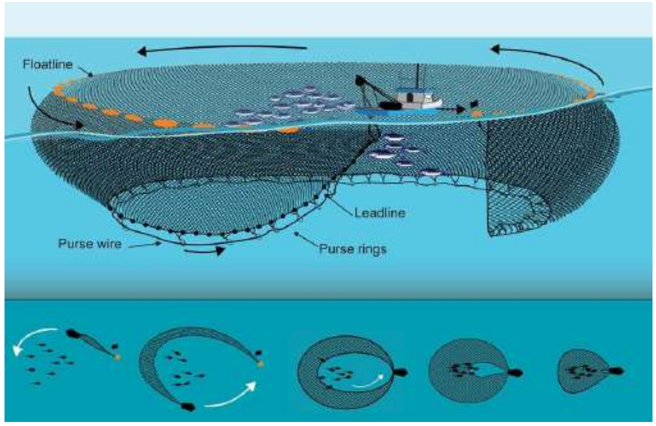


Bottom water trawl

3. According to the catch in the trawl:
   a. Shrimp trawl: Trawl net is used for catching shrimps.
   b. Fish trawl: Trawl net is used for catching fish.
5. According to the mode of operation:
   a. Side trawl: Trawl net operated from the sides of a trawler.
   b. Stern trawl: Trawl net is operated from the stern of a vessel.
6. According to the number of trawls operated from a boat:
   a. Single rig: Single trawl net operated from a boat.
   b. Double rig: Two trawl nets operated from a boat.
   c. Multi rig trawl: More than two trawls are operated simultaneously from a single boat.

Purse seining

These are comes under surrounding nets or round haul nets are long walls of webbing that surrounded a school of fish below as well from the side to prevent their escape. Purse seine is one of the most important commercial fishing methods of the world. Principle involved in this technique is surrounding a school of fish by a long wall of webbing and subsequently pulling the bottom of the net by means of a purse line. The efficiency of the purse seine got enhanced by introduction of synthetic ropes, synthetic twines and ropes, power block, improved method of fish detection by sonar, improved bulk fish handling etc.



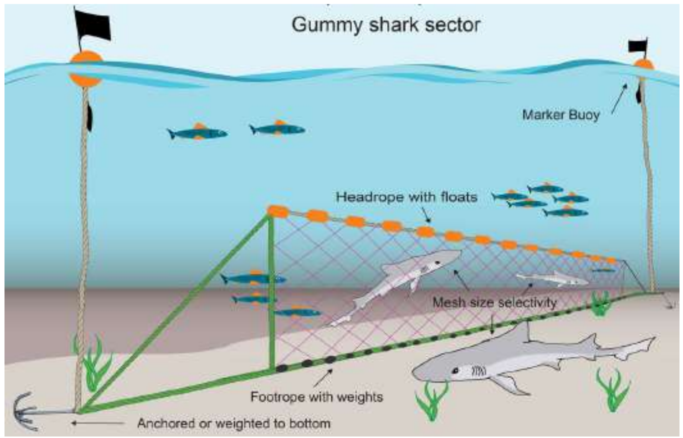
Purse seine operation

Description of the gear:

Purse seine consists of a long wall of weeping with the main body, bunt, shoulder and wing. The bunt portion is made up of a thicker twine and that is the part of the net where the catch gets accumulated. The end part of the net is called wing it is shot in size. The part of the net between the bunt and the main body is called shoulder. The upper part of the net is attached to the head rope and lower part is attached to the foot rope. There is a line called float line which carries the floats. A few rows of meshes made of thicker twine are provided at the upper, lower and sides of the webbing. These are called selvedges and are provided to take the strain. The pairs of ropes called haul in bridle are attached at the ends of the net. The ropes connecting each purse ring with the foot rope are called ring bridles.

Gill netting

Gill nets are widely used both in marine and inland water throughout the world. Gill net is highly selective fishing gear and fishes are caught by gilling because its selective nature, gill netting is one of the most suitable fish catching method from the conservation and ecological balance point of view. It is comes under passive fishing gear and it can be operated from a simple primitive craft. Commonly fishes of high economic value like seer, tuna, pomfet, lobster, mussels, salmon, sardine, mackeral are caught by this method.



Bottom set gill net

Description of the gear

It is a long wall of webbing kept suspended in water by means of floats on the head rope and sinkers on the foot rope. Size of the mesh is calculated in such a way that the fish that can only pass its head not entire body. A twine called as mounting twine attaches the webbing to the head rope and foot rope. A bigger size floats called as master floats attached to the head rope through a twine named as float line. A piece of rope is interlaced to the central part of the bridles from two arms, one is carrying a master float which is used for locating the fleet end and the other carrying master sinker which helps in setting the net.

There are several types of gill nets are available. They are classified based on method of construction, method of operation, depth of operation.

Method of construction: Simple gill nets, framed gill nets, trammel nets and combined gill nets

Method of operation: Set gill net, drift gill nets and encircling nets

Based on depth of operation: Surface gill nets, mid water gill nets and bottom gill nets. These can be either set or drift type of nets.

Use of electronics in fishing

During the time of Second World War so much of marine electronic equipment was initially developed for military use in communications, navigation and under water reconnaissance. Now this has made so much advancement in the marine fishing sector not only for fishing but also for the protection and identification of various types of endangered species. For fishing navigation and fish finding equipment’s are well developed. There are several devices in marine fishing practices among that electronic depth recorder, electronic thermometers. These can indicate water depth, bottom formations and fish locations. No wastage of fuel for boats to find the suitable fish grounds. Nets and lines can be set and hauled with greater efficiency. Rocky bottoms potentially damaging to trawls these kinds of obstacles can be detected by using this technical tool. By using this techniques fisherman can benefited in terms of economical and mechanical also.

Electric fishing is a kind of fishing in which low voltage of electric current is used to catch the fish. In this method two electrodes are put into water, anode in the fishing net and cathode near the boat. When the current is on, fish respond to it and swim toward the positive pole and are caught in large number. Even such species, which take shelter under rocks or stones and escape netting, are caught by using electric fishing. However, this method needs proper training high experience, necessary precautions must be taken while operation.

Short answer type questions:

1. Write a short note on electrical fishing?
2. Write a short note on line fishing?
3. Write a short note on classification of lines?
4. Describe trawl net in brief?
5. Describe gill net in brief?
6. Write a short note on use of electronics in fishing?

Long answer type questions:

1. Write an essay on construction, classification and operation of trawl net?
2. Write an essay on construction, classification and operation of gill net?

Unit-10

FISHERY INSTITUTIONS

Structure:

Introduction

To provide a strong base for development of fisheries in India, several research and training, promotion and regulatory institutions have been set up over the years. Two fisheries research institutes, Central Marine Fisheries Research Institute (CMFRI), Kochi and Central Inland Fisheries Research institute (CIFRI) were transferred to the Indian Council of Agricultural Research (ICAR) in October, 1967 and have since been operating continuously. In 1985, CIFRI was divided into three institutions 1. Central Inland Capture Fisheries Research Institute (CICFRI), Barrackpore 2. Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar and 3. Central Institute of Brackish water Aquaculture (CIBA), Chennai.

Central Marine Fisheries Research Institute (CMFRI), Kochi

CMFRI, Kochi

Central Marine Fisheries Research Institute (CMFRI), Kochi established by the Government of India under the Ministry of Agriculture in 1947 became a member of Indian Council of Agricultural Research (ICAR) family in 1967. Over the period, the institute has grown significantly in size, structure and research infrastructure.

Mandate:

- Assessment and monitoring of the status of the exploited and unexploited fish stocks in the Indian EEZ and evaluation of techno-socio-economics of marine fishing operations.
- Development of appropriate technologies for sea farming of finfish, shellfish, seaweeds and other cultivable marine organisms and techno-socio-economic evaluation of mariculture operation.
- Monitoring the health of the coastal ecosystems.
- Transfer of viable sea farming technologies through extension education, training and consultancy.

Central Institute of Brackish water Aquaculture (CIBA), Chennai

CIBA, Chennai

Brackish water aquaculture has been identified as one of high potential areas for increasing fish and shellfish production and for deriving maximum economic and social benefits such as better utilization of unproductive and marginally production for export and foreign exchange earnings, support to food security systems, establishment of ancillary industries, generation of employment and improving socio-economic conditions of rural poor. The headquarters of the CIBA is located in Chennai city with field and farm facilities located at Muttukadu, about 30 km south of Chennai.

Mandate:

- To conduct research for development of techno-economically viable and sustainable culture system for finfish and shell fish in brackish water.
- To act as repository of information on brackish water fishery resources with a systematic database.
- To assist the farmers in adopting new technologies in farming.
- To provide consultancy services.

Central Institute of Freshwater Aquaculture (CIFA)

CIFA, Bhubaneswar

Central Institute of Freshwater Aquaculture (CIFA) is a premier institute in freshwater aquaculture in the country under the administrative control of the ICAR, New Delhi. The present institute is had had its beginnings in the Pond culture division of Central Inland Fisheries Research Institute which was established at Cuttack, Orissa in 1949 with a view to find the solutions to problems of fish culture in ponds and village tanks. Later CIFRI has done major efforts to give emphasis to freshwater aquaculture research, initiated steps on establishment of Freshwater Aquaculture Research and Training Centre (FARTC) over 147 ha campus at Kausalyaganga, Bhubaneswar, Orissa. CIFA is also the lead center on “Carp framing in India” under Network of Aquaculture Centers in Asia-Pacific.

Mandate:

- To conduct research mainly in nutrition, physiology, genetics, pathology, pond environmental monitoring and aquaculture engineering for developing intensive and extensive warm freshwater farming systems for commercially important finfish and shellfish
- To conduct specialized training
- To act as nodal agency to provide scientific information and technology transfer for freshwater aquaculture development

Central Institute of Fisheries Education (CIFE)

CIFE, Mumbai

CIFE started its working as a Government of India setup at Mumbai on 6^{th} June, 1961 with the assistance of FAO/UDP. Later with effect from 1^{st} April 1979, the institute came under the administrative control of ICAR, New Delhi. In due recognition of its pioneering role in manpower development for fisheries sector, the Ministry of Human Resource Development HRD and UGC accorded deemed university status to CIFE on 29^{th} March, 1989. CIFE is the first deemed university in India.

Mandate:

- To conduct education and research programmes leading to post-graduate (M.F.Sc) and doctoral (Ph.D.) degrees in specialized disciplines of fisheries sciences and technology.
- To conduct capsule courses for catering to the refresher training needs of fisheries development and extension personnel.

- To conduct basic research in frontier areas of fisheries science and technology through institutional and collaborative efforts.
- Participation in sponsored projects and programmers with other institutions and agencies for fisheries research in inland, coastal and marine (both within EEZ and beyond).

Central Institute of Fisheries Nautical and Engineering Training (CIFNET)

CIFNET, Visakhapatnam

It is the only one institute of its kind in India to meet the training requirements of technical and certificated personnel such as Skippers, Mates, Engineers and Engine Drivers of power fishing vessels as stipulated in the Merchant Shipping Act. 1987. CIFNET also responsible for the development of required technical manpower for the supporting shore establishments and for effective operation of fishing vessels.

Mandates:

- To develop technical manpower.
- To conduct studies on fishing craft, fishing gears and equipments in fishing technology.

Central Institute of Fisheries Technology (CIFT)

CIFT set up in 1954 is the national center in the country where research in all disciplines relating to fishing and fish processing is undertaken. The institute started its functioning at Kochi from 1957. It is having several research centers throughout the country they are Veraval (Gujarat), Visakhapatnam (AP), Burla (Orissa), Mumbai (Maharashtra), Calicut (Kerala) and Hoshangabad (MP). It will provide the technical assistance in the handling and preservation fish, food processing etc.

Mandate:

- To evolve innovative and cost-effective technologies for fish harvest.
- To develop and standardize various aspects of post-harvest technologies with a systematic data base.
- To conduct transfer of technology through training, education and extension education programmes.
- To provide consultancy services.

CIFT, Kochi

Central Inland Capture Fisheries Research Institute (CICFRI)

The central Inland Capture Fisheries Research Institute (CIFRI) is the oldest premier research institute in the field of inland fisheries research and training in India. The institute came under the administrative control of Indian Council of Agricultural Research in October, 1967. The main objective of the Institute till 1987 (Sixth Plan) had been to conduct investigation for proper appraisal of inland fisheries resources in the country and to evolve suitable methods for their conservation and optimum utilisation. With the reorganization and strengthening of fisheries research under ICAR, the institute was renamed as CIFRI in 1987.

Directorate of Coldwater Fisheries Research (DCFR)

To conduct research in cold water fisheries, National Research Center on Coldwater Fisheries (NRCCWF) was stated as an independent centre directly under ICAR control with its temporary headquarters at Haldwani in erstwhile U.P Subsequently from May 1997 this temporary headquarters of the institute was shifted to Bhimtal about 30 km from Haldwani. NRCCWF is later upgraded as Directorate of Coldwater Fisheries Research (DCFR)

Mandate:

- To explore and asses the coldwater fishery resources in the upland areas and develop strategies for their conservation and management.

- To undertake transfer of technology through training, education and extension programmes and to provide institutional consultancy services.

Fishery Survey of India (FSI)

The Fishery Survey of India (FSI) is responsible for survey and assessment of marine fishery resources of the Indian EEZ. FSI headquarters located at Mumbai, the institute has seven operational bases at Porbandar, Mumbai, Mormugao and Kochi along the West Coast; Chennai and Visakhapatnam along the east coast and Port Blair in the Andaman and Nicobar Islands. A total of 15 ocean going survey vessels are deployed for fisheries resources survey and monitoring.

National Cooperative Development Corporation (NCDC)

NCDC started promoting and developing fishery cooperatives after its act was amended in 1974 to cover fisheries within its purview. In order to discharge these functions effectively, NCDC has formulated specific schemes and pattern of assistance for enabling the fishery cooperative to take up activities relating to production, processing, storage, marketing etc. Assistance for the following purpose is provided to fishermen cooperative on liberal terms treating the activities as weaker section programmes.

Mandates:

- Purchase of operational inputs such as fishing boats, nets and engines.
- Creation of infrastructure facilities for marketing (transport, cold- storage, retail outlets etc.).
- Establishment of processing units including ice plants, cold storage, etc.
- Development of inland fisheries, seed farms, hatcheries etc.

National Federation of Fishermen Cooperative Limited (FISHCOPFED)

It is an apex organization of fishermen cooperatives in India. It started its activities in 1982. Its goal is to facilitate the fishing industry through cooperatives. During this period, FISHCOPFED has entered into a number of activities which can be grouped into

1. Promotional
2. Welfare
3. Business

Promotional activities of FISHCOPFED include organizing conferences on various aspects, supporting training initiatives, demonstration of scientific fish culture, transfer of intermediate technology, introducing marketing techniques. It is also involved in the implementation of the centrally sponsored schemes on group accident insurance of active fishermen.

Marine Products Export Development Authority (MPEDA)

The Marine Products Export Promotion Council (MPEPC) was established with its headquarters at Ernakulum, Kerala in the early sixties to promote export of marine products. Later the Government of India introduced the special Export Promotion Scheme, which was subsequently modified as Import Policy for Registered Exporters for Fish and Fish Products. In 1965, the Govt. also brought a scheme also brought a scheme for the import of capital equipment on a priority basis by allocating special foreign exchange. The survey recommended that in the circumstances a centralised statutory agency named "The Marine Products Export Development Authority" should be set up. The Act for setting up the same was passed in the parliament and the authority was established on 16 August, 1972. There are number of ongoing subsidy assistance schemes are being implemented by the MPEDA. The schemes are

1. Export production Capture Fisheries:

   To increase the efficiency of large mechanised vessels financial assistance for installation of fish finders, global positioning system, radio telephones and fish hold on board the vessels is given to the beneficiaries.

2. Export Production Culture Fisheries:

   This scheme is exclusively to promote shrimp production Assistance in the form of subsidies is given for new shrimp farm development, small and medium size hatcheries and for Effluent Treatment Systems (ETS).

Short Answer type Questions:

1. What is the mandate of FSI?
2. What is the mandate of CICFRI?
3. What is the mandate of CIFA?
4. What is the mandate of CIBA?
5. What is the mandate of CIFT?
6. What is the mandate of CIFNET?

Long answer type questions:

1. Write an essay on CMFRI?
2. Write an essay on CIFE?

FISHERIES

Paper - III

SEED PRODUCTION TECHNOLOGY

INDEX

UNIT-1

Introduction to Seed

Structure

1.1 Introduction

1.2 Present status of Fish Seed production

1.3 Present status of Prawn and Shrimp Seed production

1.1 Introduction

The government of Andhra Pradesh has identified the fisheries sector as one of the growth engines for socio-economic development of the new state of Andhra pradesh. The vision 2029 promotes rational exploitation and utilization of the state's fishery resource in a manner consistent with the overall goal of sustainable development. Government has considered it necessary to specially undertake a fisheries policy with a view to the nature and scope of current priorities. The policy will aim to help the state in modernizing the fisheries sector by creating a state holder friendly eco-system for attracting new technology and investments. The policy promotes innovation and will ensure technology up gradation through research and development besides human resources development in the fisheries sector.

Andhra Pradesh is strategically located on the south eastern coast of India and is the natural gateway to east and south East Asia. AP has fertile river basins, extensive canal system and conductive agro climatic conditions for fishery promotion. The state has nine postal districts from Srikakulam to Nellore covers 974Kms of coastal line and is one of the largest producers of marine products. Andhra Pradesh stands first in total fish and prawn/shrimp production in India. Since 2013-14 both in terms of production and value the contribution of fisheries sector is 6.01 percent in AP's GSDP, where as the fisheries contribution is about 0.83 percent of GDP of the nation. The overall fish production has more than double in the fast one decade from 8.14lakh tons in 2005-2006 to 19.64lakh tons in 2014-1015. The share of AP in India's sea food exports has increased from about 20 percent in 2009-2010 to about 40% in 2013-2014. Andhra Pradesh has good opportunities to enhance the fisheries export and production.

1 The state has 4 fishing harbours, Visakhapatnam, Kakinada, Nizampatnam and Krishnapatnam. One major port at Visakhapatnam and 14 non major ports offering vast opportunity for exporting fish products.

2 The state has large marketing potential for fish production in urban areas within the state in other state of India. At present the national per capita fish consumption is 11Kgs. And in AP it is estimated at 7.5Kgs. The world fish consumtion is 21.0Kgs hence there is huge gap consumption which can be filled up by AP by promoting domestic market

Some challenges have been identified, which if addressed can quicken and improve the rate of the growth in fisheries in the state

- Production of good quality seed is a major challenge.
- Excessive fishing capacity causing over-fishing leading to depletion of prawn and fish fauna.
- Barring the ban period, fishing activity is undertaken almost though out the year through unsustainable fishery practices thus disturbing the life cycle of fish and prawn.
- Lakh of access to modern technology, modern fishing facilities and equipment etc….

Successful food- fish production is largely dependent on the availability of quality fish seed amongst various other factors associated with ongrowing. Difficulties in accessing adequate fish seed can therefore constrain production, business and food- fish supplies.

Deficiencies in fish seed supply within India were anticipated eleven years ago with the then level of production estimated as being able to satisfy less than half of customer and consumer demands at the time.

In early seventies, riverine spawn accounted for over 92% of total seed availability. But, in due course of time fish farmers experienced difficulty in obtaining required amount of pure 'Seed', as the number and quality seed deteriorated due to various environmental problems playing havoc with the natural aquatic habitats. Moreover, the availability of adequate quantity of 'Seed' of cultivable species is the most important prerequisite for the development of 'fish culture'.

During the last few decades efforts have been made by fishery scientists to tackle the pressing problem of acute shortage of quality of fish seed by evolving suitable methods of breeding carps in Bundhs or in fish farms purely by Induced Breeding Technology.

1.2 Present Status of Fish Seed Production

During the Sixth and Seventh Plan period, the government laid adequate emphasis on production of fish seed (major carps) to meet the growing requirement of fish farmers in the country. In the process, a number of commercial fish seed farms and hatcheries were established in the government sector. These farms and hatcheries alongwith the private enterprise (mainly restricted to West Bengal and Assam) did bring the desired results and around late eighties the country seemed to be self sufficient in meeting the seed (major carps) requirement of farmers.

From Eighth plan onwards, the government has been encouraging fish seed production in the private sector. In the process, fish seed production has increased from 9691 million fry in 1989-90 to 16589 million fry in 1999-2000 with a growth rate of 4.60% per annum. During Eighth Plan the growth rate for seed production was 5.44% per annum. However, the growth rate during the first three years of the Ninth Plan has been 2.1% per annum. This is likely to be increased by the end of the ninth plan.

India is reckoned to be self sufficient in carp seed production to support aquaculture. However, much still requires to be done in the area of fish seed production and besides production of quality fish and shrimp seed, the deficit areas needs promotion. The carp seed production infrastructure in the country is inadequate and inefficient particularly in public sector and is localized in certain states only. Diseases free and diseases resistant carp seed is to be ensured with strict quarantine measures.Brood stock maintenance is to be encouraged on the seed farms. Further technologies for raising seed of minor carps, cat fishes and cold water fish species, particularly of game fish, indigenous ornamental fishes and species for mariculture programmes are required to fill the gaps and for further promoting aquaculture through diversification. Genetic upgradation of candidate species for aquaculture through genetic selection process is an immediate necessity so that better performing fish seed stock is made available to the aquaculturists. Application of bio-technology should be given emphasis in fisheries sector, particularly in aquaculture.

Seed being the basic input into culture system, its production has been accorded priority in terms of brood stock management, establishment of hatcheries, refinement of induced breeding techniques, rearing and production of quality seeds across the country. It is estimated that a total of 17,000 million fry (Indian major carps and exotic carps) shall be produced by the end of the Ninth plan.

The target set for fish seed production for the Tenth plan for the Indian major carps and exotic carps are based on an annual (of 8%) growth rate and it is expected that about 25,000 million fry will be produced by the end of the Tenth plan (2006-07). Besides, adequate infrastructure and efforts on priority are required to produce seed of shrimp (about 20,000 million PL) and Finfish (about 150 million fry) such as Sea bass, Grey mullet, Grouper, Snapper, Chanos sp. etc.) for diversifying fisheries activities during the Tenth plan.

India is the second largest in aquaculture production in the world. Fish production has increased from 41.57 lakh tonnes (24.47 lakh tonnes for marine and 17.10 lakh tonnes for inland fisheries) in 1991-92 to 82.90 lakh tonnes (32.20 lakh tonnes for marine and 50.70 lakh tonnes for inland fisheries) in 2010-11.

1.3 Present Status of Prawn and Shrimp of Seed Production

In the context of the ever increasing demand for export of prawns, attention is being focussed on possibilities of large scale commercial culture of marine as well as freshwater prawns. Marine and freshwater species suitable for culture are widely distributed and their young ones occur in natural habitats, during certain parts of the year, in varying abundance. In brackishwater areas, the prawn seed is collected using the traditional method, where tidal water alongwith its fauna is taken in at the high tide and young ones are trapped. Though plenty of prawn seed are collected every year from its natural sources, these generally meet the seed requirements of small scale culturists only. Large scale collection of seed sometimes may not be possible, and at the same time the population is decreasing due to over exploitation. If seed is available in large quantities, prolonged storage of collected seed often results in heavy mortal. Non-uniform size and mixture of species are also problems in natural collection. Hence, prawn hatcheries are necessary for production of prawn seed in large quantities.

In India about 2.2 million ha. of Brackishwater prawn cultivable land is available. So far only 50,000 ha. of the above land is converted into prawn culture farms which was facing already scarcity of prawn seed from natural sources. For a full fledged extension of Brackishwater aquaculture in the above said total available land, the basic requirement is steady supply of young prawn larvae. The estimated prawn seed required for all the stocking available 50,000 ha. of Brackishwater area in our country (which is under culture at present) is worked out as 600 crores if prawn seed for fours crops (at a stocking density rate of 30,000/ha). The development of shrimp hatchery has most important role for intensive shrimp farming in India. Since limited numbers of shrimp seed can be obtained directly from natural resources.

As early as half a centruy ago, Hudinaga successfully shrimp and reared of Penaeus japanicus to the mysis stage (hudinaga 1955). Unforunately world war II interrupted further development for more than 10 years. It was not until thelate 1950's, that several Americans became highly interested in Penaeid hatchery work. In India also Marine hatcheris started by mid 1970's and adopted slowly by different state, central and private organisation, in different parts of the country like Narakkal (Kerala), Regional shrimp hatchery, Azicode (Kerala), Paradeep (Orissa), Okha (Gujarat), Dahanu (Maharastra), Villarpadu (MPEDA) (kerala), Madras (Tamilnadu), CIFE, Bombay and at BWFF Kakinada (A.P.) Mahabalipuram by Hindustan lever (Tamilnadu).

Status of SPF in India.

The development of SPF (Specific pathogen free) stocks is probably a viable long term solution for India. The marine product export development authority (MPEDA) has already begun efforts in SPF development. Two entrepreneurs have been permitted to import 500 SPF Litopenaeus *vannamei*, while a proposal to import 10000 P. *monodon* broodstock has been approved by the government. A consultant for transfer of technology on SPF shrimp has been identified and he has already prepared a prefeasibility report. The side for the nuclear breeding center has also been identified on the Andaman and

Nicobar Islands and hatchery facilities at the Andhra Pradesh Shrimp Seed Production and Research Center (TASPARC) and the Odissa Shrimp seed Production Supply and Research Center (OSSPARC). Presently these centers known as Rajiv Gandhi Center for Aqua Culture. Broodstock multiplication center for L.vannamei (pacific white shrimp) suppliers for seed production and supply to farmers.

Short Answer Type Questions

1. **What are opportunities for fisheries in Andhra Pradesh?**
2. **Write Andhra Pradesh state, India and World per capita fish consumption?**
3. **Name the four harbors of Andhra Pradesh?**
4. **Write any two challenges fisheries in Andhra Pradesh?**
5. **What is the present status of India and Andhra Pradesh in fish and prawn production?**
6. **How many coastal districts in Andhra Pradesh? What it's coastal length?**
7. **Expand TASSPARC and OSSPARC?**
8. **Expand RGCA? What it's function?**
9. **What are the advantages of seed production technology?**
10. **Expand MPEDA?**

UNIT 2

Life cycles of Fish, Prawn, Shrimp and Crab

Structure

2.1 Introduction

Aquaculture has great scope now-a-days. Aquaculturist should mention the good management practices. A person should know that biological aspects of aquatic organisms such as their life cycle, food, feeding, maturation, reproduction etc.

2.2 Life Cycle of Fish

Fishes are cold blooded aquatic vertebrates. Male and female are separate. Generally fishes do not show any sexual dimorphism. But at the time of maturity they attain some secondary sexual characters. Fishes generally breed during monsoon season. Female reproductive organs (female gonods) ovaries, when fishes are ripen ovaries produce ova or egg. Male fishes having a pair of testis in lower abdominal cavity ventral to the kidneys. Testis produce spermetocytes (Male gametes). The fusion of unidentical gametes called an Isogamy, as a result fertilization takes place. Generally in fishes fertilization is external, means union of gametes in water or outside the body. In some fishes internal fertilization is takes place. Example shark fishes. Mostly fishes (teleosts) or oviparous and few are viviparous (sharks). Eggs are mesolecithal and life cycle is direct means no larval stages metamorphosis into the adult.

Each fish species has a unique reproductive strategy and favors certain habitats for spawning and for early development of their newly hatched young. Many Great Lakes fish can be found in shallow water during part of their life cycle. Many species use shallow waters of lakes or rivers as spawning habitat either in the spring or fall. Some, such as northern pike, prefer wetlands with aquatic vegetation. Others such as lake whitefish prefer shallow reefs, which provide rich areas for food and rocky structure to protect the eggs and later the fry.

Fish life cycles vary among species. In general, however, fish progress through the following life cycle stages:

Eggs: Fertilized eggs develop into fish. Most eggs do not survive to maturity even under the best conditions. Threats to eggs include changes in water temperature and oxygen levels, flooding or sedimentation, predators and disease.

The number of eggs produced by a single female differs considerably and depends upon several factors like her age, size, condition and species. The egg is generally surrounded by a shell but when it leaves the ovary, it is enclosed in a vitelline membrane. Generally, the egg is spherical or oval in shape and has some amount of yolk in it. Eggs of bony fishes are of two main types.pelagic eggs are buoyant and provided with a thin, nonadhesive membrane, while demersal eggs are heavy and sink to the bottom, and are covered by a hard adhesive membrane.

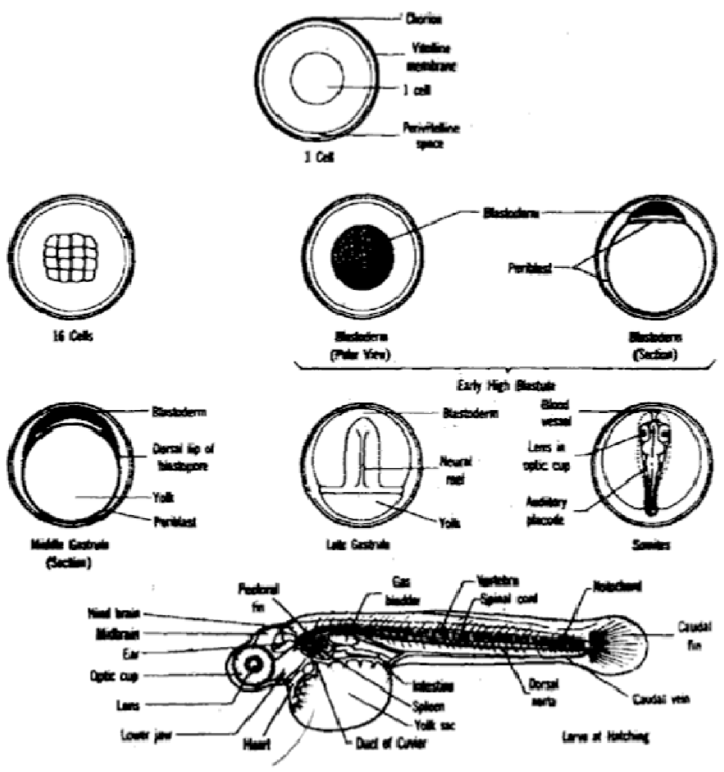


Fig. 2.1 Developmental stages of a bony fish.

Sticky, demersal eggs become attached to the debris of the bottom and are prevented from being swept away along the current of water at the time of deposition. Marine fishes produce either pelagic or demersal eggs, but the eggs of fresh water fishes are generally demersal. Pelagic eggs are of small size and single large oil globule may be present on the surface of its yolk. The eggs of some species (scomberisocidea, belonidae and exocoetide) have sticky threads for attachment with some object or with each other.

Hatchlings: After completion of embryonic development of the fish egg hatched into young once. The newly hatched young once of fish are called hatchlings. The hatchling has big head and big yolk sac. Head bears big prominent pigmented eyes. It is inertly suspended in water. It shows regaling movements mouth and anal apertures are not formed. It is transparent, internal organs easily seen externally. It need not any food up to three days because it utilizes yolk for further development.

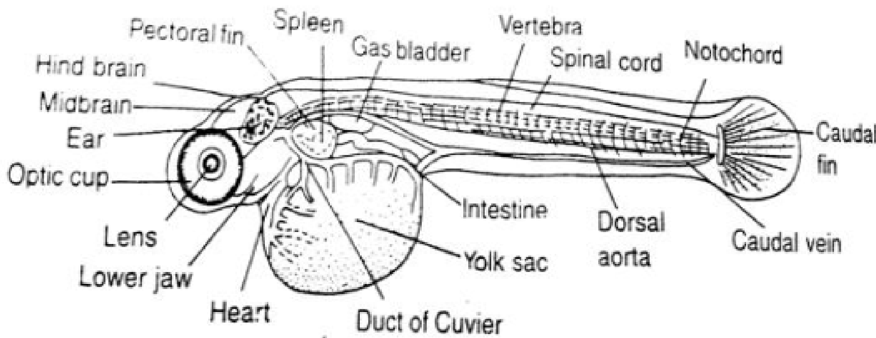


Fig 2.2 Hatchling showing various parts

Larval Fish

Larval fish live off a yolk sac attached to their bodies. When the yolk sac is fully absorbed the young fish are called fry.

Stage I: This is called prolarva with fairly large sized yolk sac. The yolk sac is broad anteriorly, tapering towards the posterior end, and has a row of Pigments on its upper part. It has a broad head, pigmented eyes, and a median continuous fold. The dorsal fin is demarcated but rays are not present in it. The caudal fin is truncate and 7-8 rudimentary rays are present in it. Anal fin is not demarcated and the pelvic fin is not yet formed. The pectoral fin is represented by a membranous flap without any rays.

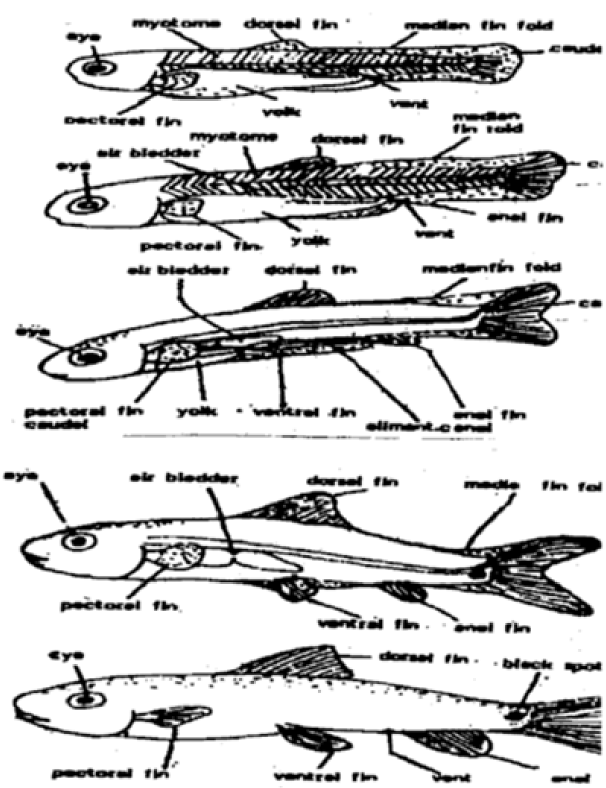


Fig 2.3 Fish larval stages

Stage II : Yolk sac is slightly reduced, and chromatophores are present on the head. Dorsal fin is further demarcated and 7-8 rudimentary rays can be seen in it. Caudal fin consists of *15-16* rays. The anal fin is slightly demarcated but rays are not seen in it. The pectoral fin does not contain rays and is still in the form of a membranous flap. The air bladder is now visible.

Stage III : The yolk sac is considerably reduced. The gape of the mouth extends backwards. The dorsal fin is almost complete with rays but is still connected with the caudal fin which is now deeply forked and contains 19 rays. The anal fin now has three rudimentary rays. A rudimentary pelvic fin can he seen as a minute bud. Pectoral fin is still without rays. Alimentary canal is now visible and chromatophores are present on the head.

Stage IV : Yolk is completely absorbed and the it resembles the adult fish. The dorsal fin is fully developed and is not connected with the caudal fin. The anal fin contains 7 rays and is still connected with caudal. Pelvic in is further developed. Pectoral fin is still without rays and a black spot is present on the caudal peduncle

Stage V : It larva is almost like the adult fish and all the fins are fully developed. Anal fin contains 9 rays and is separate from the caudal fin. Pectoral fins are well developed and contain 9-10 rays. Black spot on the caudalpeduncle and the chromatophores on the back of the larva are more prominent.

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Fry

Fry are ready to start eating on their own. Fry undergo several more developmental stages, which vary by species, as they mature into adults. Young fish are generally considered fry during their first few months (during their first few months to less than one year in some species).

Juvenile

The time fish spend developing from fry into reproductively mature adults varies among species. Most fish do not survive to become adults. Threats to survival include fluctuations in water temperature, changes in oxygen levels, Competition for habitat, and predators.

Adult: When fishes are able to reproduce, they are considered adults. The time it takes to reach maturity various among species and individual fish. With a shorter life spans reach maturity faster. For example, female round gobies mature in approximately one year and life for two to three years. Lake sturgeon can live from 80-150 years, but female don't reach maturity until they are approximately 25 years old.

Maturation and Spawning

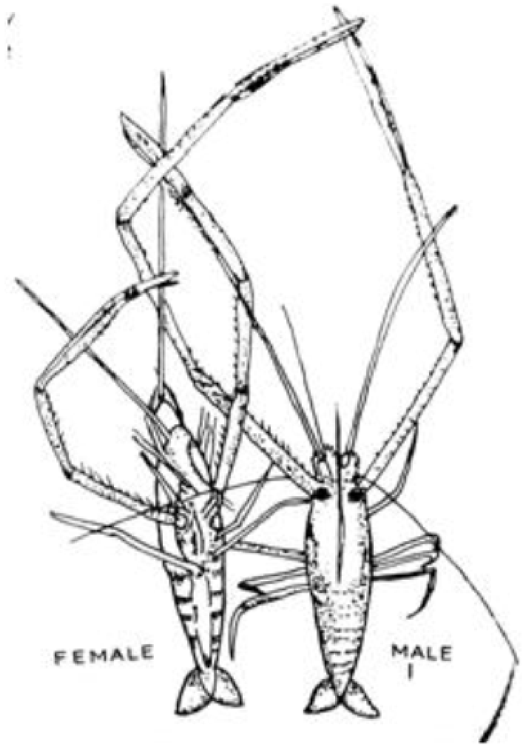
Both male and female gonads undergo marked cyclic morphological and histological changes before reaching fun maturity and becoming ripe. This is called maturation of the gonads. Most of the fishes exhibit seasonal cycle in the production of gametes. The expulsion of gametes from the body into the surrounding water is called 'spawning resulting in fertilization'. Fish spawns during a specified period which depends upon several factors. The period during which the gonads attain full maturity and spawning takes place in the population is called the breeding season of the species. After spawning, a new crop of germ cell is formed, which gradually mature to become ready for the next season.

2.3 Life cycle of Prawn

Introduction:

Fresh water prawn belongs to phylum arthropoda class crustacia. They are the sexes are separate (dioecious) and sexual dimorphism is weel marked. Male is bigger than size then female. In male base of thoracic legs more closely approximated than in female. In male second chelate legs are longer, stronger and more spiny than in female. In male paired genital openings lie on the coxae of 5^{th} pair legs while they lie on the coxae of 3^{rd} pair of legs in female. They are euryhaline they can tolerate higher changes in salinity of water.

Although freshwater prawns require brackish water in the initial stages, most of their lifecycle is spent in turbid, riverine systems. They are not cold tolerant so production in northern climates can be limited.



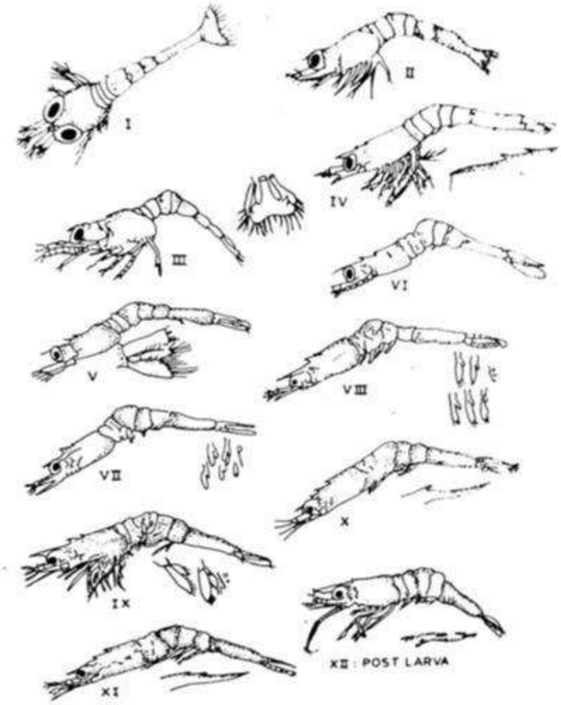


Fig. 2.5 Larva stages I - XII of M. rosenbergii

Adult male and female M. rosenbergii

Freshwater prawns have a hard outer shell that must be shed regularly in order to grow. This process is called "molting". Because of these periodic molts, growth occurs in increments, rather than continuously. This results in four distinct phases in the life cycle; egg, larvae, postlarvae, and adult.

Females become sexually mature before six months of age. Mating occurs only between hard-shelled males and ripe females that have just completed their pre-mating molt and are soft-shelled. Within a few hours after mating, eggs are laid and transferred to the underside of the tail where they are kept aerated and cleaned. Although first spawns are often not more than 5,000 to 20,000 eggs per female, mature females have been reported to lay between 80,000 to 100,000 eggs during one spawning. The eggs remain attached to the abdomen until they hatch. The bright-yellow to orange color of newly spawned eggs gradually changes to orange, then brown, and finally to grey-black. At 82º F, eggs hatch 20 - 21 days after spawning
.

I. Egg **II. Larva** **III. Post Larva**

Fig. 2.6 Life cycle of M. rosenbergii

After hatching, larvae are released and swim upside down and tail first. Although larvae can survive for 48 hours in freshwater, they must be transferred to brackish water (9 to 19 parts per thousand) for optimum survival. Larvae undergo 11 molts over a period of 15 to 40 days before transforming into postlarvae. The rate of this transformation depends upon food quantity and ~~quality, temper~~at ure, and other water quality variables. Larvae feed primarily on zooplankton and larval stages of aquatic invertebrates. See larger chart of the larvae stages

At this point, the prawns resemble small adult prawns, about 0.3 to 0.4 inch long and 50,000 to 76,000 per pound. They change to principally bottom dwelling, crawling individuals. Postlarvae can tolerate a range of salinities. The postlarvae prawn's diet expands considerably and they may become cannibalistic under conditions of food limitation. Although no standard definition exists, the term juvenile is used to describe the freshwater prawn between postlarvae and adult.

2.4 Shrimp Life Cycle

Introduction: Commercially important edible marine prawn are called shrimps. It belongs to phylum Arthropoda class – crustacia order Decapoda. Shrimps are nocturnal and omnivorous in nature. Sexes are separate. When they attain sexual maturity they show sexual dimorphism. On ventral side of the male shrimp between first pair of pleopods a copulatory organ is present called petasma which useful in insemination female shrimp. Ventral side of the female shrimp fifth pair of walking legs bilobed structure is called theylucum. This receives spermatocytes from male shrimp during mating period. After coupulation female shrimp migrate towards shallow water. After some period inseminated female shrimps ready to spawn. Male shrimps are mature earlier than the female ones. The phenomenon is called protrandrous. Mature inseminated in female released eggs iinto water along with spematocytes which are stored in the theylycum during the mating period.

Thus external fertilization is takes place in shrimps.

1. Eggs : Shrimp eggs are thought to sink to the bottom at the time of spawning. Egg diameter is less than 1/64 in. Most spawning is believed to occur in high salinity oceanic waters.

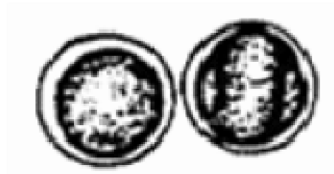


Fig. 2.7 Eggs

2. Nauplius : There are five naupliar stages. The first stage is about the size of the egg and succeeding stages are slightly larger. Nauplii have limited swimming ability and usually are a part of the oceanic plankton.Nauplinds is the first

larval form of shrimp. It hatches out of the egg sheel in about 1-14 hours after spawnning, depending upon the temperature and environmental conditions. It is a free swimming larvae and it swims with the help of its birmous appendages. They get the desired nutrition from the yolk in the body. Hence it does not required any feed. The nauplius has six substages and the body length vaires from 0.32 to 0.50 mm. The number of stylets on the second antennae varies from 5 to 11 and caudal stylets vary from 2 to 14. In the late nauplius stage the rudimentary cephalothoracic carapace forms with two groups of 7 spines each. the duration of the nauplius stage lasts for 36-96 hours.6 substages of nauplius are found in P. monodon P. Indica.

Fig. 2.8 Nauplius

3. Protozoea : The three protozoeal stages range in size from 1/25 to 1/12 in. These planktonic forms are found in oceanic waters. Protozoea have undergone development of their mouth parts and the abdomen has begun to develop. It is the second larval form of shrimp. The nauplius after the sixth moult forms the protozoae. The larvae swim by flexing the joined appendages. Protozoea has three stages. It has large cephalothorax with an anterior rostrum, two prominent stalked compounds eyes, well developed.

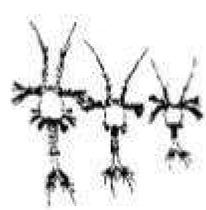


Fig. 2.9 Protozoea

Cephlic and anterior thoracic appendages, rudimentary posterior thoracic appendages and a long abdomen with a forked etlson. The first stage, the eyes are simple and sessile, body is distinct as the head and tail. Third cthoracic segment a very long body is found and segmented upto the 9th thoracic segment. In the second stage, the compounds eyes are found and are protruded. At the centre of the anterior maring of the carapace a protrusion appears.

Five abdominal segments are prominent. In the third stage, dorso mdian spines and

uropod development appear. The 6th abdominal segment is very long and the caudal segments develop with caudal appendages. Feeding starts from the first stage. During the intial stages it feeds on minute pytoplananokton. The durection of protozoea stages I-III is about 38-90 hours, depending upon the temperature and food. They fed with unicellular Algae like, chaetoceros, skeletonema, chlorella.

4. Mysis : There are three mysid stages ranging in size from 1/8 to 1/5 in. These are planktonic in the ocean. Mysids have early development of legs and antennae. After the third moult of protozoea, the mini prawn/Mysis larva/ schizopod larva is developed. The head and thorax fuse completely to form the cephalothorax. The carapace extends upto the eighth thoracic segment. It has biramous appendages on all the thoracic segments and a long abdomen with five pairs of pleopods and a pair of uropods. It has 3 stages. In Mysis stage-I the pleopods are not developed. Pleopod buds appear in stage-II and fully formed pleopods with segments are seen in stage-III. The body is bent at the junction of thorax and the abdomen and the walking legs move rapidly up and down. The larvae swim backwards. The duraction of mysis stage is about 118-207 hours. It developds into the post-larval stage after 3 months of the mysis stage. they fed on zooplankton like nauplia of artemia, moina etc…

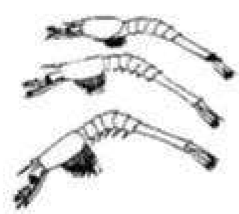


Fig. 2.10 Mysis

5. Postlarva : The two postlarval stages for white shrimp are about 1/6 to 1/4 in. Brown shrimp postlarvae are larger, up to 1/2 in. The walking and swimming legs have developed and the postlarvae appear as miniature shrimp. The second postlarval stage rides the flood tides into the estuaries, apparently becoming active during flood tide and settling to the bottom during ebb tides. The postlarvae ultimately settle in the upper parts of tidal creeks

'a

6. Juvenile : Postlarval shrimp develop directly into juvenile shrimp. Growth is rapid, up to 2 1/2 in. per month. Juveniles are similar to adults except they are characterized by a much longer rostrum (horn). Juveniles typically remain in the marsh creeks until reaching about 4 to 4 1/2 in. before moving into the deeper rivers.

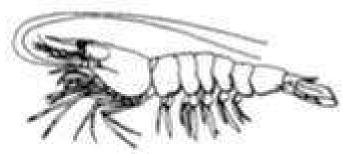
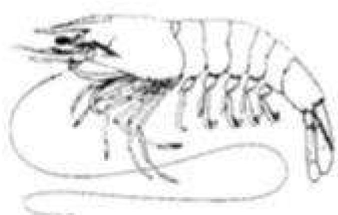


Fig. 2.12 Juvenile

7. Sub-adults : Sub-adults move into the deeper waters of the estuaries and may remain there for a month or more before moving seaward. These shrimp continue to grow but at a slower rate than juveniles. Sub-adults usually do not exhibit any signs of ovarian maturity. They feed on both veg and non vegetarian food materials.



8. Adults : Adults may be 5 to 8 inches in length. Adults are usually found in the ocean, but in dry years may delay migration until cold weather occurs. Spawning females are characterized by brightly colored ovaries that can be seen under the shell on the upper side of the body. Adults may be found near the beaches out to 5 or 6 miles from shore. Some species are known to migrate hundreds of miles along the coast.

Fig. 2.14 Adult

2.5 Life Cycle of Crab

The crabs' breeding timetable is fixed around the phases of the moon. Spawning (the dropping of their eggs into the sea) must occur before sunrise on spring tides during the last quarter of the moon, regardless of any other factor. The timing of spawning is the only certain and predictable part of the whole migration; all other stages of the migration will vary with the prevailing weather.

The crabs will start their migration if there is enough time for them to complete their downward migration, mate and develop eggs before the next suitable spawning date.

The red crab breeding migration comprises a series of separate actions on the crabs' part that follow on from one to the other in a programmed sequence. These separate actions in combination make up the breeding migration and one action will not occur unless the preceding action is accomplished. If there isn't enough time for them to be able to do all of these things before the next spawning opportunity, they will delay the start of their migration and attempt to meet the following month's spawning date.

The first action that occurs is movement of crabs to the sea. The largest mass movement of crabs takes place in this first downward migration. Males farthest inland start this movement and are progressively joined by more and more crabs (both males and females) as the movement progresses toward the sea.

When the crabs arrive at the shoreline, they dip in the sea to replenish body moisture and salts. The male and female crabs then move back on to the shore terraces where the males dig burrows for mating. Mating takes place and then the males again dip in the sea and then they will start their return migration.

The females remain behind in the mating burrows to brood their eggs. This takes a couple of weeks. A day or two before the spawning date the females emerge from the breeding burrows with ripened eggs and move to the shoreline where they again dip in the sea and then retreat to shade.

Before the turn of the high tide and just before dawn the females will again move to the waterline and around the turn of the tide they will drop their eggs into the sea. After they have jettisoned their eggs the females commence their return migration.

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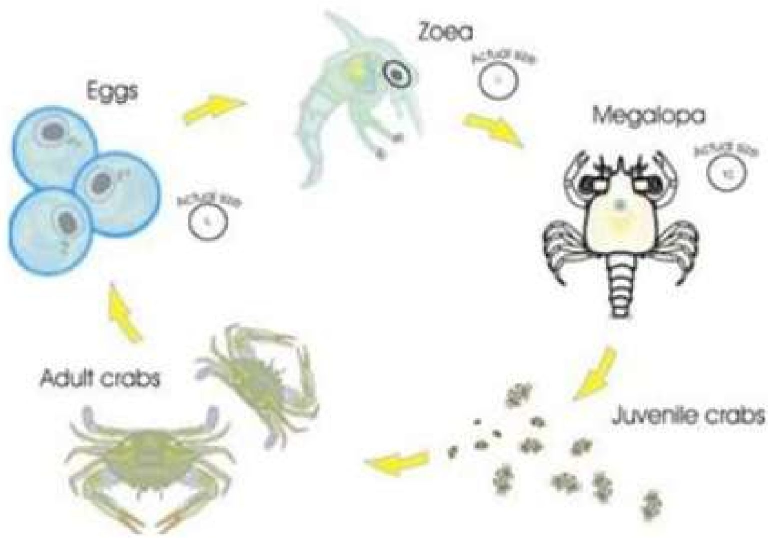
The next phase of the breeding migration takes place in the sea. The eggs that the females drop into the sea hatch immediately into larvae. They grow through several larval stages into tiny prawn-like animals called megalops. After about four weeks the megalops emerge from the sea and they moult into baby crabs. The baby crabs then move inland and settle at suitable localities. The successful emergence of baby crabs is unpredictable but is incredible when large numbers emerge. Some years very few, or none, emerge. After about 4 years growth crabs will take part in the breeding migrations and the life cycle continues.



If the rains stop or peter out, the crabs will delay the start of their migration, or, if they have started migrating, they will stop moving and stay wherever they are until the rains begin again. It is rare that substantial rains will begin early enough in the year for a spawn during the last lunar quarter in October - but it has happened! Spawning in November or December are the more usual, which means that rain must commence in the preceding month and continue.

All phases of the crabs' breeding migration involve colossal numbers of crabs and usually occur all over the island. If the rains continue, there is usually a second, and sometimes even a third, smaller, downward migration by crabs that did not join in the first migration. When this happens it is possible to see crabs on return journeys mingling with the crabs on their downward migration. It can become confusing for all concerned! We are sorry that we can not be more explicit about the timing of the start of the red crab migrations, but the weather as you know cannot be accurately predicted.

The best advice we can give is to be at Christmas Island during the last quarter of the moon in either November or December for the best chance of seeing something interesting happe ning in the annual red crab migration. If you are able to arrive earlier and to stay longer the more parts of the migration sequence you will be able to experience.

Short Answer Type Questions

1. What is external fertilization?
2. What type of eggs are found in fishes?
3. Write the difference between pelagic and demersal eggs of fish?
4. Define hatchling?
5. Draw the labeled diagram of fish hatchling.
6. What is moulting?
7. Define thelycum and petasma in shrimp?
8. Write the main larval stages of shrimp?
9. Define 'Protrandrous' give an example.
10. What is Megalopa?

Long Answer Type Questions

1. Describe the life cycle of fish with the help of neat labelled diagram.
2. Write an essay on life cycle of fresh water prawn?
3. Explain the different stages present in life cycle of shrimp?
4. Describe the life cycle of crab

UNIT 3

Seed resources in India

Structure

3.1 Introduction

3.2 Freshwater fish seed resources

3.3 Shrimp seed resources

3.1 Introduction

India is the sixth largest producer of fish in the world (6.41 million tonnes) and second in world aquaculture production (2.22 million tonnes). About 95 percent of India's aquaculture production comes from inland aquaculture. Of late, inland fish production has surpassed marine fish production. India produces about 17,000 million fry annually. Fry and finger ling size of the fish stages are treated as seed in aquaculture.

Among the different states, West Bengal is ranked first in inland fish production as well as fish seed production (8,400 million fry). Indian freshwater aquaculture is based mainly on polyculture of Indian major carps, such as catla, rohu and mrigal and three exotic carps, namely, silver carp, grass carp and common carp. Fish seed destined for aquaculture are obtained from three sources, i.e. rivers, bundhs and hatcheries. During the period from 1964 to 1965, 92 percent of the country's fish seed were obtained from rivers, while in the 1980s, bundhs contributed to 63 percent of the total seed source.Rivers are traditional sources of fish seed for aquaculture. The Ganga River system is the largest river system and is the home to Indian major carps.Fertilized egg eggs

spawn, fry and fingerlings constitute riverine seed. Spawn/fry collection is undertaken in few States. Among coldwater fish seed resources, trouts (exotic) and mahseers are found in the Himalayan region and the Peninsular Indian rivers that originate in the Western Ghats.

Presently, hatcheries account for 95 percent of seed source. A steady increase infish seed production from the 1980s can be attributed to the use of Chinese type carp hatchery technology and the application of ready-to-use spawning agents. There are more than 420 carp hatcheries, producing about 34 292 million spawns (17,000 million fry). The Chinese type carp hatchery is most widely used, followed by the jar hatchery.

The traditional method of transportation of fish seed is the open system, which uses earthen/aluminium/galvanized iron or tin containers for seed transportation. The closed method of transportation of fish seed in plastic bags with oxygen and water is more widespread. Broodfish are transported in open FRP tanks/plastic pools/tarpaulins mounted in trucks. Hatchery production of sterile common carp fry is now receiving increased attention.

(i) riverine collection

(ii) bundh breeding and

(iii) hatcheries (through induced breeding).

In addition to these sources, common carp seed produced without hormone injection, was initially included as the fourth source and was accordingly categorized as ‘common carp breeding’ until 1964 –1965. Since then, the data of the common carp seed is included with that of the other carps produced through induced breeding.

Over the years, the hypophysation technique has been standardized and refined, new broodstock diet developed, spawning agents (alternative to pituitary) used successfully, new breeding and hatching devices evolved and better larval rearing techniques developed. However, there still remains a big gap between seed production and requirement. At present, the lion’s share of India’s fish seed production comes from hatcheries. India now produces about 17 000 million fish fry which is much less than the demand.

3.2 Freshwater Fish Seed Resources

a. Riverine Fish Seed Resources

The freshwater fish resources of India (Table 7.11.3) are found mainly in five major river systems, i.e. (i) the Ganga, (ii) the Brahmaputra and (iii) the Indus in the North, (iv) the Peninsular East Coast and (v) the West Coast River in the South (Figure 7.11.3) (Jhingran, 1991).

The Ganga River System

The Ganga River system has a total length of about 8,047 km and is among the largest river systems in the world. It harbors the richest freshwater fish fauna of India ranging from the cultivable Gangetic (major) carps to mahseers and other coldwater fishes of the Himalayas, the hilsa (a clupeid) catfishes and a wide array of other fishes of considerable commercial importance.

The Brahmaputra River system

The Brahmaputra River system, with a combined length of 4,023 km has a rich fauna in its upper stretches, but without much economic value. However, its middle and lower stretches have several species of carps, catfishes, the anadramous hilsa and other air breathing fish.

The Indus River system

The Indus River system, though massive as a whole, covers only a small part of northwest India, harboring the exotic rainbow and brown trouts in the upper reaches and a variety of indigenous carps and catfishes in the lower sections. The trout streams of Kashmir constitute one of the world's richest sport fishing waters attracting anglers and tourists all over the world.

The East Coast River system

The East Coast River system in peninsular India is rather a composite system of rivers, the main constituents of which are the Mahanadi, the Godavari, the Krishna and the Cauvery, with a combined length of about 6,437 km. The Mahanadi has all the Indian major carps common with the Ganga system. The other rivers, besides their own indigenous fish fauna of several carp species, catfishes, murrels, prawns, etc. have had their water enriched by repeated transplantation of the Gangetic carps from the north. The transplants have established themselves and contributed significantly to the current fish fauna of these rivers. The tributaries of the Cauvery from the Nilgris have coldwater fishes like trout.

The West Coast River system

The West Coast River system in the south drains the narrow belt of Peninsular India, west of Western Ghats and includes the basins of the Narmada and the Tapti which are rich in fauna. The other rivers that originate in the Western Ghats possess carps, catfishes, mahseers, murrels, perches, prawns, etc.

b. Reservoir fish seed resources

Information on India's reservoir fish seed resources is scanty. The reservoirs in Uttar Pradesh and Madhya Pradesh, by virtue of their being connected with the Ganga River system have natural stocks of major carps. But in view of the large volume of water impounded by them, the original stocks are being supplemented through regular stocking with major carp fingerlings. The reservoirs across other basins, however, do not have natural stocks of major carps.

Hence, major carp fingerlings produced elsewhere are brought and released in these reservoirs. Several schemes were formulated for the construction of fish seed farms at reservoir sites to facilitate effective stocking operations. In most cases, where they were constructed, they did not function successfully due to poor soil quality (high porosity).

The population of predatory and weed fishes dominated the catches of many reservoirs, thus reservoir stocking with desirable varieties of fish proved to be not fruitful. However, in many instances fish breed either in the reservoirs or in tributaries or streams which eventually drain into the rivers or reservoirs, leading to natural stocking of reservoirs.

Seed Resources/Supply

Until the late 1970s, riverine seed collection was the main source of seed of IMC for aquaculture contributing to 91.67 percent of the total fish seed production during 1964–1965. Bundhs (a special type of tanks where riverine conditions are simulated during monsoon and carps bred) accounted for a major portion of fish seed from the 1960s through to the 1980s. With the advent of the technique of induced breeding of IMC by Chaudhuri and Alikunhi (1957) and exotic carps by Alikunhi, Sukumaran and Parameshwaran (1963a) through hypophysation, it became possible to obtain quality seed of major carps for aquaculture.

This resulted in an increased reliance on induced breeding for obtaining quality fish seed. During 2002–2003, induced breeding accounted for most of the seed produced in the country (Figure 7.11.6), with bundhs and rivers contributing to nearly 5 percent. Inspite of the intensive collection of carp spawn and fry in certain sections of rivers, a regular survey of such resources had not been made prior to 1964–1965, except for a few cases. The Central Inland Fisheries Research Institute (CIFRI) located at Barrackpore, Kolkata (formerly Calcutta), helped in locating new carp seed collection centres from 1949 through to 1957. In 1964, CIFRI initiated, in 1964, a pioneering programme on seed prompting investigations in various river systems with a view to assess the the following:

(i) quality and quantity of fish seed, availability

(ii) gears used for spawn collection

(iii) methods of collection

(iv) measurement of fish seed

(v) factors responsiblefor fluctuation in seed availability and other aspects on an all-India basis.

The diverse geographical and climatic conditions of India are reflected in the riverine resources of the country. The most significant difference in the rivers of the north and those of peninsular India lies in the greater abundance of the IMC in the former and their poor availability in the latter which naturally has a bearing on the production of quality fish seed and its potential in the two regions. The riverine fish spawning grounds are generally located in the middle reaches of rivers. Of all the river systems, the Ganga is the richest in terms of carp seed resources.

3.3 Shrimp Seed Resources

Shrimp farming has received the greatest attention of all forms of mariculture. Starting in the early 1970s, shrimp farming expanded rapidly and is still expanding with a steady increase in production tonnage. Seed supply is the most important initial requirement of shrimp farming; however, this issue did not receive much attention until severe shortages in wild seed supply were experienced. Most of the world's wild stock of shrimp is now overexploited, which has led to strong reliance of shrimp farms on the wild shrimp seeds.

Shrimp fry collection has also been reported as a major cause of the steady decline in the coastal fisheries resources and, consequently, shrimp fry fishery has become an important concern too. Hatchery production of shrimp seeds started in 1980s and has been a potential alternative of wild shrimp seed. While precise data do not exist globally, a reasonable estimate would suggest that 65–75% of all post-larvae (PL) used by shrimp farms at present are produced in hatcheries.

However, in the absence of effective effluent treatment facilities, shrimp hatcheries are likely to produce high loads in effluents, discharged ultimately into the coastal waters. The present paper reviews the environmental issues related to wild shrimp seed collection and, given the absence of sufficient data from field observation, discusses the possibility of environmental impacts resulting from mass production of shrimp seeds in hatcheries.

Shrimp seed supply from the wild

Although artificially produced shrimp PL provides the major source of shrimp seeds, shrimp farms still depend on wild source in many areas. However, the target species, the tiger shrimp, P. monodon constitutes only a very small portion of the total catch. Consequently, huge mortality and loss of other species have been reported for every single P. monodon PL collected from the wild. Primavera (1998) reported an estimated loss of 475 juvenile shrimp in Malaysia, 15–330 in Philippines, and 47–999 in India for every single PL.

Artificial seed production

Hatcheries have shown the most rapid growth of any ancillary economic activities related to shrimp farming because hatcheries are believed to be able to develop socalled 'pathogen-free'', and also because hatchery PL are reported to produce a better growth and survival over wild fry. Hatcheries utilize a combination of live feeds, such as microalgae and brine shrimp nauplii (Artemia). The principal algal species employed are Skeletonema, Chaetoceros, Tetraselmis, Chlorella, Brachionus and Isochrysis.

Along with the addition of supplemental formulated diets, high density (3.5–5 · 106 cells/l) pure culture of algae particularly diatoms is a common practice to ensure continuous supply of live foods; artificial diets are used for broodstock. Considerable amounts of wastes accumulate in the tanks because of higher feed loss (30% or higher) and higher FCR (2.0 or higher) (Boyd and Clay, 1998). The excess nutrients stimulate growth of phytoplankton, which eventually die, sink and decompose on the bottom of the ponds, consuming large amounts of oxygen in the process. Gr€aslund et al. (2003) listed as many as 290 chemical and biological substances presently in use in shrimp systems; the major groups are treatment compounds, fertilizers, pesticides and disinfectants, antibiotics, probiotics, immunostimulants, vitamins, and feed additives.

All of these groups are in use also in hatcheries (Juarez and Fegan, 2001; DeWalt etal., 2002) despite the fact that many of them have not been scientifically proven to have a positive effect o n production. Sara and Erik (2001) reported that a wide variety of chemicals and biological products are used in Asian shrimp farming including hatcheries. They recommended reducing the use of chemicals and biological products because of the risks to the environment, human health and to production.

Some chemicals used in shrimp farming, such as organotin compounds, copper compounds, and other compounds with a high affinity to sediments leave persistent, toxic residues, and are likely to have a negative impact on the environment. The potential impacts of chemical and biological products were

discussed among others by Sara and Erik (2001) and Gr€aslund et al. (2003). Hatchery facilities are generally built using cement cisterns or other concrete materials and are engineered to achieve a high degree of water exchange, often as high as 100–200%. Unlike earthen ponds where a major part of the wastes and chemicals are consumed and trapped, many wastes in hatchery systems are discharged with effluent waters through the outlet channels which usually open into nearby drainage systems or rivers. Juarez and Fegan (2001), in a survey of 36 shrimp hatcheries in the Western Hemisphere, reported daily discharge quantities of 50–2000 m3 from hatcheries with shrimp PL production ranging 10–100 million PL/month, depending on the size of the hatchery. Most hatcheries in their report did not have facilities for monitoring chemical composition of their discharges. With no published data on the waste loads produced by shrimp hatcheries throughout the world, the Indian Association of Shrimp Hatcheries (personal communication) reported a high degree of effluent loadings in shrimp hatcheries, Varin et al. (1998) isolated 45 strains of marine bacteria from larval black tiger shrimp, brine shrimp nauplii and rearing seawater in Thailand.

Short Answer Type Questions

1. Define the term ‘seed’ in aquaculture.
2. Name any three sources of fish seed.
3. Write the different stages of fish seed.
4. Name the riverine fish seed resources present in India.
5. What algal species used as live feed in shrimp hatchery.
6. What is the need of hatchery?
7. What are the disadvantages of wild spawn?
8. What are the advantages of artificial seed production.

Long Answer Type Questions

1. Describe the Riverine fish seed resources in India.
2. Explain the different shrimp seed resources.

UNIT 4

Seed Procurement

Structure

4.1 Introduction to Seed Procurement

Fish seed is the most important component for fish culture. The freshwater resources of our country for fish culture are estimated to be 2.85 million hectares of pond and tanks. In addition to this, another 2.05 million hectares of water area is available in the form of reservoirs or lakes. It has been estimated that nearly 14250 million fry would be required for stocking even the present available cultivable resources of 2.85 million hectares on a conservative stocking rate of 5000 fry/ha. The present production is 15007 million fry. Apart from this, at least an additional quantity of 4100 million fry are required for stocking the available area of lakes and reservoirs with an average stocking rate of 2000 fry/ha. This indicates that there is a necessity to raise the fry to stock the available water resources. The fish seed is obtained from 3 sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat. The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

4.2 Seed procurement from Natural Seed Resources

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.India has five major river systems (Fig. 2.1). These are : Ganga river system, Brahmaputra river system, The Indus river system, East coast river system and West coast river system.

Indian Major Riverine Systems

The Ganga river system

River Ganga covers the states of Haryana, Delhi, Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal. The length of the Ganga river system is 8,047 km. It is the largest river and contains the richest freshwater fish fauna in India. The fish eggs are collected from the breeding grounds and downstream. Eggs are collected from 1-2' deep water by disturbing the bottom and scooping them with a gamcha.The collection of spawn on a commercial scale is prevalent in these states alone contributing 51.9% of the country’s total production. The major carp spawn is available from May to September. The melting snow is responsible for floods and bring the carp spawn. The first appearance of spawn in India occurs in the Kosi followed by the main Ganga, Gomati and its other western tributaries. Billions of carp fry and fingerlings are caught in north Bihar from July to October.

The Brahmaputra river system

It is found in the states of Assam, Nagaland, Tripura and comprises the fast flowing river, which distribute the commercially important major carps. Length of this river system is 4,023 km. The north-bank tributaries of Brahmaputra are comparatively large with steep shallow-braided channels of coarse sandy beds and carry heavy silt charge, while the south-bank are comparatively deep.

The seed collection is made in this fast-flowing river with steep banks by fixing two long bamboo poles near the banks with a boat tied on to them across the current. The percentage of major carps are poor. The northern Gauhati centre investigated in 1969 revealed only rohu content of 9.58%. The river, being torrential and flashy due to steep gradients of its tributaries, changes its current pattern very rapidly, hence, the carp seed is less and difficult to collect.

The Indus river system

It is rather rich when compared to the Brahmaputra river. The Beas and the Sutlej and their tributaries cover the states of Himachal Pradesh, Punjab and Haryana. There is no commercial fishery for major carps in Himachal Pradesh, with the upper reaches having cold water forms. Punjab is a good source for carp fishery. Length of Indus river system is 6,471 km.

East coast river system

The rivers flow towards the east into the Bay of Bengal. It comprises the Mahanadi, Godavari, Krishna and Cauvery river systems. The length of east coast river system is 6,437 km.Mahanadi is the largest river of Orissa and the state's only major source of fish seed. The river mainly harbours the hill stream fishes from its origin upto Sambalpur. Large number of spawn collection centres are identified between Sambalpur and Cuttack. Godavari and Krishna river system is the largest of the east coast river system, found in Maharashtra and Andhra Pradesh. No spawn collection centres exist in Godavari river in Maharashtra. The delta regions of these rivers are very abundant in fishes, but the percentage of major carp spawn is only 20.3% in the Godavari at Rajamundry. The upper regions of the Cauvery, being fast-flowing and sufficiently cool, are unsuitable for carp fishery, the middle and lower reaches harbour a fairly good fishery of major carps.

West coast river system.

The major rivers of the west coast are Narmada and Tapati, which are found in Madhya Pradesh, Maharashtra and Gujarat. Length of the river system is 3,380 km. The upper stretches of the rivers being rocky and unproductive, are not suitable for seed collection. The remaining parts are good for seed collection. The major estuarine systems of India are the Hoogly-Matlah estuary of river Ganga, Mahanadi in Orissa, the Godavari-Krishna in Andhra Pradesh, the Cauvery in Tamil Nadu and the Narmada and the Tapati in Gujarat.

The important brackishwater lakes of the country are the Chilka in Orissa, the Pulicat in Tamil Nadu and the Vembanad in Kerala. The common feature in the estuaries is the occurrence of horse shoe shaped sand bars at river mouths. Estuaries receive freshwater during the south-west monsoon months, from July to October. All the estuaries are good sources of freshwater and brackishwater fish and prawns.

Lakes and Reservoirs

Naturally formed lakes and man-made reservoirs constitute great potential fishery resources of India. Lakes and reservoirs are estimated to have an area of about 2.05 million ha. in our country. Important lakes in India are Chilka, Pulicat, Ooty, Kodaikanal, Nainital, Logtak lakes, etc. Important large reservoirs in India are Nagarjunasagar, Nizamsagar, Gandhisagar, Shivajisagar, Tungabhadra, Krishanarajasagar, Hirakud, Beas , Govind sagar, Ramapratapsagar, Bhavanisagar, Matatila, Rihand, Kangasabati, etc.

4.3 Collection of Seed from Natural Resources

Availability of fish seed in large quantities is a primary requisite to develop fish culture in India. Indian major carps Catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhina mrigala) are preferred for cultivation in freshwater ponds and tanks throughout the country. Natural habitat of these Indian major carps is rivers,and there original spawning grounds are the flooded rivers. Since a long time traditional methods of collection of carp spawn and fry from those natural resources were built up, particularly in Bengal, which soon spread to other states of eastern India. Fish sed trade even today depends on this resource in few places. With a view to providing scientific basis, seed prospecting investigations were initiated in various river systems of in India.

Attempts wer made to standardise the spawn collection nets, to evolve methods of collection and to ascertain factors responsible for fluctuations in the availability of fish seed in relation to time and place.

Site Selection for Seed Collection

A pre-monsoon survey is conducted to ascertain the topography of the terrain and bank features at and in the vicinity of a site to determine the extent of operational area. The topography of dry beds and bank features to gauge the likely current pattern of the river at different stages of flooding. The distribution and composition of the fish fauna in the selected stretch of the river, resident or immigrant, for assessing the abundance of major carps during the monsoon season. The location of tributaries, rivulets and canals along with their main river, as they might constitute important connecting links between the river and breeding grounds. The identity and accessibility of the site. The bends and curves of various shapes in the river course often show a precipitous, fast eroding bank on one side called erosion zone and a flat, gently sloping bank exactly opposite called shadow zone (Fig. 2.2). These banks are not useful for spawn collection. Best seed collection sites lie on the side of the sloping bank but at the spot the current force the seed to the sides by centrifugal force. These spots are best to operate nets to collect large amounts of spawn.

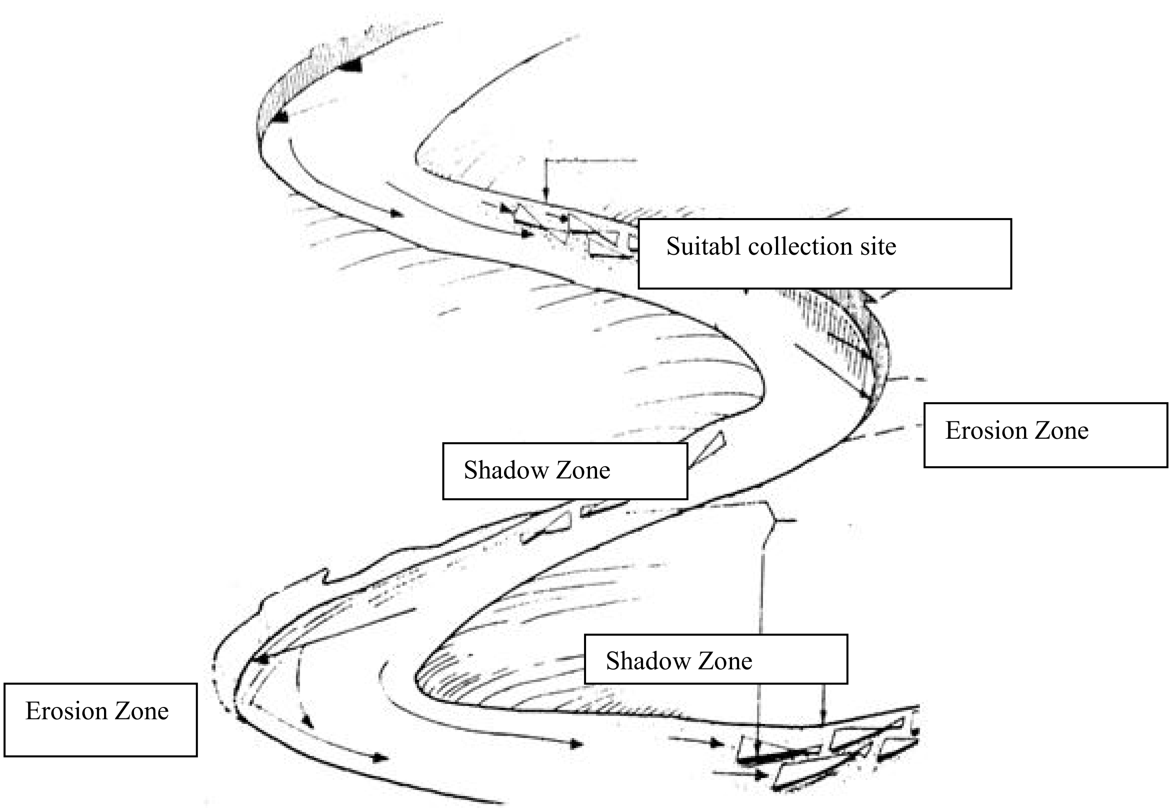


Fig 4.1 A diagrammatic riverine course showing suitable and suitable sites for spawn collection

Methods of Seed Collection

Generally shooting nets are used to collect the seed in the rivers. A shooting net is a funnel-shaped net of finely woven netting, and is fixed with the mouth of the net facing the current. It is operated in the shallow margins of a flooded river. At the tail end of the net, there is a stitched - inring of split bamboo or cane, and to this is attached, during the operation, a receptacle, termed the gamcha. A gamcha is a rectangular open piece of cloth. The seed moving along with the marginal current collects in the gamcha, and is stored in hapas or containers after removal.

Benchi jal is used to collect the seed in Bengal. **Midnapur net** is also used in Bengal, especially in the south-western parts, to collect the seed. The shooting net (Fig. 4.2) is fixed in line with the water current direction. The bamboo poles are fixed firmly at the selected site and the net is fixed to bamboo poles. Two bamboo poles are fixed near the mouth and other two poles are fixed at tail ring. The anterior end of gamcha is then tied round the tail ring. The gamcha is fixed in position with the help of two more bamboo poles. In order to select the spot of maximum availability of spawn within a specified stretch of the river concerned, a number of trial nets are simultaneously operated at a number of suitable spots. After selecting the spot, the operation is started with full battery of nets. Once it is done, the collection from the tail piece of each net is scooped one after the other in quick succession every 15 minutes or depending upon the intensity of spawn. The contents of the gamcha are then scooped immediately in to a container half filled with river water. The collection is then passed through a mosquito netting sieve so that the unwanted organisms and non floating debris can be removed. The spawn are measured and kept in hapas for conditioning, then transported to fish farms and stocked in nurseries.

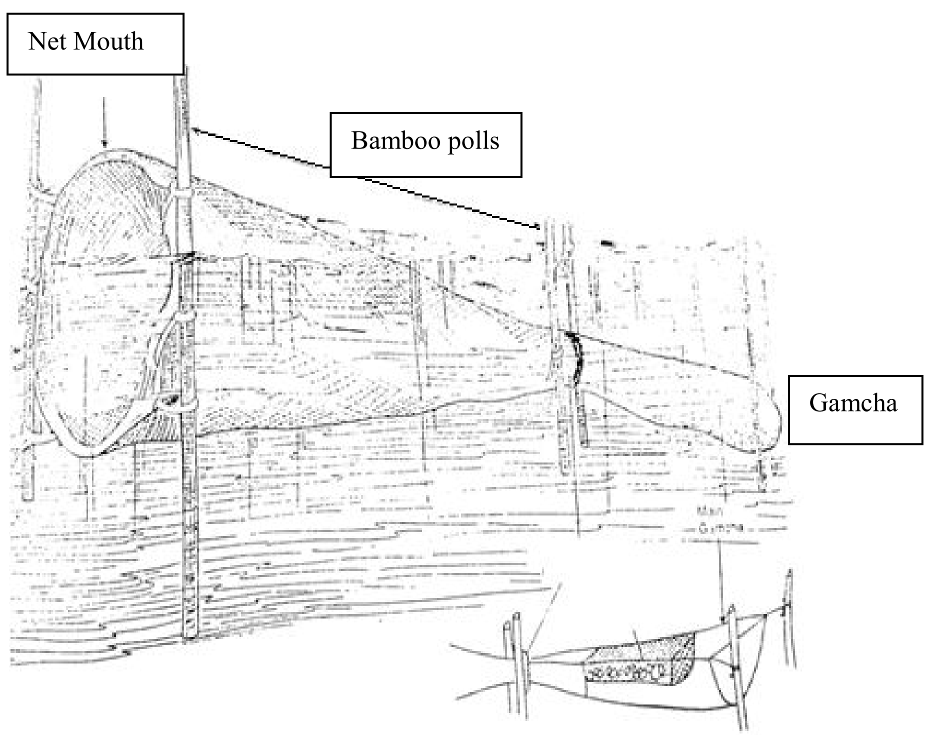


Fig. 4.2 Shooting net

4.4 Factors Effecting Seed Collection

Floods and water currend play an important role in the collection of seed.

Flood

Floods show positive correlation with spawn. There may be three or more floods in a season. The pattern of flood is that the water first rises, then recedes. After few days again a second flood is caused and so on. Carps breed during floods in the rivers. In the first flood of the season the spawn of undesirable species is available. The major carp seed is available in subsequent floods. In between the floods the catches of major carp seed are less. The availability of spawn are linked with zthe floods. In the receding phase of the floods results in the draining of spawn out of the breeding grounds down the river. Spawn is available both during day and night ; more seed is found in night catches.

Water Current

There is no effect on spawn when the water current is mild (0.086 km/hr). No significant effect is seen on spawn upto 0.4 km/hr water velocity. With increased water velocity all the spawn is carried away down the stream. The slow and gentle current velocity varying from 0.5-3 km/hr is the best to collect the spawn. While faster currents of the mid-stream carry little spawn, low velocities of less than 1 km/hr are unfavourable for spawn catch. In deeper parts of the river, the spawn is not available due to non-generation of floods.

Other Factors

There is no effect of turbidity, pH and dissolved oxygen on spawn availability in the rivers. However, turbidity is associated with floods, and determines the efficiency of spawn collection. The turbidity reduces the mesh size of the net, and it is better to clean the nets at regular intervals. Air and water temperatures never show any effect on the spawn availability.

The optimal temperature is 28-31^{o}C. Overcast conditions with breeze and with or without drizzle is found ideal for spawn collection. The stormy weather is totally unfavourable for spawn collection due to disorder currents and waves and the uprooting of shooting nets. Light also does not show any effect on spawn collection. The occurrence of plankton have no connection with the availability of spawn or its abundance in rivers. Spawn associations found abundant from the onset of monsoon dwindle thereafter to almost nil at the end of the season.

4.5 Identification of Eggs, Spawn, Fry and Fingerlings of Culturable Fishes in India

In order to avoid wastage of precious rearing space, identification and segregation of different species from a mixed collection of fish seed should be accorded utmost importance. An exhaustive account on the egg and larval (spawn, fry and fingerlings) stages of carps, catfishes, murrels, mullets, cichlids, featherbacks and other fishes has been given by Jhingran (1991).

Egg : The eggs of IMC and medium carps are non-adhesive, while those of catfishes (e.g. *Notopterus* and *Mastocembelus*) are adhesive. The eggs of murrels and *Anabas* are identified by their floating nature (Jhingran, 1991). The colour of eggs is used as a reliable criterion for the identification of species.

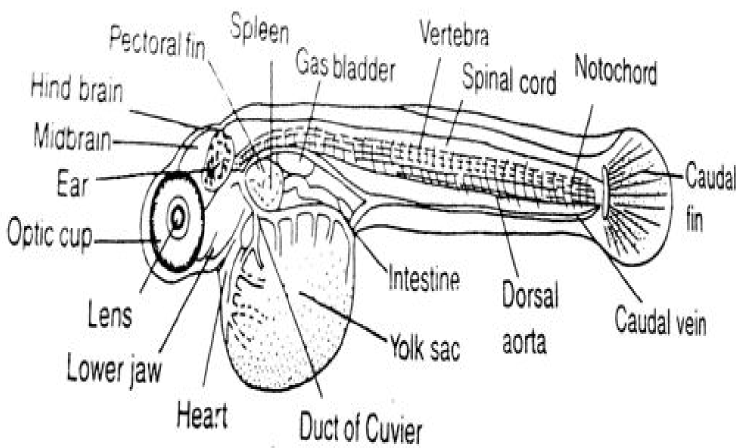


Fig 4.4 The Hatchings or Prolarvae showing various parts

Spawn: It is difficult to identify major carps at spawn stage as the spawn of medium and minor carps also have similarity with the former. However, a mixed collection of fish seed can be categorized as desirable and undesirable spawn. If the length of spawn is more than 5 mm when yolk sac is completely absorbed, it is considered a desirable spawn wherein the IMC account for more than 10 percent of the total spawn.

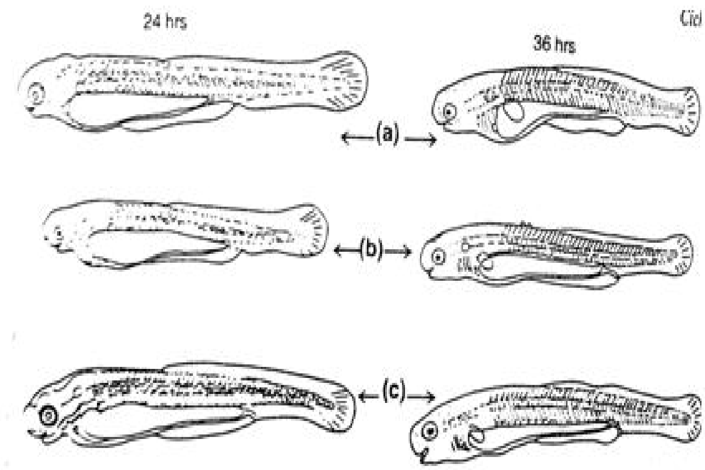
The spawn is regarded as undesirable if the length is less than 5 mm when yolk sac is completely absorbed. The undesirable spawn have less than 10 percent IMC. On the other hand, it is relatively easy to identify IMC at fry stage based on the number of dorsal fin rays and morphological characters.

Fry (14-25 mm): The carp fry can be distinguished from that of catfishes and murrels by the number of dorsal fin rays as follows:

(a) Major carps: number of undivided dorsal fin rays >11

(b) Minor carps: number of undivided dorsal fin rays 11 or <11

(c) Catfishes and murrels: pigmented (either black, brown or orange)



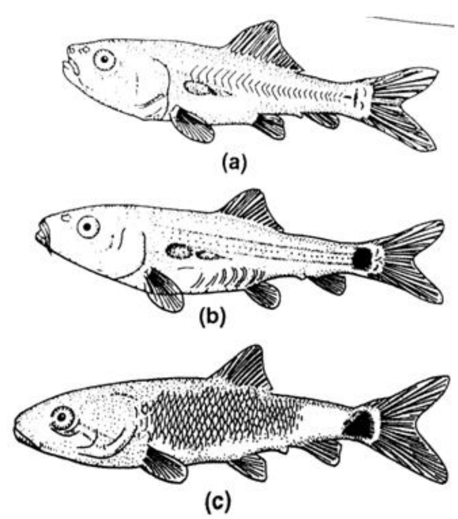


Fig. 4.5 Larva of Catla, Rohu and Mrigal

Fig. 4.6 (a) Catla, (b) Rohu (c) Mrigal

Keys to identify Species/Group

Catla : Large head; no distinct spot on caudal peduncle, opercular region brightly reddish

Rohu : A dark spot present on caudal peduncle; a pair of barbels present; lips fringed.

Mrigal : Small head and slender body; a triangular dark spot on caudal peduncle; no barbels, lips thin, not fringed.

Common carp: Eyes prominent; no reddish glow on operculum; deep body; 2 pairs of barbells; no prominent spot on caudal peduncle

Silver carp: small scales and eyes; lower jaw upturned; fins dark

Grass carp: body elongated; head broad with short. round snout; no barbells; body dark grey above and silvery on the belly

Catfish fry: head large; thin body; large barbells; scaleless body and movement wriggling

Murrel fry: orange/ brownish; move in shoals near the surface of water

8.5 Seed Transportation

Transportation of breeders, fry and fingerling is a common phenomenon in fish culture systems. The fish seed are transported from hatchery units to the fish farm to rear them in culture systems. The breeders are usually transported from culture system to hatchery units for breeding either by induced breeding or naturally. The fish seed is also transported from natural collection centres to the fish farm. Hence, transportation of fish seed is an important step in the fish culture practices. Now-a-days, there is anawareness for taking up fish culture almost throughout the country, whether it is freshwater or brackish water, due to non-availability of fish seed at the place where it is required.

Reasons for Fish Mortality during Transportation

Effect of CO and Dissolved Oxygen

Mortality of fish seed may be expected during transportation. It is mainly due to the depletion of dissolved oxygen and accumulation of gases like ammonia and carbon dioxide in the medium of fish seed carriers. These gases are lethal as they may reduce the oxygen carrying capacity of fish blood. However, the lethal limits owing to carbon dioxide in fish depends on the level of dissolved oxygen. It has been reported that fry of more than 40 mm in size may die at 15 ppm of carbon dioxide at a dissolved oxygen level of less than 1 ppm. Such fry may die only at 200 ppm, if the dissolved oxygen is around 2 ppm. Carbon dioxide given out during respiration dissolves in water and renders it more and more acidic which is injurious to fish. In transport of fish the shortage of oxygen has to be tackled either by replenishing the oxygen which is used up or by economising its use by regulating the number of fish seed and by reducing its oxygen demand. The oxygen utilisation of fish in transport is dependent upon a number of factors like the condition of the fish - normal, active and excited condition of fish, temperature, size and species. The oxygen consumption of different species of the same size or weight varies considerably. For example, 400 common carp

fingerlings of 40-50 mm size can be transported for two days in seven litres of water under oxygen packing. Only half of the number of other major carps and 1/8 of number of milk fish fingerlings of the same size can be transported under same conditions. Low to moderate temperatures are preferred for fish transport, since the amount of oxygen in water increases with the decrease of temperature and keeps the fish less active. Increase of CO2 depresses the active metabolic rate. Further increase proves fatal. In oxygen packed closed system CO2 forms a limiting factor. Mortality of seed in such a system is mainly due to bacterial load in the medium. With the death of a few seed, bacteria increase enormously and utilise more oxygen. Bacteria increase from 250/ml in the beginning to over 110 million/ml in 24 hours. CO2 is found toxic to seed at 2.5-5 ppm concentration.

Effect of Ammonia

A large amount of NH3 is excreted by fishes. If ammonia concentration is 20 ppm, total mortality of fish occurrs in oxygen packed packets. As NH3 increases in water, the oxygen content of blood decreases and its CO2 content increases. NH3 interferes with O_2-CO_2 exchange capacity of blood with the outside medium. The rate of NH3 excretion increases 10 times with a rise in water temperature from 8- 15^0C. Increase in water temperature and decrease of dissolved oxygen reduce the tolerance of fish to NH3.

Effect of temperature

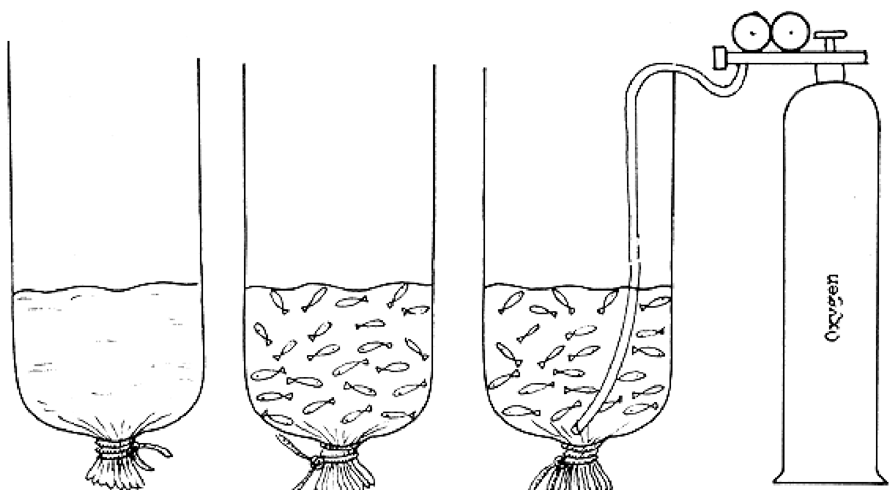
Temperature has a distinct effect on oxygen utilised by the fish. Metabolism increases continuously with increased temperature till the attainment of lethal temperature limit. Each species displays its own characteristic rate of increase at a given range of temperature.

Fish, prawn and their seed face hyperactivity during transportation. As a result, lactic acid tends to accumulate in their tissues and severe oxygen debts are created. Fish take a long time to overcome this oxygen debt even in their natural life in ponds and other habitats. This may be due to the death of fish after few hours after handling, transport and liberation even in oxygen-rich water. Hence, the use of sedatives is most important in modern live-fish transport technology. Due to hyperactivity the bigger fish often suffer injuries which may cause death or severe external infection. If the fish and their seed are of different sizes, the smaller ones are very much affected and die. This risk may be avoided by selecting for transport fish of uniform size, and by sedating the fish.

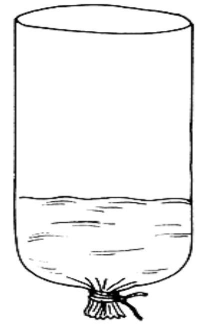
By taking the above factors in to account, suitable steps are to be taken in tackling these problems and deciding the number of individuals to be put in the containers depending upon the time and duration of transport. The fish seed to be transported is kept under conditioning so that their bellies are empty and excretion during transport is limited. Further, the conditioning will help in acclimatizing the fish to limited space in the containers. If the fish is brought directly from the pond into the container it is very active and hits to the sides of the container thus getting injured. The transport medium, water, should be filtered through a plankton net so as to make it free from phytoplankton and zooplankton which are present in the water and consume some oxygen themselves.

Techniques of Transport

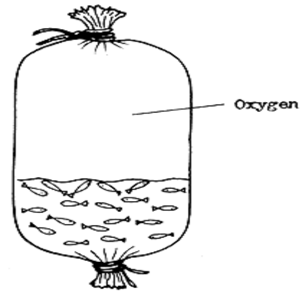
Several types of containers are used in the transport of fish seed. These are mud pots, round tin carriers, double tin carriers, oxygen tin carriers and tanks fitted on lorries. The containers are transported by bicycles, carts, rickshaws, boats, lorries, trains and aeroplanes.



(1) 5–6 l of clean water (2) Put recommended number of young fish (3) Hold oxygen pipe at the bottom



Plastic bag with water



Bag with baby fish

Mudpots

Mudpots are commonly used in Assam, West Bengal and Orissa for transporting spawn, fry and fingerlings. This is a traditional method. Mud pots of about 15 litres capacity are used for transportation of fish seed. The pots are filled with water of spawning ground to about two thirds of their capacity. After filling the pot with water, about 50,000 spawn are introduced. It is better to condition the spawn in the hapas for about three days without feeding prior to transportation. Otherwise, due to feeding more excreta is produced which pollutes the water in the pot, leading to the death of fish seed. To avoid the mortality of fish seed due to asphyxiation, water is changed once in every five hours. The temperature of water in mudpots is not affected easily, which is an advantage in transport. This method, however, has several drawbacks, such as, the mudpots are liable to break in transit, which may result in the loss of the seed. Fish seed may be injured due to the shaking of pots.

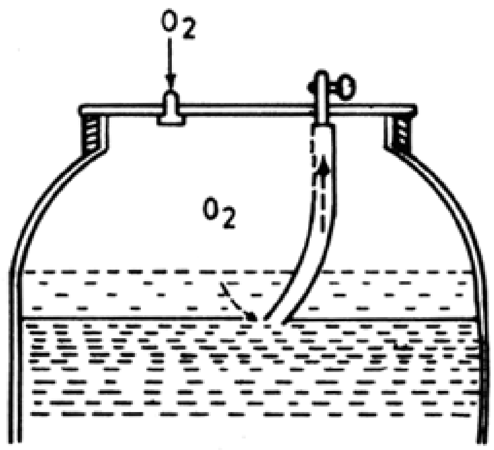
Possible for transportation only for short distances and short durations. Frequent changes of water may result in mortality of fish seed due to difference in water quality. Considering these factors modern methods of transportation have now been propounded.

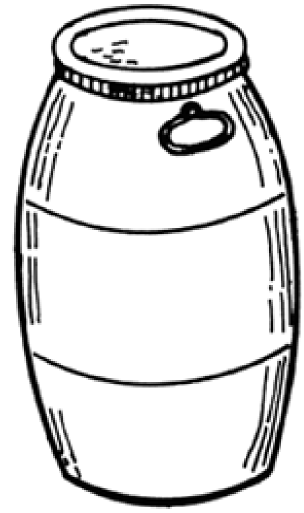
Round Tin Carriers

Round tin carriers are used for transport of fish seed from several years. The tin is made up of galvanised iron sheet. It is a round container having a diameter of 18" and height 8". The lid has a number of small holes, which are useful to get oxygen. This container has a capacity of gallons of water, but is filled up only with 8 gallons of water. The seed is introduced into it and transported to various places.

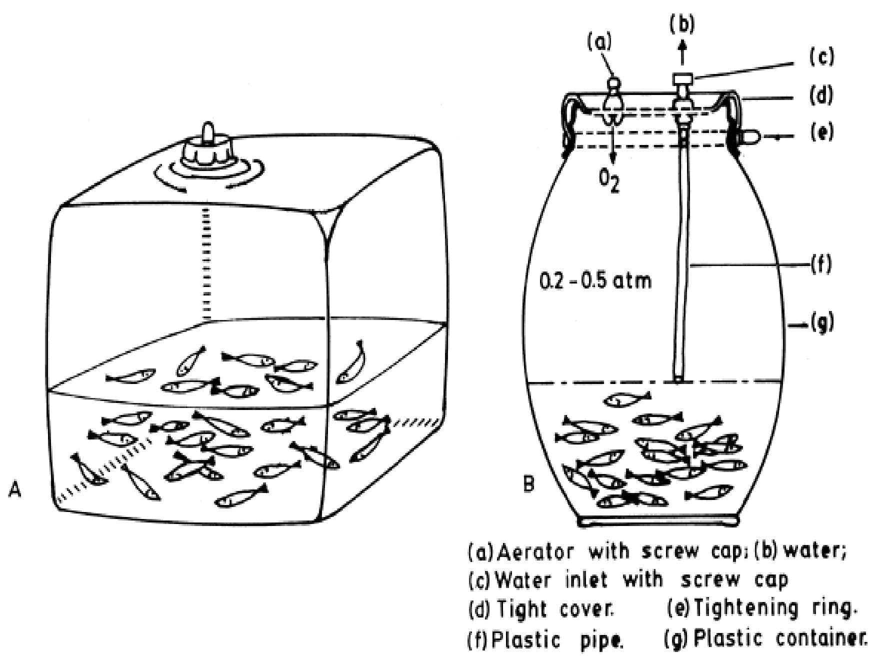
Double tin carriers

Double tin carriers are made up of galvanised iron and has two parts - outer and inner tins. The outer tin is 13" x 13" x 8" and the inner one is slightly smaller than outer one and can be easily kept inside the outer tin. The outer tin is open and with a handle. The inner tin is closed with a lid and entire tin has small openings. The inner tin is filled with water after keeping it in the outer tin, then fish seed is introduced into it. It holds about 6 gallons of water and is generally





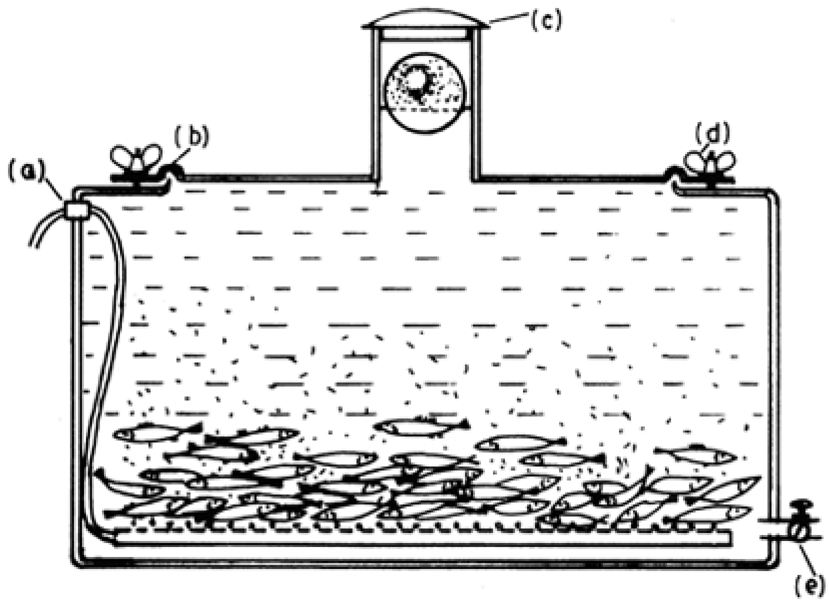
used for carrying a small number of fish seed by hand.



Oxygen tin carriers

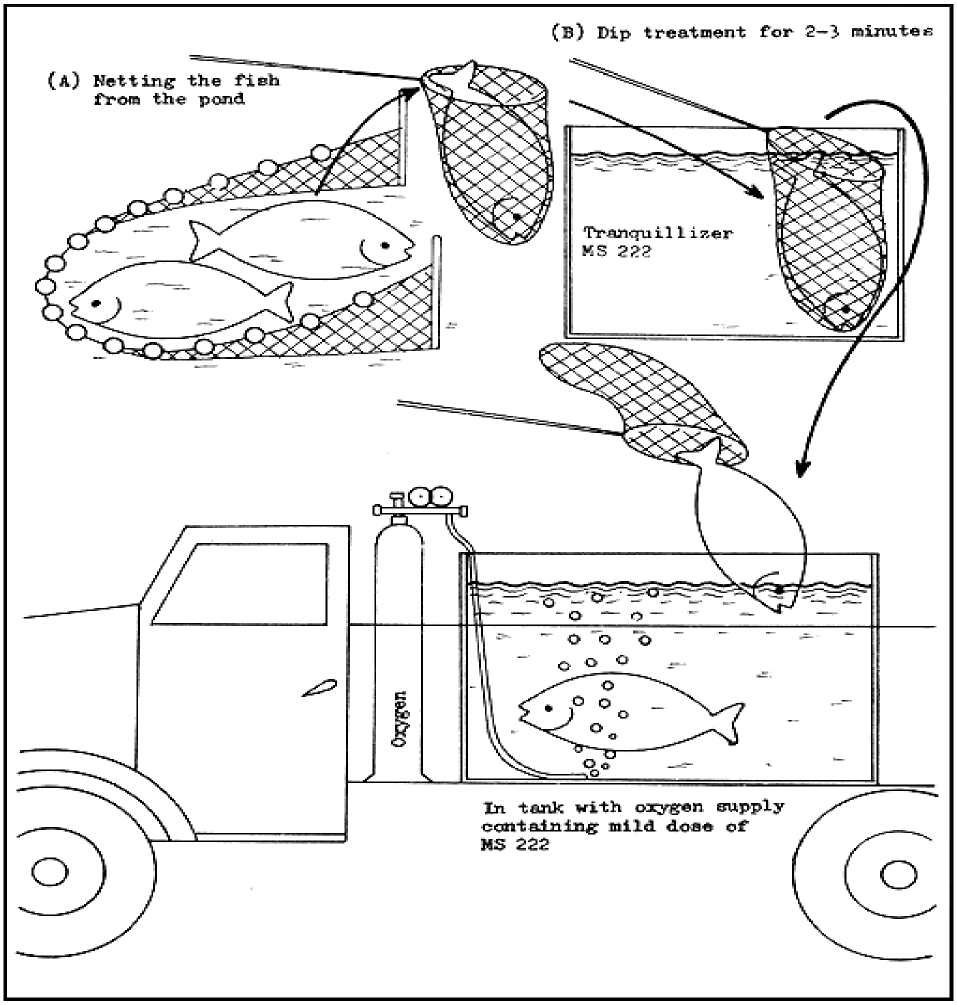
Tins of 18" x 28" size and big polythene bags of 17" x15" size are used in this method. In this technique, fish seed are transported by road, train and air. The polythene bags are filled with water, seed and oxygen and packed in the tin, then transported. This is the most common method of fish seed transportation and the latest in technique of transporting the fish seed. After checking the damage, the good polythene bags are kept in a tin container and about 1/3 of its capacity is filled with aerated pond water.

The fish seed, starved for one day and acclimatized are then carefully introduced into the bag. 20,000 fry can withstand packing in one bag for a journey of 12 hours. Similarly 200 fingerlings in one bag can withstand a journey of 12 hours. The number of fish seed to be packed



a Aeration device b Rubber joint
c Removable cover d Tightening screw
e Outlet valve.

in a bag has to be decided depending on the distance and size of the seed. A tube from the oxygen cylinder is then allowed into the bag and the portion of the bag, about 10 cm from the top is twisted and a string is kept ready for tying. The oxygen is then drawn in from the cylinder through the tube until 2/3 of the bag is inflated or the top of the inflated bag is slightly below the top of the tin. The string is tied round and the tin is closed. The packed tins are kept in a cool place. To ensure better survival rate, the tins should be transported during the morning or evening. Card board containers are used in place of tin containers.



Tanks Fitted on Lorries

For road transport lorries with one or two large tanks of suitable dimensions fitted at the rear can be advantageously used. This will facilitate seed transport problem to a large extent.

Use of Anesthetics in Transportation

Recent investigations have shown that the fish seed could be anesthetised for transportation for ensuring better survival rate. The purpose of this is to ensure that the fish seed survives for a longer period of time, and also to minimise the concentration of toxic gases like ammonia and carbon dioxide in the medium by lowering the metabolic rate of the fish seed. Anesthetised fish seed have been found to survive for double the time of unanesthetised seed, besides ensuring a better survival rate, which is about 90%. Carbonic acid has been found to be the best anesthetic compared to others such as quinaldine, sodium amytal, urathane, veronal chloroabutanal and TMS-222 (Tricaine Methan Sulphonate). Carbonic acid is not only cheap but also safe and easy to use. To about 8 litres of water in bag containing fry, 8 ml of 7%, sodium bicarbonate solution and 8 ml of 4% sulphuric acid are added so as to produce 500 ppm concentration of carbonic acid. This anesthetised bag should be immediately filled with oxygen.

Absorbants are added to the medium during transportation to eliminate toxic ammonia from the medium and safeguard the fish seed from mortality. These absorbants are permutit, synthetic amerlite resin, pulverised earth and clinoptilolite. Addition of sodium phosphate, which acts as a buffer, at a rate of 2 gm/lit. of the medium may bring about a favourable pH of the medium for fish seed during transit. Due to the non-availability of some anesthetics and the risk involved in the improper use by laymen, the method has remained at the level of a scientist only.

Estimation of Quantity of Fish Seed for Transportation

The number of fish seed to be transported in closed and oxygen packed containers may vary according to the type and size of the fish seed, mode of transport, duration of transport and the environmental temperature, etc. The number of fish seed for transportation in containerscan be calculated using the following formula

(D -2) x V

N = R x H

Where : D is dissolved oxygen in ambient water in ppm.

V is volume of water in litres.

R is the rate of oxygen consumption by individual fish seed in mg/kg/hr.

H is period of transportation in hours.

N is number of seed to be introduced.

Short Answer Type Questions

1. Name the major river systems present in India?
2. What rites are suitable for Fish seed collection from the river?
3. Draw the labelled diagram of shooting net?
4. Name any two main factors which effecting natural seed collection?
5. What is gamcha?
6. Write any two reasons for fish seed mortality during transportation?
7. What is the use of anesthesia in fish seed transportation?
8. Write the effect of temperature during the fish seed transportation?
9. Define the term conditioning used during transportation of fish seed?
10. Write the formula of estimation of quantity of seed for transportation.

Long Answer Type Questions

1. Describe the major Riverine system found in India?
2. Write an essay on fish seed collection from natural resources?
3. Describe the factors effecting the fish seed collection from natural resources?
4. Describe the reasons for fish seed mortality during transportation?
5. Describe the methods of fish seed transportation?

UNIT 5

Induced Breeding Technology

Structure

5.1 Introduction

Carps breed in flowing waters like rivers. Naturally they never breed in confined waters. The seed collected from natural resources is generally a mixed stock with both desirable and undesirable varieties. Separation of desirable seed from mixed stock is a big problem. Due to the handling, the desirable varieties may die. If any predaceous fish seed is found, they injure desirable fish seed. Another big problem is never get required number in natural collection. Availability of pure seed is very difficult. To overcome all these problems induced breeding is an excellent technique to get pure and required fish seed. It has several advantages.

With induced breeding pure seed of desirable species can be obtained. Suppose rohu seed is necessary, only rohu seed can be produced in a couple of days. Required number of seed can be produced with this technique. Suppose a fish farm needs 1 crore fish seed, this number can be produced very easily in less time. The problems of identification and segregation of seed does not arise. This technique is very simple. Healthy seed can be produced. Fish can be spawn more than one time in one year. Hybridization is possible. In induced breeding techniques, four main types of materials are used to give injections to fish - pituitary gland extractions, HCG, ovaprim and ovatide.

5.2 Brood stock Management

Broodfish is a prerequisite for all induced breeding programmes. Proper broodstock will lead to better breeding responses, increased fecundity, fertilization, hatching and larval survival rates and more viable fish seed. Hence, the subject of broodfish management has assumed great importance in hatchery management.

Carp broodfish pond. Carp broodstock ponds are generally large (0.2-2.5 ha), 1.5-2.5 m deep, rectangular, seasonal or drainable and earthen in nature. Water inlet and outlet should be such that they simulate riverine/fluviatile conditions, which is the natural habitat for IMCs and Chinese carps.

Source of broodfish. Since selective breeding and hybridization programmes of pedigreed fish are not carried out in fish seed farms, the source of broodfish is stock ponds from the same farm or different farms. In order to avoid inbreeding in a hatchery, it is necessary that fresh fish germplasm from natural sources or other hatcheries is introduced regularly with timed periodicities. If this is not done, inbreeding depression may set in, which has been reported to have occurred in some carp hatcheries in India (Eknath and Doyle, 1985).

Care of broodfish. The recommended stocking density of carp brood fish is 1,000- 3,000 kg/ha, depending upon the species. Systematic studies on nutritional requirements of carp broodfish are limited. It is customary to feed carp broodfish with a traditional diet consisting of rice bran and oil cake (1:1 ratio) at a feeding rate of 1-2 percent of their body weight daily. In addition to the artificial feed, the grass carp is also given tender aquatic weeds/terrestrial grass. However, the breeding habits of some species like common carp demand their separation from other carp species due to their natural breeding in ponds with aquatic vegetation. As a result the common carp broodfish is segregated sex-wise and stocked in separate ponds to prevent accidental spawning in pond. However, the rest of the species can be stocked in a communal pond or stocked in separate ponds after species-wise and/or sex-wise segregation. Catla, in particular, needs to be separated from the rest of the species as it shows poor response to hormonal injection when stocked with other species. It is believed that catla broodfish. in separate ponds after species-wise and/or sex-wise segregation management is a pre-requisite

The number and quality of eggs produced is significantly affected by the conditions under which the broodstock is maintained. The quality of broodstock diet, feeding regime, the quality of broodstock and water management are the principal factors that influence the condition of the broodstock. Most seed farms raise broodstock on their own farm and maintain them in ponds at densities of 1 000-2 500 kg/ha. The earthen broodstock ponds vary in area from 0.2 to 1.0 ha, with depth ranging from 1 to 2 m. Most farms use water from perennial reservoirs. The main steps in the preparation of broodstock ponds are: (i) control of aquatic weeds, which is done manually; (ii) eradication of unwanted fish by applying mahua oilcake at 2 000-2 500 kg/ha and pond liming at 100-200 kg/ha depending on the pH of soil and water; (iii) fertilizing the pond with cattle dung, at 15 000-20 000 kg/ha/yr or poultry manure at 5 000-10 000 kg/ha/yr to enhance heterotrophic food production. In addition, 200-400 kg/ha/yr NPK mixture is applied in split doses at fortnightly or monthly intervals. The initial dose of organic manure is reduced by half if mahua oil cake is used for eradicating unwanted animals.

After stocking, the pond with carps that are one-year old or more, are fed with a conventional feed containing a mixture of groundnut oilcake and rice bran (at 1:1 or 1:2 ratio) at 1 - 2 percent body weight once daily. To ensure better and timely development of gonads, fish breeders use a special broodstock diet (protein: 25-30 perecent) prepared

using locally available cheap feed ingredients.

This diet is nutritionally superior, advances maturation and spawning by one or two months and results in increased fecundity and better seed quality.

5.3 Induced breeding with different inducing agents

Induced Breeding with Pituitary Gland Extraction

Fish breeding by pituitary gland extraction is an effective and dependable way of obtaining pure seed of cultivable fishes and is practiced today on a fairly extensive scale in India as well as many other countries in the world. It involves injecting mature female and male fishes with extracts of pituitary glands taken from other mature fish.

Fish Pituitary Gland

Pituitary gland is nothing but Hypophysis (gr. Hypo means lower physis means brain) Pituitary gland is an endocrine gland. It stimulates and regulates the all other endocrine glands of the body. Hence it is known as master gland of endocrine system.
Fish pituitary gland is a small, soft body and creamish white in colour. It is more or less round in carps. It lies on the ventral side of the brain (Fig. 3.1) behind the optic chiasma in a concavity of the floor of the brain-box, known as Sella turcica and enclosed by a thin membrane called duramater. In few fishes it is attached to the brain by a thin stalk, known as the infundibular stalk. Based on the infundibular stalk, the glands are classified into two types, namely, platybasic - without stalk, have an open infundibular recess and leptobasic - with stalk, have obliterated infundibular recess. Leptobasic type of pituitary glands are found in carps and platybasic type found in channidae and nandidae. The size and weight of the gland varies according to the size and weight of the fish. In Labeo rohita, the average weight of the pituitary gland is 6.6 mg in 1-2 kg fish, 10.3 mg in 2-3 kg fish, 15.2 mg in 3-4 kg fish and 18.6 mg in 4-5 kg fish.

Pituitary gland secretes the gonadotropic hormones, FSH or Follicular Stimulating Hormone, and LH or Luteinizing Hormone. Both hormones are Secreted through out the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity.

The FSH causes the growth and maturation of ovarian follicles in females and spermatogenesis in the testes of males. LH helps in transforming the ovarian follicles into corpus lutea in females and promoting the production of testosterone in males. These hormones are not species specific, i.e., a hormone obtained from one species is capable of stimulating the gonads of another fish. However, there is great variability in its effectiveness in different species. Experiments conducted on induced breeding of fishes have clearly shown the relative effectiveness of fish pituitary extracts over mammalian pituitary hormones, sex hormones and various steroids. This is the reason why fish pituitary is being extensively used today in fish breeding work all over the world.

Collection of Pituitary Gland

The fish donating the pituitary gland i.e., the fish from which the pituitary gland is collected is called the donor fish. The success in induced breeding of fish depends to a great extent on the proper selection of the donor fish. The gland should preferably be collected from fully ripe gravid fishes, as the gland is most potent at the time of breeding or just before spawning. The potency of the gland decreases after spawning. Glands collected from immature or spent fishes usually do not give satisfactory results. Glands in induced-bred fishes collected immediately after spawning have also been found to be effective and can be used for reeding of other fishes. Most suitable time in India for collection of pituitary glands of major carps is during May to July months, as the majority of carps attain advanced stages of their maturity during this period. Since common carp, Cyprinus carpio is a perennial breeder, its mature individuals can be obtained almost all the year round for the collection of glands. The glands are usually preferred to be collected from freshly killed fishes but those collected from ice-preserved specimens are also used.

Several techniques are adopted for the collection of pituitary glands in different countries. In India, the commonly adopted technique of gland collection is by chopping off the scalp of the fish skull by an oblique stroke of a butcher's knife. After the scalp is removed, the grey matter and fatty substances lying over the brain are gently cleaned with a piece of cotton. The brain thus exposed is carefully lifted out by detaching it from the nerves. In majority of the cyprinids, when the brain is lifted, the gland is left behind on the floor of the brain box. The duramater covering the gland is then cautiously removed using a fine needle and forceps. The exposed gland is then picked up intact without causing any damage to it because damaged and broken glands result in

loss of potency. Glands are also collected through foramen magnum. It is, in fact, a much easier method of gland removal which is commonly practiced by the professionals for mass-scale collection in crowded and noisy fish markets. In this method of gland collection, the fish is required to be essentially beheaded. In markets, glands are collected from fishheads that are already cut by retailers. In the cut fish-heads, the foramen can be clearly seen from behind holding grey matter and fatty substances in it. The brain lies on the ventral sides of the foramen. For taking out the gland, the grey matter and fatty substances are first removed by inserting the blunt end of the forceps into the foramen and pulling out the entire matter without disturbing the brain. The brain is lifted up carefully and pushed forward or is pulled out of the hole. The gland lying at the floor of the brain box is then picked up using a pair of fine tweezers. An experimental worker easily manages to collect about 50- 60 glands in one hour by adopting this technique of collection.

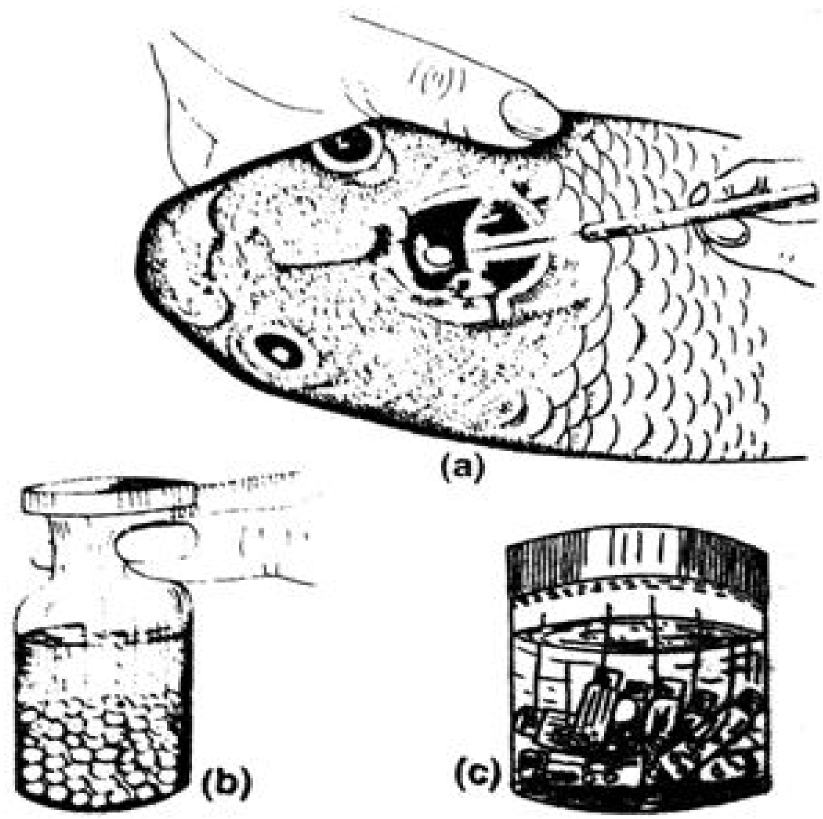


Fig. 5.1 Collection of Pituitary Gland

Preservation of Pituitary Glands

If the collected glands are not meant for use then and there, they must be preserved. Due to their glyco- or muco- protein nature, they are liable to immediate enzymatic action. The pituitary glands can be preserved by three methods - absolute alcohol, acetone and freezing.

Preservation of fish pituitary gland in absolute alcohol is preferred in India. Moreover, experiments done so far with alcohol preserved glands on Indian major carps have given more positive results than with acetone preserved glands.

The glands after collection are immediately put in absolute alcohol for defatting and dehydration. Each gland is kept in a separate phial marked serially to facilitate identification. After 24hours, the glands are washed with absolute alcohol and kept again in fresh absolute alcohol contained in dark colour bottles and stored either at room temperature or in a refrigerator. Occasional changing of alcohol helps in keeping the glands in good condition for longer periods. In order to prevent moisture from getting inside the phials, they may be kept inside a dessicator containing some anhydrous calcium chloride. It is preferable to keep the glands in a refrigerator. They can be stored in refrigerator upto 2-3 years and at room temperature upto one year. Acetone also is a good preservative. In this method, soon after collection, the glands are kept in fresh acetone or in dry ice-chilled acetone inside a refrigerator at 100 C for 36-48 hours. During this period, the acetone is changed 2-3 times at about 8-12 hours intervals for proper defatting and dehydration. The glands are then taken out of acetone, put on a filter paper and allowed to dry at room temperature for one hour. They are then stored in a refrigerator at 100 C, preferably in a dessicator charged with calcium chloride or any other drying agents.

Preparation of Pituitary Gland Extract

Preserved glands are then weighed. This is essential for accurate determination of the dose to be given according to the weight of the breeders. The weight of the gland may be taken individually or in a group. To get a more accurate weight, a gland should be weighed exactly after two minutes of its removal from alcohol. The pituitary extract should be prepared just before the time of injection. The quantity of gland required for injection is at first calculated from the weight for the breeder to be injected. The glands are then selected and the required quantity of glands is taken out of the phials. The alcohol is allowed to evaporate, if the glands are alcohol preserved ones. Acetone-dried glands are straight away taken from the phials for maceration.

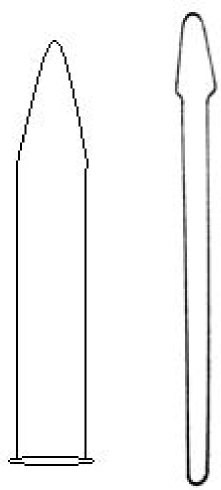


Fig. 5.2 Tissue homogenizer

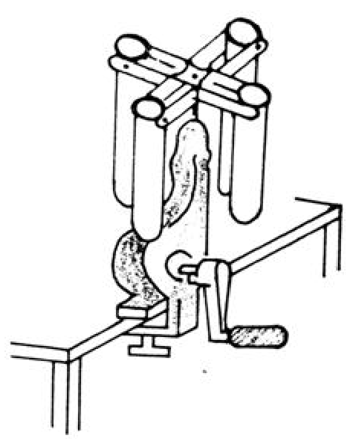


Fig. 5.3 Centrifuser

The glands are then macerated in a tissue homogeniser by adding a measured quantity of distilled water or common salt solution or any physiological solution which is isotonic with the blood of the recipient fish. The most successful results of induced breeding in the Indian major carps have so far been obtained with distilled water and 0.3% common salt solution.

The concentration of the extract
is usually kept in the range of 1-4 mg of gland per 0.1 ml of the media i.e., at the rate of 20- 30 gm. of the gland in 1.0 ml of the media. After homogenation, the suspension is transferred into a centrifuge tube. While transferring, the homogenate should be shaken well so that settled down gland particles being mixed with the solution come into the centrifuge tube. The extract in the tube is centrifuged and the supernatent fluid is drawn into a hypodermic syringe for injection.

The pituitary extract can also be prepared in bulk and preserved in glycerine (1 part of extract : 2 parts of glycerine) before the fish breeding season so that the botheration of preparing extract every time before injection is avoided. The stock extract should always be stored in a refrigerator or in ice.

Technique of Breeding

The induced breeding operation of major carps is taken up when regular monsoon sets in, the fishes become fully ripe and water temperature goes down. Females having a round, soft and bulging abdomen with swollen reddish vent and males with freely oozing milt are selected for breeding. A male breeder can also be easily distinguished by roughness on the dorsal surface of its pectoral fins.

1. Dosage of pituitary extract

The most important aspect of induced breeding of fish is the assessment of proper dosages of pituitary extract. The potency of the gland varies according to the size and stages of sexual development of the donor, as well as the species of the donor fish, time of collection of glands and their proper preservation. The dose of the pituitary gland is calculated in relation to the weight of the breeders to be injected.

An initial dose at the rate of 2-3 mg. of pituitary gland per kg body weight of fish is administered to the female breeder only. Male breeders do not require any initial dose, if they ooze milt on slight pressure on their abdomen. Two males against each female make a breeding set. To make a good matching set, the weight of the males together should be equal to or more than the female. In case the condition of any one of the two males is not found in the freely oozing stage, an initial injection may be administered to the male at the rate of 2-3 mg/kg body weight. After 6 hours, a second dose of 5-8 mg/kg body weight is given to the female, while both the males receive the first or second dose at the rate of 2-3 mg/kg body weight. Slight alterations in doses may be made depending upon the condition of maturity of the breeders and the prevailing environmental factors. In the absence of a chemical balance, 1-3 pituitary glands are effective for a pair of fish.

2. Method of injection

Intra-peritonial injections are usually given through the soft regions of the body, generally at the base of the pelvic fin or sometimes at the base of the pectoral fin. But there is some risk of damaging the internal organs, specially the distended gonads when administering an intra-peritonial injection in fully mature fishes. Injections are usually given at the caudal peduncle or shoulder regions near the base of the dorsal fin. While giving injections to the carps, the needle is inserted under a scale keeping it parallel to the body of the fish at first and then pierced into the muscle at an angle. There is no hard and fast rule regarding the time of injection. Injections can be given at any time of the day and night. But since low temperature is helpful and the night time remains comparatively quieter, the injections are generally given in the late afternoon or evening hours with timings so adjusted that the fish is able to use the quietude of the night for undisturbed spawning. The size of the needle for the syringe depends upon the size of the breeders to be injected.

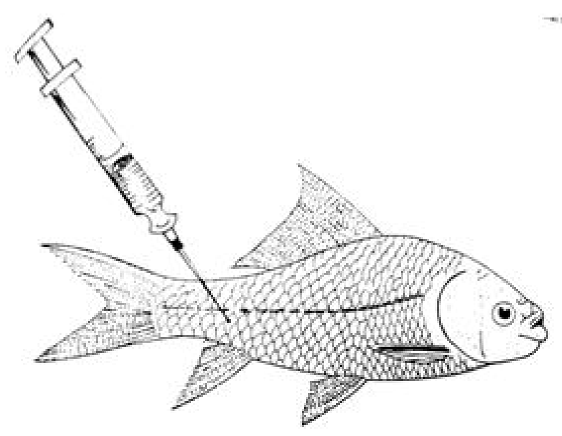


Fig. 5.4 A brood fish being injected at the caudal region

3. Breeding hapa and spawning

After the injection, the breeders are released immediately inside the breeding hapa. A breeding hapa is generally made of fine cloth in the size of 3.5 x 1.5 x 1.0 m for larger breeders and 2.5 x 1.2 x 1.0 m for breeders weighing less than 3 kg. All the sides of the breeding hapa are stitched and closed excepting a portion at the top for introducing the breeders inside. Generally, one set of breeders is released inside each breeding hapa, but sometimes, in order to save on pituitary material, community breeding is also tried by reducing the number of male breeders. After the release of the fish, the opening of the hapa is securely closed so that breeders may not jump out and escape. Instead of hapas, cement cisterns or plastic pools as big as hapas can also be used for breeding. Spawning normally occurs within 3-6 hours after the second injection. Soon after fertilisation, the eggs swell up considerably owing to absorption of water. Fertilised eggs of major carps appear like shining glass beads of crystal clear transparency while the unfertilised ones look opaque and whitish.

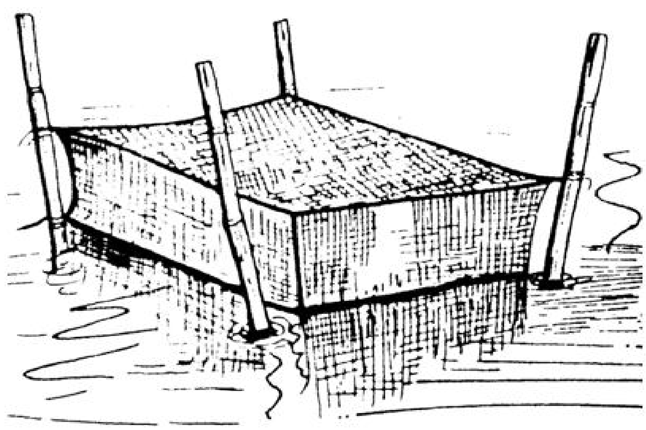


Fig. 5.5 Breeding Hapa

The size of eggs from the same species of different breeders varies considerably. Fully swollen eggs of the Indian major carps measure 2.5 mm in diameter, the largest being that of catla and the smallest of rohu. The carp eggs are non-floating and non-adhesive type. The yolk possesses no oil globule. The Indian major carps have a profuse egg laying capacity. Their fecundity, on an average, is 3.1 lakh in rohu, 1-3 lakh in catla and 1.5 lakh in mrigal. The developing eggs are retained in the breeding hapa undisturbed for a period of at least 4-5 hours after spawning to allow the eggs to get properly water-hardened. After this, the eggs are collected from the hapa using a mug and transferred into a bucket with a small amount of water. The breeders are then taken out and weighed to find out the difference before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by conducting random sampling before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by carrying out random sampling.

Induced Breeding with H.C.G.

Today pituitary gland extraction is a well established technique for induced breeding all over the world. Its large scale use poses the following problems with regard to availability and quality of pituitary gland (P.G). Inadequate supply of P.G., high cost, variability in pituitary gonadotropin potency and cheating by unscrupulous P.G. suppliers.

To overcome these problems, Human Chorionic Gonadotropin (H.C.G) has been found as an alternative for pituitary gland. H.C.G. was discovered in beginning of 1927 by Aschheim and Zondek. They extracted good quality hormone with luteinising gonadotrophic activity from the urine of pregnant women. Russian workers first used chorionic gonadotropin in 1964 with a trade name as Choriogohin and got good results on Loach. Bratanor (1963) and Gerbilski (1965) used H.C.G on carps and trouts and achieved great success. Tang (1968) stated that when Chinese carps were treated with fish pituitary in combination with C.G., effectiveness on induced breeding increased. A perusal of literature indicates that H.C.G. is effective either alone or in combination with P.G. extract in inducing various fishes all over the world. H.C.G. is a glyco-protein or sialo-protein, because of the carbohydrate molecules attached to the protein molecules. Its primary function is to maintain the production of oestrogen and progesterone by the corpus luteum. It is produced by the placenta and excreted through the urine during early stages of pregnancy (2-4 months). H.C.G comprises of 2 sub-units a and b and has a molecular size of 45,000-50,000 daltons. There are 17 amino acids in it, out of which alanine, proline, serine, cystine and histidine are important. Due to the large number of amino acids, H.C.G. has a high protein content. The molecular weight has been reported as 59,000 by gel filtration and 47,000 by sedimentation equilibrium. During early stages of pregnancy H.C.G. is rich in the urine of pregnant women. Several methods are employed for the extraction of H.C.G. Aschheim and Zondek (1927) used ethanol for precipitation.

Katzman and Caina used different absorbents. Commercial crude H.C.G extraction is made with gel filtration. Follicle stimulating hormone (FSH) and luteinising hormone (LH) of the pituitary play an important role in the normal reproduction of fish i.e., in promoting the development of gonads, growth, maturity and spawning. H.C.G is more or less similar in character and function to F.S.H and L.H. As pituitary gland is used for induced fish breeding, H.C.G can also be used for early ripening of gonads.Superiority of H.C.G over P.G can be measured on the following grounds. Fish attains maturity faster with H.C.G., the spawn of the breeding season can be increased with H.C.G ., H.C.G. ensures better survival of spawn, it reduces the time gap between preparatory and final doses, H.C.G is more economical and has a long shelf life, H.C.G is easily available from a standard source, hence is more reliable,

The calculated quantity of crude H.C.G is taken into a tissue homogeniser and stirred for 5-10 minutes with measured distilled water. It is centrifuged for 3-5 minutes. The clear light yellowish supernant liquid having the H.C.G hormones is taken and injected immediately. Any delay in use will result in the loss of the potency. In case of silver carp (Hypophthalmichthyes molitrix), use of H.C.G is found to be quite successful. The dosage is 4-6 mg/kg. body weight of male, and 6-8 mg/kg body weight of first dose and after about 6-7 hours, 10-12 mg/kg body weight of second dose for female which gave good results. Use of only H.C.G in the breeding of Indian major carps has not given successful results so far. A combination of 60-80% H.C.G and 40-20% P.G for Indian major carps and grasscarps (Ctenopharyngodon idella) is successful. Fishes which are induced to breed with H.C.G alone are mullets, Cyprinus carpio, Lctalurus punctatus, Oreochromis nilotica. Recent work shows that the combination of H.C.G and P.G. is more recommendable than H.C.G or P.G alone. More work needs to be done to standardize the dosage of H.C.G for induced breeding of major carps and Chinese carps.

Induced Breeding with Ovaprim

M/s Syndel Laboratories Limited, Canada
have manufactured a new drug called as ovaprim. Ovaprim is a ready to use product and the solution is stable at ambient temperature. It contains an analogue of 20 ìg of Salmon gonadotropin releasing hormone (sGnPHa) and a dopamine antagonsist, domperidone at 10 mg/ml. The potency of ovaprim is uniform and contains sGnRHa which is known to be 17 times more potent than LHRH (Peter, 1987). The dopamine antagonist, domperidone used in ovaprim is also reported to be better than another commonly used antogonist, pimozide. Ovaprim being a ready to use product and one which does not require refrigerated storage, appears to be the most convenient and effective ovulating agent. This drug is administered to both female and male brood fish simultaneously in a single dose, unlike pituitary extract which is given in two split doses. This reduces not only the handling of brood fish but also helps in saving considerable amount of time and labour which will add on to the cost of seed production. The spawning response in treated species is found to be superior to the pituitary extract injected species.

The efficiency of ovaprim for induced breeding of carps have given highly encouraging results in catla, rohu, mrigal, silver carp, grass carp, big head, etc. The effective dose required for various species of carps is found to vary considerably. The common dose for all carps is 0.10-0.20ml ovaprim/kg body weight of males and 0.25-0.80 ml ovaprim/kg body weight of females. Female catla is found to respond positively for a dose range of between 0.4-0.5ml/kg, while rohu and mrigal respond to lower doses of 0.35 ml/kg and 0.25ml/kg respectively. Among exotic carps, silver carp and grass carp are bred at doses ranging between 0.40-0.60ml/kg.
Big head carp bred successfully at 0.50ml/kg. For males of Indian carps, 0.10-0.15ml/kg and for exotic male carps 0.15-

0.20 ml/kg of dosages are found to be optimum. The method of injection is the same as pituitary.

In many countries including our country, ovaprim is used on a large scale for induced breeding of all cultivable fishes successfully. In India, initial trials were conducted during 1988 in Karnataka, Andhra Pradesh and Tamil Nadu. Ovaprim has unique advantages over pituitary hormone - ready to use liquid form in 10 ml vial, consistent potency and reliable results, long shelf life, and can be stored at room temperature, formulated to prevent over dosing, male and female can be injected only once simultaneously, reduces handling and post breeding mortality, repeated spawning possible later in the season and high percentage of eggs, fertilization and hatching.

Induced breeding with ovatide

Ovatide is an indigenous, cost-effective and new hormonal formulation for induced breeding of fishes. The new formulation is having the base of a synthetic peptide which is structurally related to the naturally occuring hormone, goanadotropin releasing hormone (GnRH). GnRH is not a steroidal hormone and belongs to the class of organic substances called peptides. It is presented as a low viscosity injectable solution which is not only highly active but also cost-effective compared to other commercially available spawning agents. It is also effective in breeding major carps and catfishes. The doses for females are 0.20-0.40 ml/kg for rohu and mrigal, 0.40-0.50 ml/kg for catla, silver carp and grass carp and 0.20-0.30 ml/kg for calbasu. The dosages for males are 0.10-0.20 ml/kg for rohu, mrigal and calbasu, 0.20-0.30 ml/kg for catla and 0.20-0.25 ml/kg for silver carp and grass carp.

The advantages of ovatide are: It is cost-effective hormonal preparation, it gives high fertilisation and hatching percentage (85-95%), it is increases egg production through complete spawning, it produces healthy seed, it is easy to inject due to its low viscosity, it does not cause adverse effects on brood fish after injection, it can be administered in a single dose to brooders, it can be stored at room temperature, it is quite effective even under climatic adversities and ovatide is available in the market as 10ml vial, which costs Rs. 300. It is cheaper than ovaprim. The selection of brooders and injecting methods are similar to pituitary extract.

Induced Breeding with Ovopel

Ovopel, developed by the University of Godollo in Hungary, is a preparation containing mammalian GnRH and the water-soluble dopamine receptor antagonist, metoclopramide. The concentration of D-Ala6, Pro9NEt-mGnRH and metoclopramide are in the form of 18-20 micro gm/pellets and 8-10mg/pellets respectively. The hormone is thus available in pellet form. Each pellet contains superactive gonadoptropin releasing hypothalamic hormone analogue with an equal effect which a 3 mg normal acetone-dried dehydrated carp hypophysis gland has. Induced propagation of fish had been shown to be more effective if the hormone was administered in two doses, prime dose and resolving dose, as reported by Szabo, T., 1996.

For cyprinids successful results were reported when 2-2.5 pellets/kg were administered to female brood fish. However, preliminary trial with single injection of Ovopel gave encouraging result on a few species of Indian major carps and *Clarias batrachus*.

The required amount of ovopel was calculated on the basis of weight and condition of brood fish. The pellets were pulverized in a mortar and dissolved in distilled water. The trails were conducted in July-August of 1999. The new inducing agent. ovapel is easy to store, simple to use and less expensive, as reported by Szabo. T, 1996. However, in India, detailed studies to establish its efficacy and economic viability are required to be undertaken. The hormone has been successfully tested for ovulation in several species of cyprinids, the Common carp, the Silver carp and the tench (Horvath et al, 1997) in Europe. Ovulation was also reported in African Cat fish (Brzuska, E. 1998). In India, Ovopel was used with success in induced breeding of major carps in UP, Haryana and Punjab. In Assam the trials conducted recently on Labeo rohita (Rohu), Cirrihinus mrigala (Mrigal), Labeo gonius (Gonius) and Clarias batrachus (Magur) gave encouraging results. This indicates the possibility of using this new hormone preparation for commercial production of fish seeds if made available to farmers at a competitive price.

Other Substances used for Induced Breeding

Other substances like LH-RH analogues, steroids, and clomiphene are used for induced breeding of fishes.

LH-RH analogue

Various analogues of Luteinizing hormone -releasing hormone (LH-RH) have been used for induced breeding of fishes. Investigations have revealed that the potential action of releasing hormone when dopamine antagonist is simultaneously used with the analogues is (10-100ìg/kg) used successfully in China. An analogue of teleost GNRH is found to be more potent than LH-RH. GNRH (Gonadotropin releasing hormone) stimulates GTH (Gonadotropin hormone) in teleosts (dosage 25-100 ìg/kg).

Steroids

Selected steroid hormones are used to induce fish. The effects of steroid hormones on ovulation are seen primarily as germinal vesicle breakdown

(GVBD). Ovulated oocytes require at least 4 hours to become fertilisable in mullets, whereas in most of the fishes oocytes are fertilisable immediately. The action of pituitary gonadotropins on oocyte maturation is known to be mediated through steroid hormones. Deoxycorticosterone acetate (DOCA) and cortisone effectively stimulate (dosage 50 mg/kg of fish) ovulation in Heteropneustes fossilis (Goswamy and Sunderraj, 1971). 17á-hydroxy-20B dihydroprogesterone (17á-20BDP) is useful to induce gold fish, trout and pikes (Jalabert, 1973). Other steroid hormones commonly used for spawning teleosts are cortisone acetate, deoxycortisol, deoxycorticosterone, hydroxycortisone, progesterone, 11 deoxycorticosterone and 20B progesteron. The advantages of steroids are: most compounds are available as pure preparations in synthetic forms, the quality of steroid preparations is uniform and steroid hormones are much cheaper than gonadotropin preparations.

Clomiphene

It is an analogue of the synthetic non-steroidal estrogen chlorotrianisene. It is known to have antiestrogenic effects in teleosts. It triggers the release of gonadotropins. The injections of clomiphene (10 ìg/g) induced ovulation within 4 days in gold fish, whereas with same dosage, common carp spawned successfully after 40-64 hours.

5.4 Stripping

Chinese carps however do not spawn naturally and when they spawn, the percentage of fertilisation is generally very low. Stripping or artificial insemination is therefore followed.

Fig. 5.6 Stripping

The female fish is held with its head slanting upwards and tail down and belly facing the vessel, and the eggs are collected into an enamel or plastic trough by pressing the body of the female. The male fish is then similarly held and milt is squeezed out into the same trough. The gamets are then mixed as soon as possible by means of a quill feather to allow fertilisation. The fertilised eggs are then washed a few times with clean water to remove excess milt and allowed to stay undisturbed in freshwater for about 30 minutes. The eggs are then ready for release into the hatching tanks.

Technique of hatching the eggs:

The eggs collected from breeding hapas are transferred into the hatching hapas. A hatching hapa consists of two separate pieces of hapas, the outer hapa and the inner hapa. The inner hapa is smaller in size and is fitted inside the outer hapa. The outer hapa is made up of a thin cloth in the standard size of 2 x 1 x 1 m while the inner hapa is made of round meshed mosquito net cloth in the dimension of 1.75 x 0.75 x 0.5m. All the corners of the outer and inner hapas are provided with loops and ropes to facilitate installation. About 75,000 to 1,00,000 eggs are uniformly spread inside each inner hapa. The eggs hatch out in 14-20 hours at a temperature range of 24-31^{0}C. The period of incubation, in fact, is inversely proportional to the temperature. After hatching, the hatchlings escape into the outer hapa through the meshes of the inner hapa. The inner hapa containing the egg shells and the dead eggs which are removed when the hatching is complete. The hatchlings remain in outer hapa undisturbed till the third day after hatching. During this period, they subsist on the food stored up in their yolk sac. By the third day the mouth is formed and the hatchlings begin directive movement and feeding. At this stage they are carefully collected from the outer hatching hapa and stocked into prepared nurseries.

It has been found that Indian major carps could be induced to spawn twice in the same season with an interval of two months. The breeders after the first spawning are fed with groundnut oilcake and rice-bran in the ratio 1:1 at 2.5 percent of the body weight. When favourable climatic conditions occur, they mature and are ready for sp.

5.5 Factors Effecting Induced breeding

Environmental factors like temperature, water condition, light, meteorological . conditions, etc. are important factors controlling the reproduction of fish.

Temperature

There is an optimal temperature range for induced breeding of culturable fishes. Critical temperature limits exist, above and below which fish will not reproduce. However, certain teleosts can be made to ripen below the critical temperature by using goandotropins. Warm temperature plays .a primary role in stimulating the maturation of gonads in many fishes. Temperature has a direct effect on gonads regulating their ability to respond to pituitary stimulation and effects on primary synthesis and release of gonadotropins. Major carps breed within a range of temperature varying from 24-31°C. Some scientists did not find any correlation between water temperature and percentage of spawning success in induced fish breeding. If an effective dose of pituitary, HCG or ovaprim is given to fish, they spawn successfully even if there is a substantial increase or decrease in water temperature.

Light

Light is another important factor controlling the reproduction in fishes. Enhanced photoperiodic regimes result in early maturation and spawning of fishes like Fundulus, Oryzias, etc. Some fishes like Salmo, Salvelinus etc., attain delayed maturation and spawning. Cirrhinus reba attains early maturation when subjected to artificial day lengths longer than natural day even at low temperature. The requirement of light for activation of the reproductive cycle vary from species to species and from place to place, as the day length and temperature differ depending on the latitude of the place concerned.

Water currents and rain

Rheotaxtic response to water current is well established in fishes. Rain becomes a pre-requisite to spawning of fishes, even when they are subjected to induced breeding. Fresh rain water and flooded condition are the primary factors in triggering the spawning of carps. The sudden drop in the level of the electrolytes in the environment caused by the heavy monsoon rains induces hydration in the fish and stimulates the gonads resulting in its natural spawning. Successful spawning of fishes has been induced on cloudy and rainy days, especially after heavy showers.

Hormonal influence

Gonadotropins have been found to increase during spawning and decrease afterwards. Due to the presence of females, there is an increase in gonadotropin level in males. FSH and LH have been reported to influence gonadal maturity in carps. Ihere are other factors that influence the spawning of fishes. Availability of nest building site stimulate fish to spawn. Factors called the repressive factors like accumulation of metabolic eliminates (Ammonia, faecal pellets, etc.) inhibit spawning.

5.6 Breading of common carp

Common carp (*Cyprinus carpio*) generally breeds in confined water. Spawning takes place in shallow marginal, weed infected areas from January to

March and from July to August. Common Carp is also observed to breed round the year. Controlled breeding of common carp is conducted to achieve better spawning and hatching.

Fig. 5.7 Sticky fish eggs

A set of selected brooders one female and two males are put together in breeding hapa. In order to ensure successful spawning sometimes the female fish is injected with pituitary gland extract at a low dose 2 to 3 mg per kg. Body weight. Freshly washed aquatic weeds (Hydrilla, Najas, Eichhornia etc) are uniformly distributed inside the hapa. These aquatic weeds act as egg collections. The quantity of weed used is roughly double the weight of the female introduced. Each weed attached with 40,000 to 1,00,000 eggs are distributed into a single hatching hapa. After 4 or 5 days the weeds are taken out carefully.

Short Answer Type Questions

1. Define Induced breeding technology.
2. What is Brood stock?
3. Why the pituatory gland is used as induced agent in artificial breeding of fish.
4. Where the pituatory gland is located infish? Write its gonodotropic hormones.
5. Why the pituitary gland is called as master gland of endocrine system?
6. What are the agents used in preservation of pituitory glands?
7. Draw the diagram of spawning hapa.
8. Expand H.C.G. What its use?
9. What is stripping method?
10. What environmental factors control the reproduction of fish.

Long Answer Type Questions

1. Explain the fish brood stock management.
2. Describe the Induced breeding with pituitary gland extraction.
3. Describe the factors effecting Induced breeding.
4. Write short note on

   a) HCG b) Ovatide c) Ovaprim
5. Short note on

   a) Ovapel b) Stripping c) Common carp breeding

Unit-6
Fish Hatchery Management

Structure

6.1 Introduction

The term ‘hatchery’ or ‘hatchery proper’ is often used for an indoor facility of fish spawning, egg incubation, hatching and rearing of the hatchlings to post larval stage. One of the major requirements in aquaculture is the appropriate technology for the breeding, hatching and rearing of fish through a standarised method which may apply on national level.

There are different types of hatchery facilities in use, depending on the species, localities and investment capabilities of the aqua culturists. However, the basic requirements are almost similar viz., necessary facilities for holding or rearing an adequate brood stock; spawning or stripping and fertilization of Ova, incubation of fertilized ova and rearing of larvae to the required stage for transfer to nurseries or other culture facilities.

6.2 Types of hatcheries

Many types of hatcheries have been established so far for hatching fish eggs. The main aim of the hatcheries is to improve the percentage of the hatching of eggs. The different types of hatcheries are

Earthen hatching pits

The earliest hatchery was the earthen hatching pit with a dimension of 3' x 2' x 1'. Based on the requirements the size may vary. These pits are prepared in several rows and their inner walls are plastered with mud. After filling them with water, the collected eggs are introduced into them. About 35,000-40,000 eggs per pit are kept for hatching. Hatching takes place within 24 hours. Pits are also interconnected, properly irrigated and have draining facilities. A constant flow of water is useful to ensure proper aeration and to reduce the accumulation of wastes, thereby improving the survival rate. The percentage of hatching in hatching pits is 30-40%.

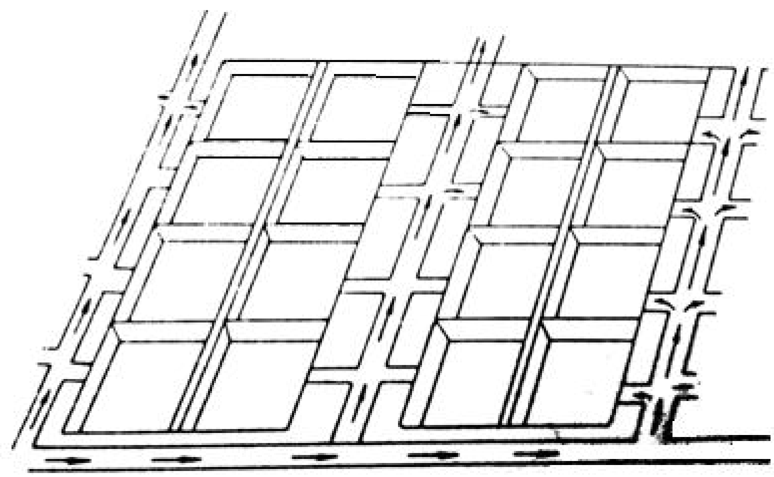


Fig.6.1 Earthen hatching pits

The advantages of earthen hatching pits are

1. These are best suited for hatching eggs from dry bunds. Wide areas near dry bunds can be used for digging earthen pits, so as to use a less quantity of eggs in each pit.
2. Fresh accumulated rain water from the bunds enters into the pits for hatching.
3. Expenditure is very low and the technology is inexpensive.

These pits have some disadvantages also. Huge mortality often occurs due to fluctuations in temperature, because the eggs are hatched in open areas. Depletion of oxygen often occurs which causes heavy mortality of spawn. Continuous water flow has to be maintained in the pits till the spawn are collected. If sufficient water is not available, mortality of spawn occurs.

The Chittagong type of hatching pits are similar to earthen hatching pits, but in each pit a piece of cloth and mosquito nets are used additionally. The cloth is kept just above the bottom of the pits. The mosquito net is arranged above the cloth. The spawn, after the hatching, pass through the net and are collected on the cloth. The net containing the egg shells and the dead eggs is removed after 3 days of hatching. When the yolk sac is fully absorbed, the spawn are taken out

Earthen pot hatcheries

This is the oldest method adopted for hatching. Locally made earthen pots are used for hatching. The collected eggs are kept in pots and hatching takes place inside the pot. The fluctuations of temperature and pH are moderate. This method is not very popular. The percentage of hatching is about 40%.

Cement hatching pits

The hatching pits are lined with cement. The eggs are kept in these pits for hatching. The main advantages of these pits are that the recurring expenses are less, they are easy to operate, and regular flow of water is maintained. But capital investment is high and the mortality is mainly due to depletion of oxygen and increase in water temperature. The percentage of hatching is 30-50%.

Hatching hapas

Double cloth hatching hapas are most extensively used. The hapa is fixed in the water with the help of bamboo poles in shallow waters. This hapa is double walled, with an outer wall made of either thin or coarse muslin cloth, and an inner wall made of round mesh mosquito netting cloth. The most frequently used cloth for a hatching hapa is 2 x1 x 1 m in size for the outer one, and the inner wall size is 1.75 x 0.75 x0.9 m. The water depth is maintained around 30 cm. These hapas are arranged in a series. 75.000-1,00,000 eggs are kept in one hapa inside the inner wall for hatching. After hatching, the hatchlings enter into outer hapa through the mosquito netting cloth, leaving the egg shells, the spoiled eggs and the dead eggs. After hatching, the inner hapa is removed. The hatchlings in the outer hapa are kept for a period of 40 hours till the yolk sac is absorbed. The percentage of hatching is 40-50%.

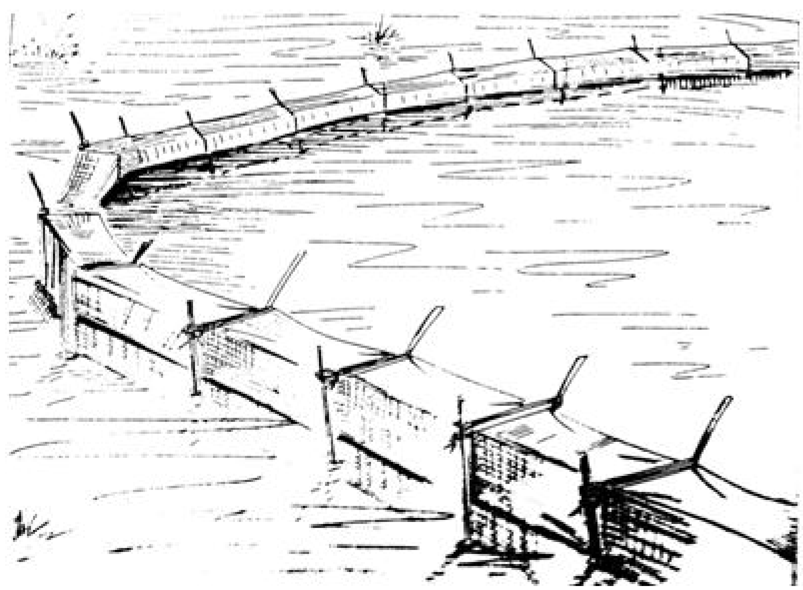


Fig. 6.2 A row of hatching hapas fixed together in a pond

The main advantages are that the cost is very less and the eggs are away from earth which will not pollute and cause mortality. The disadvantages are the pores of hapas get clogged due to silt deposition which causes heavy mortality, crabs cut the hapas easily, they have a short life period of about 2 years, weather fluctuations result in mortality and they need more water.

Garfil hatching hapas can also be used in place of cloth hapas. The design, construction and arrangement are similar to cloth hapas. The hatching percentage is 50-60%. The advantages are suitable mesh size can be selectively used for inner and

Floating hapas

Floating hapas are an improvement over the conventional hapas. These are designed to cope with the rise and fall in the water level. These can be easily fixed even in rock}' areas without bamboo poles. They can also be fixed in deeper areas so that a mild water current passes through the hapa: this helps in better exchange of water and aeration. It is similar to a conventional hapa, but it is mounted on frames which are made up of polythene or aluminum pipes. Floats are fixed to the hapa for floating. It is tied to fixed objects with long ropes so that it will not be carried away by the current. It is collapsible and can be assembled very easily. The size of outer hapa is 2 x 1 x 1 m and that of the inner one is 1.75

x 0.75 x 0.5 m. The hatching percentage is 50-70%. Silt may get deposited in the hapa which causes mortality of the spawn. It may be dispositioned due to the movement of water and rearranging is time consuming. The hatching rate is not high.

Tub hatchery

This hatchery was introduced in Madhya Pradesh. It is an improvement over fixed hapas and provides for hatching in running water. It has a continuous flow of water by gravity and siphons. This system has a series of 8-12 glavanised iron hatching tubs connected to each other with a regular flow of water. Each series consists of an overhead drum. Each tub is 2.5' x 2.5' x 1.5' in dimension and has two nets, an outer and inner one. The fertilised eggs are transferred into the tubs for hatching. The percentage of hatching is 50-70%. Vigilance round the clock is necessary in this system.

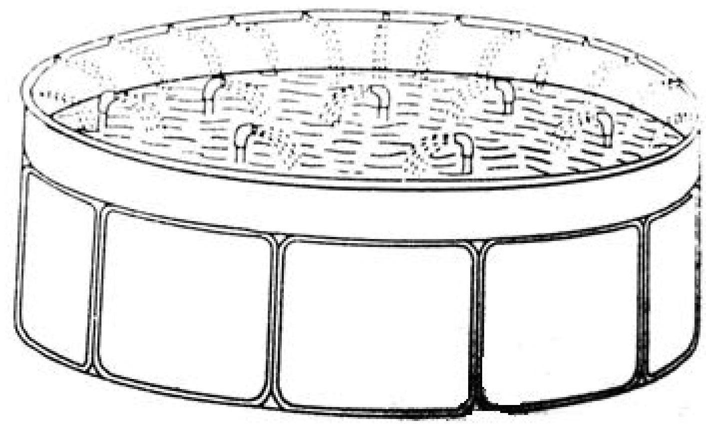


Fig. 6.3 Plastic made nursery, rearing, hatching pool

Cement cistern hatchery

Tub hatchery has been replaced by cement cisternae hatchery. Cement cisternae are built below the dams of the dry bundh. Pond water is supplied to these cisternae. Each cistern is 2.4 x 1.6 x 0.45 m in dimension and they are connected in two rows. These are not interconnected and each has separate inlets and outlets. About 3,00,000 eggs are kept in each cistern for hatching. The percentage of hatching is 50-70%.

Vertical jar hatchery

This technique is an improved method over the hapa technique and ensures 90% survival offish hatchlings. The hatchery consists of a continuous water supply, breeding tank, incubation and hatchery apparatus and a spawnery. The vertical jars are made up of glass, polythene and iron.

1. The greatest advantage of the jar hatchery is its very low water requirement. One unit of 40 jars can handle 20 lakh fertilized eggs in a day, and it would need just 20,000 litres of water.
2. It can be operated in a compact area. The space needed to accommodate the 40 jars unit would be around 10 square metres or at the most 20 sq. metres, and such a unit is sufficient for hatching out 20lakh eggs. Compared to this, the hatching hapa in ponds requires 150 square meters of space.
3. In summer, with the water temperature shooting up over 32^0C, hatching will be adversely affected in hapas. But in jar hatcheries, it is possible to overcome this by air-conditioning the room.
4. Developing embryos can be seen with naked eyes and so rectification can be attempted depending on exigencies.
5. A set of 40 jars would cost Rs. 10,000 with accessories. These jars last for 10 years. Hence, the cost per year for 20 lakh hatchlings would be Rs. 1000. But in the case of hapas, to handle 20 lakh hatchlings costs Rs. 9000. The hapas last only for two years and involve more labour. This indicates that jar hatchery is more convenient and also more economical cost-wise.
6. In a day, in a space of about 20 square metres, one can hatch out 20 lakh eggs with a survival rate of about 90%. During the monsoon period about 200 million eggs can be handled in this hatchery.
7. An added advantage of the jar hatchery is that in the same airconditioned room even breeding can be carried out successfully. Breeders respond well at temperatures of 26-28°C.
8. Adverse water conditions can be changed in ajar hatchery. In summer the hydrogen sulphide content is increased, especially in reservoirs, and this affects the hatching in hapas in the ponds fed with the above water. This could be treated in overhead tanks before supply to the hatchery jars.

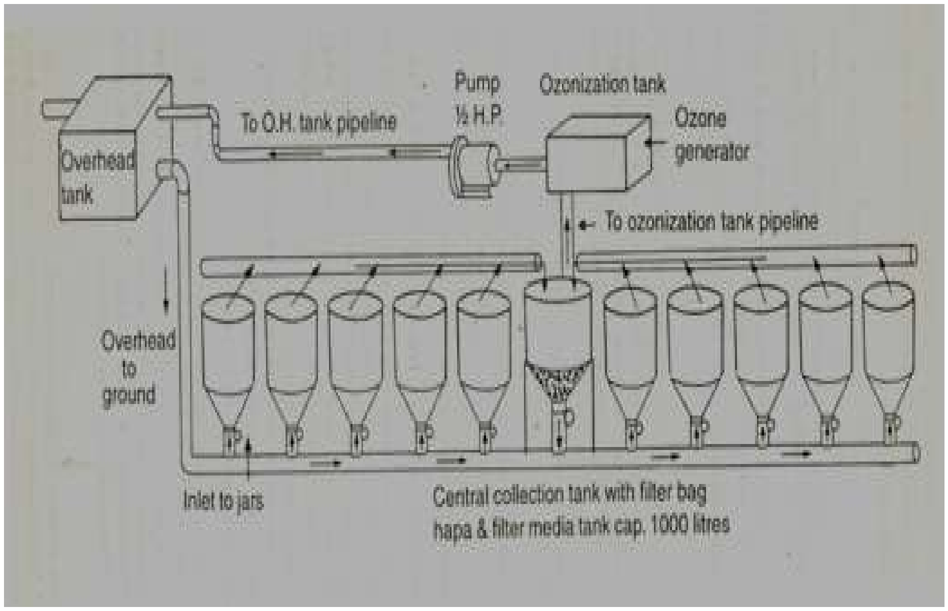


Fig. 6.4 Vertical jar Hatchery

The main disadvantages are as it is made of glass, it is prone to easy damage; difficult to shift to different places and subject to breakage during transport; temperature control system is not provided; metabolites are not removed from the circulating water, and. additional air circulation is not provided. In the transparent polythene sheet hatchery, glass jars are replaced by transparent polythene containers. Each polythene jar is 27cm in height, 10cm diameter and has a capacity of 2 liters.

In the giron jar hatchery, glass jars are replaced by galvanized jars. This unit is durable, cheaper and has more capacity. It is also more suited for local village conditions. The jars are conical and have a short spout at the top to serve as an outlet. The height of the jar is 75cm and its diameter is 23cm. The jars are fixed in an angular iron framework. The rate of the water flow is maintained at about 1 lit/min.

Plastic bin hatchery

This unit consists of eight hatchery cum spawnery units (HCS units) and a 5,000 litres water tank. The tank receives water from a natural resource by pumping. The tank is connected to the inlet pipelines of each unit. The HCS units can be arranged in a series to facilitate inlet connections. In this hatchery 2 crore eggs are kept for hatching. The percentage of hatching is 70-80%. Each unit consists of an outer container and the inner common egg vessel. The outer hatchery container is a rectangular aluminium sheet tub of 54" x 18" x 22" dimension and 243 litres capacity. It is unequally divided into three chambers. At a time 8 litres of eggs are placed for hatching in each hatchery unit. It also consists of an inlet outlet and drain pipe. The common egg vessel is made of a 14 gauge aluminium sheet which has 2.5mm diameter perforations. Three egg vessels are placed in each outer container. It is cylindrical in shape with a 12" diameter and 12" height. There is an arrangement of a plunger-lid which can slide and can be fixed at any desirable height on a vertical aluminium rod having a series of holes at 1 cm distance. The lid is useful to cover the eggs placed in the vessel closely so as to prevent any over flow and at the same time to enable efficient circulation of water. Each egg vessel can hold about 2 lakhs of eggs. The advantages are that the cost is less as it is primarily made of plastic, and is easy to operate. The

Plastic bucket hatchery

It consists of an outer plastic bucket with a perforated aluminium bin egg vessel and a galvanised iron sheet spawnery. The plastic bucket height is 47 cm, 30 cm diameter and the capacity is 45 litres. It has 3 inlets at the bottom and 2 outlets at the top. The eggs are kept in the egg vessel for hatching. The survival rate is 70-80%.

Hanging dipnet hatchery

This hatchery unit has a spawning tank, two hatching tanks, two breeding tanks and an overhead tank. The spawning tank is 2.36 x 3.23 x 0.9 m, hatching tanks are 3.3 x 1 x 1 m and breeding tanks are 1.2 x 0.7 x 1.06 m in size. The water is supplied from an overhead tank, which is fixed at 3.2 m height over the roof. All the tanks are with inlet and outlet pipes. Sprayers are fixed over all the tanks. Air coolers are used for cooling the water. Hatching dipnets are fixed in the hatching tanks. These nets are barrel shaped with steel rings. The size of the net at the top is 65 cm and at the bottom 46 cm. Dipnets are covered with 1/16 inch mesh cloth. A 50 mm brass spray head is fined at the bottom of each net. About 1 lakh eggs are kept in each net. During hatching, 1-1.5 lit/min water flow is maintained. The hatchlings enter into spawning tanks. The percentage of hatching is about 80%.

Circular cisternae hatchery

It has a drum which is made up of a galvanised iron sheet with one metre diameter and one metre height. At 5 cm above the bottom of the drum an inlet pipe is fixed at an angle of 45°. The inlet pipe is connected with the main water supply. Near the inlet a check valve is fixed to regulate the incoming water flow into the drum. The inlet pipe creates water circulation inside the drum. The surplus water goes out through the outlet, which is fixed at the top of the drum. The eggs are kept in the drum, and due to the water circulation the eggs are also circulated. A monofilament cloth with 60 mesh per inch at the outlet prevents the escape of eggs. After the hatching the egg shells get disintegrated and escape along with the surplus water. The hatchlings are found inside the drum and these are collected later. Due to the circulation of water plenty of dissolved oxygen is available to eggs and hatchlings. The percentage of hatching is about 90%.

6.3 D-variety Hatcheries

The seed production is dependent on nature, but the problem has now been solved with the evolving of a modern hatchery model CIFED- 81. It is now possible to breed fish without rains in this modern hatchery. Thus, we have become independent of the monsoons and natural environment. The broode

are kept in the breeding unit, while hatching is done in jars having control over silt, oxygen, temperature and metabolites. This hatchery system consists of breeding and hatchery units.

Breeding Unit: This unit consists of air conditioners, breeding tanks, sprayers, water current system, aeration system, water pumps, overhead tanks and a filter unit. The breeding unit is installed in an airconditioned room. An air conditioner of 1.5 ton capacity is used. The air-conditioned room may have an area of 22.5 sq.m. and two breeding tanks of 440 x 115 x 80 cm size each, for breeding 240 kg females in 30 operations in four months of breeding season. The breeding tanks are either plastic pools, LDPE tanks, cement tanks or fibreglass tanks. The breeding tanks are provided with fine 75 mm diameter showers and spray channels arranged around the upper edge of the tanks. The spray and showers have independent operating systems, but can be used simultaneously if required. The water in the breeding tank is recirculated by a 1/16 HP pump and oxygenated through spray and showers. In each of the breeding tanks two floating hapas 180 x 90 x 90cm in size are arranged. In each floating hapa a close net hapa of 170 x 80 x 80cm size with a mesh of 20mm and an opening for the introduction of injected brooders is fixed. In this system, 2.4 million eggs can be obtained in one operation.

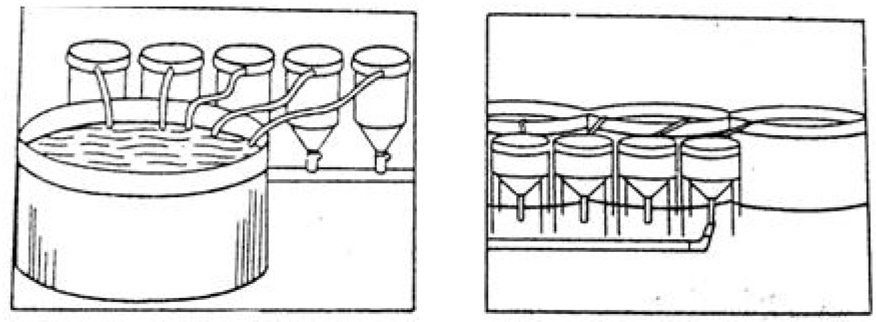


Fig. 6.5 D-variety hatchery model CIFE D-81 and CIFE D-85

Reservoir, pond or tube well water is directly pumped through the filter unit to remove silt and suspended solids into overhead tanks. Water is supplied to the breeding tanks through spray and showers from overhead tanks. The spray and showers increase the dissolved oxygen, keep the water cool and simulates natural conditions. Besides, aeration is also arranged by means of an oil free air compressor or blower.

Hatching unit: This unit consists of overhead tanks, vertical hatchery jars, oil free air compressor and blower, spawneries, spray and floating hapas. The hatchery is installed in a shed or building, where temperature can be maintained at 27-29° C. Aeration is arranged to increase the dissolved oxygen of water between 7-9 ppm. The hatchery jars are made up of low density polythene. The height of the jar is 62.5 cm, the upper part is 44 cm and the capacity is 40 litres. A 37 cm diameter pipe with a control valve is fitted below the jar. Each jar has an independent control valve. The outlet is found at the top of the jar. The jars are arranged in a series. An inner egg vessel of 20 litres capacity is used inside the hatchery jars for removing the egg shells after hatching. Every three jars are provided with a spawn receiving low density polyethylene tank of 1450 litres capacity, 6' diameter and 3' height. Water spray is arranged around the upper edge of each tank.

Spawn receiving tanks: The spawn receiving tanks are provided with 50 mm diameter overflow pipes, which are connected to the storage tank, from which the water is again pumped back to the overhead tank through a filter for recirculation. A fine meshed nylon floating hapa is arranged in the spawn receiving tank to accommodate the spawn. The spawn is received from the hatchery jars to this hapa through a 32mm diameter flexible PVC pipe to avoid any injury to the spawn. Showers and spray are provided to cool and aerate the water. Aeration is arranged in the hatchery jars and also in the spawn receiving hapa to increase the dissolved oxygen level, and the eggs are kept in floating condition in the egg vessel.

Operation of D-81 hatchery unit: Selected breeders are subjected to induced breeding and introduced in the breeding hapas. In case the water temperature is too high, the fishes are acclimatized gradually by lowering the temperature to 26-27° in the breeding unit. Then the spray and showers are started. The air-conditioner is put off when temperature reaches 26°C, but the spray and showers are kept in operation. After breeding takes place, the big meshed hapa is removed along with the spent brooders. The eggs remain in the breeding compartment of the hapa. After 5 hours the eggs are transferred to the hatching unit. After 4 hours of spawning the eggs are transferred to the egg vessel which is fixed in the hatchery jar. About 2 to 2.25 lakh eggs can be accommodated in each hatchery jar depending on the species. Continuous mild aeration and water flow are maintained in the jars for free floating of eggs. The rate of water flow is maintained at 1-2 litres/59 min.

The eggs hatch within 14 hours. When the hatching is complete, the egg container with the shells is removed. Then the flow rate of water in the jars is slightly increased for speedy transfer of the hatchlings into the spawn receiving tank. The remaining hatchlings if any are transferred into the hapa by siphoning with a 25 mm diameter pipe. Once the jar is emptied, water flow in the hatchery jars is stopped. The spray is arranged around the upper edge of the spawn receiving tank and is kept in operation to ensure high level of dissolved oxygen and low temperature. The aeration and spray are kept in operation continuously until the yolk sacs of the hatchlings are absorbed, which normally takes 2 days. The percentage of hatching is 93-98%.

The advantages are

1. Material used is low density polyethylene, hence difficult to break.
2. Easy to pack and transport to different interior places.
3. Controlled temperature system is introduced.
4. Metabolites are removed from the circulating water by filtration.
5. Due to the additional aeration, oxygen in water is raised to 7-9 ppm.
6. Even when fertilization of eggs is low, the hatching rate is high.
7. The system ensures breeding and hatching without rains and monsoon.
8. Due to the filtration, the water is free from sediments and silt.
9. Each jar has a provision for independent regulation of aeration and water flow. In case of mortality, pollution or disease in any of the jars, it can be isolated from the rest of the system.
10. The common carp eggs normally hatch in 72 hours, but in this system these hatch out within 42 hours.

This system has no disadvantages at all. During 1984, large size HDPE D-84 jars were used in place of polythene jars. HDPE D-84 jars of 160 litres water capacity and a loading capacity of 0.75 million have been designed and successfully operated with a 92-95% survival rate.

6.4 Chinese Hatchery

The Chinese spawning and hatching systems are based on continuous flow of water by gravity to breed carps and hatch the eggs. The cost of construction and operation of a Chinese hatchery is less when compared to any other design for die same production capacity. In India also, the Chinese hatchery system is now considered to be highly suitable for the production of quality fish seed. Chinese type of. Hatchery consists of four main components, viz., overhead water storage tank, the spawning/ breeding pond, incubation hatching pond and hatchling receiving pond. This system is designed for fish breeding and incubation. The water required for the hatchery system is regulated through the pipe supply

from an overhead tank. The duration of one operation for hatching is 4 days. It can be repeated after a period of 4 days.

Overhead water storage tank : The floor of the tank should be 2.6m. above ground level. The inside dimension should be 5.5 x 2.7 x 2.2m and it should have a 30,000 liters capacity. Water supply to the overhead tank should be arranged by pumping water from an open well or a deep tube-well. The overhead tank is used to supply sufficient water for the spawning, incubation and storage tanks. A smaller overhead tank with a 5,000 litres capacity is also useful for this type of an operation. Spawning pond: It is a circular masonary/ concrete pond with an inside diameter of 8 m. It has 50 cubic metres of water holding capacity. The inside depth at the periphery is 1.20 m. which slopes down to the centre at 1.50m. A water supply line is laid along the outside of the wall, and the inlet to the pond is provided at 14-16 places equally spaced and fixed at an angle of 45° to the radius of the tank using a 20 mm diameter pipe with a nozzle mouth, all arranged in one direction.

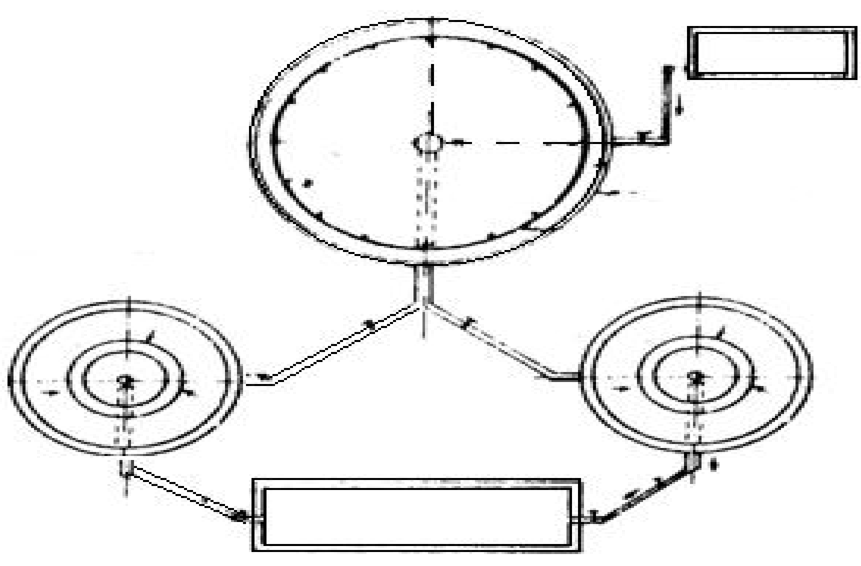


Fig. 6.6 Circular hatched system

These are fixed to the vertical wall and the nozzle mouth is flush with cement plaster face and near the bottom along the periphery of the pond. In the fitted through which, on opening the valve, fertilized eggs along with water are transferred into incubation pond for hatching. The water flow in the spawning pool create an artificial riverine condition for the fish to breed. The shower and a perforated galvanised iron pipe are useful to increase the dissolved oxygen About 70kg. of males and 70 kg. of females can be kept in the spanning tank which can yield 10 millions of eggs in one breeding operation. Incubation ponds: There are two circular incubation ponds each of 3.6 m. internal diameter. There are 2 chambers in each pond. The dimension of the outer chamber is 4 m.. having an outer masonry/ concrete wall. Another circular wall with a fixed nylon screen is provided at 0.76 m. clear distance from the outer wall. These tanks are about one metre in depth with 9-12 cubic metres of water holding capacity. They hold 70,000 million eggs/cubic metre. The inner chamber is provided with 10 cm diameter vertical outlets with holes at different heights for taking out excess of water of the incubation pond. The spawn along with water flows from these ponds to spawn collection pond.

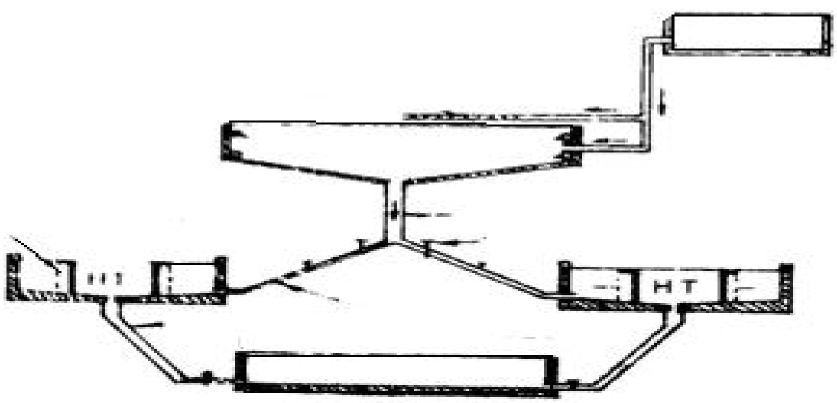


Fig. 6.7 Circular spawning pool

From the overhead tank., the initial 7.5 cm. diameter pipe line is reduced to a 5 cm. diameter pipe line, and then to a 1.2 cm. diameter pipe line. 8 number of outlets are fitted in the floor of the incubation pond, with each outlet having duck mouth opening fixed at an angle of 45° towards inner wall. All the outlets are fixed in one direction only. Water supply pipes are fitted from the circular spawning tank by a 10 cm. pipe line which is then bifurcated into 2 pipelines off cm. diameter each, one for each of the incubation tanks which are further connected to duck mouth outlets in the floor of incubation ponds. There is an outlet of 7.5 cm. diameter through which the hatchlings pass into the hatchling receiving pond. This opening is also used for complete dewatering of the outer chamber of the incubation pool. Desired water movement is about 0.2-0.3m/sec.

Hatchling receiving pond: This is a rectangular masonry concrete tank. The inside dimensions are 4 x 2.5 x 1.2m. This is located at a lower elevation than the incubation pond. So as to drain out the water from it by gravity, lift ground levels may permit. Fresh water supply from the overhead tank is provided

by a 7.5cm. diameter pipe line, bifurcated into 3 numbers of 3cm. diameter pipelines. These pipelines are arranged so as to provide the spray for aeration. From each of the incubation ponds 7.5 cm. diameter pipes are provided for transfering and regulating spawn intake into the spawn receiving pond. Hooks are fixed in two opposite side walls of the pond for fixing the net for the collection of spawn. Steps are also provided for getting into the pond for the collection of spawn. The overflow from this pond is discharged into an open drain and suitably utilized in the earthen ponds, if possible.

Operation of the Chinese hatchery: Brooders are kept in the spawning pond for about 4-8 hours for conditioning. Then between 4-6 PM, the first injection is given to the females. After 6 hours a second dose of injection is given *to the female and one dose to the male. After 4 hours of the injection, the water* jets are started so as to get the circular motion in the water. After 4-8 hours of the second injection, breeding takes place. One crore of eggs can be treated at a time in one operation. The eggs are collected from the bottom and are transferred into the incubation pools through pipes by opening the valves. Arrangements are made to chum the water again in the incubation pools. In 4 days time, the spawn is about 6 mm in size and then it is taken into the hatching' spawn receiving pool. From there it is lifted and stocked in separate water ponds until they reach the fry stage. If oxygen is less, aeration can be given through a compressor in the incubation pool at the rate of 6 kg/ cm2 run by a 1 HP motor. For aeration water showers, water jets, etc can also be provided depending upon the requirement. During the breeding season lasting about 120 days in a year, the breeding and hatching operations can be carried out in about 30 batches, each batch of 4 days. About one crore eggs can be hatched in one batch, and with a 95% hatching success, 285 million spawn of about 6 mm size can be produced. The main advantages are that the structures are of permanent nature, the hatchery is easy to operate and it needs less manpower.

Short Answer Questions :

1. What is Hatchery?
2. Name any two types of Hatcheries .
3. What is hatching hapa?
4. Draw the diagram of floating hapa.
5. Write main components of Chinese hatchery.
6. Why the Chinese hatchery more advantages than the vertical jar hatchery?
7. Write any two advantages of earthen hatching pits.
8. Write any two examples live feed.
9. Write any two advantages of D Variety hatchery.
10. Draw the label diagram of Chinese hatchery.

Long Answer type questions :

1. Describe the different types of seed hatcheries.
2. Explain the unit components and operation of D-Variety hatchery.
3. Explain the vertical jar hatchery with neat diagram.
4. Describe main components and operation of Chinese hatchery.

UNIT-7

Bundh Breeding

Structure

7.1 Introduction

In various countries, pond breeding species are generally preferred for fish culture as they do not involve the difficulties in the collection and transportation of young fish. But the widely cultured species of carps reputed for their very fast growth and culture conditions do not ordinarily breed in ponds and as such their young ones have necessarily to be collected mainly from the flooded rivers where these carps spawn annually during-the short monsoon season. Indian major carps ordinarily breed in flooded rivers during the south-west monsoon months of June to August. They also breed in reservoirs, tanks and irrigation dams. In the confined waters of ponds they do mature but do not breed. If these matured breeders are transferred from confined waters to semi-confined rain-fed ponds, where the pond bottom is of muddy nature, the fish breeds whenever there is a good rainfall and a drop in temperature of water. This indicates that the few factors which are responsible for breeding may not be found in the ponds. The semiconfined rain-fed seasonal water bodies have more dissolved oxygen, light, waves, water current and turbidity, and less temperature, which stimulate ovulation. Based on the above factors, the places where excess of rain water is used in creating riverine conditions, which stimulate ovulation in fishes, are known as bundhs. The bundhs are suitable places in producing fish seed.

7.2 Types of bundhs

The bundhs are of two types viz. wet and dry bundhs.

Wet bundh

These are also known as perennial bundhs. The wet bundh is a perennial pond located on the slope of a vast catchment area of undulating terrain with proper embankments having an inlet facing towards the upland and an outlet towards the opposite lower ends. During summer, only the deeper portion of the pond retains water containing breeders. The remaining portion is dry and is used for agriculture. After a heavy rain a major portion of the bundh gets submerged with water flowing in the form of streamlets from the catchment area and excess water flows out through the outlet. The fish starts spawning in such a stimulated natural condition in the shallow areas of a bundh.

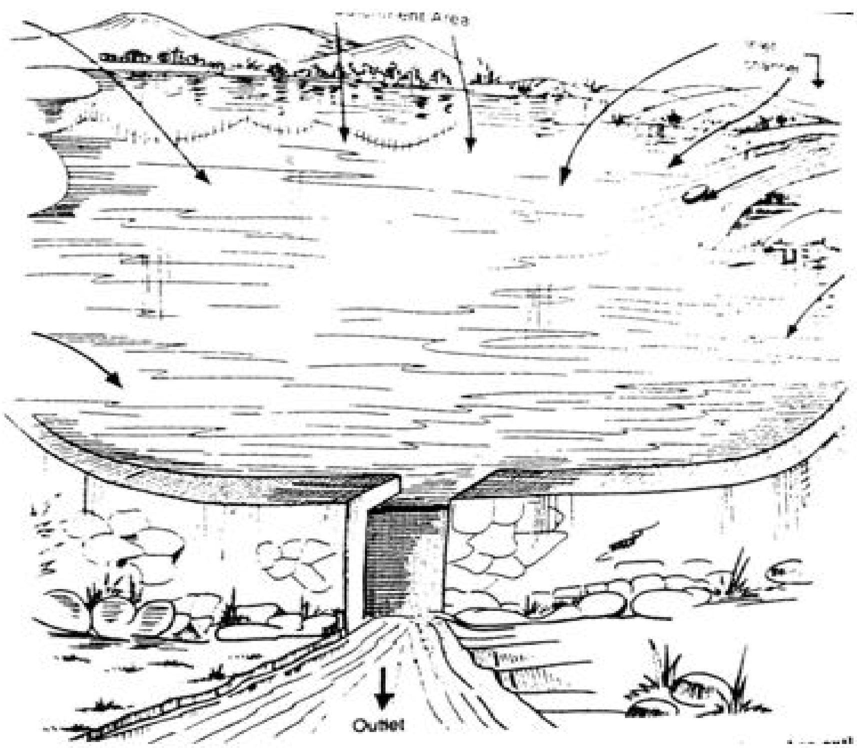
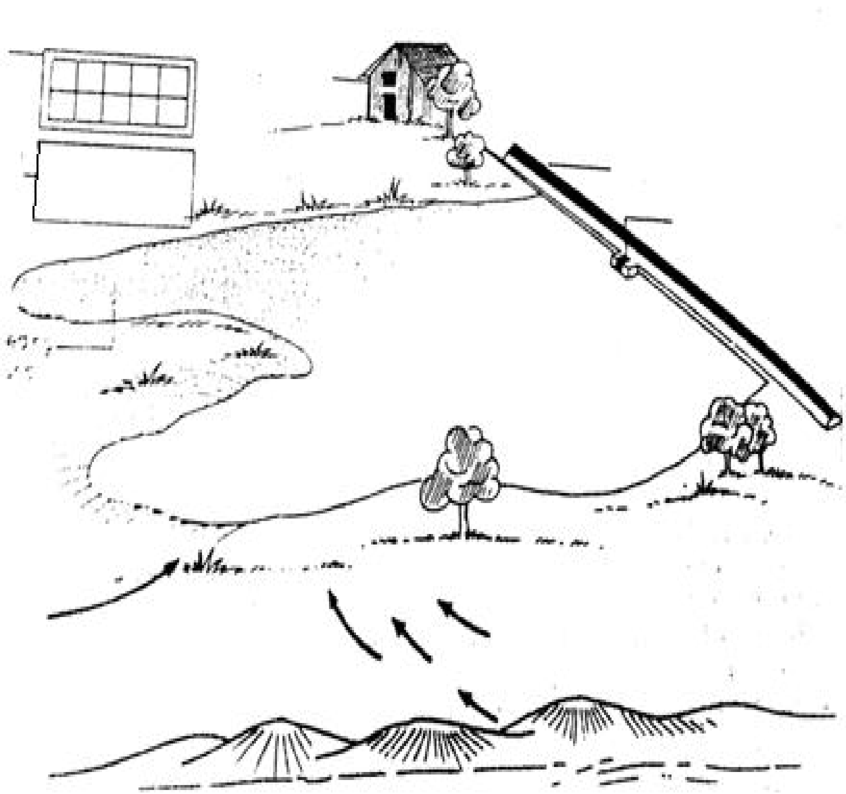


Fig. 7.1 Wet bundh

The outlet is protected by fencing to prevent the escape of breeders. The wet bundhs are comparatively much bigger in size than the dry bundhs. These are also known as perennial bundhs.

Dry bundh

A dry bundh is a shallow depression enclosed by an earthen wall, which is locally known as a bundh on three sides, and an extensive catchment area on the fourth. Bundhs get flooded during the monsoon, but remain completely dry for a considerable period during the remaining part of the year. These are seasonal rainfed water bodies, and are also known as seasonal bundhs. The topography of the land has a great role to play in the location and distribution of the dry bundhs. It is preferred to have undulated land because it provides a large catchment area and facilitates quick filling of the bundh even with a less rain, at the same time quick and easy drainage due to gravitation. In West Bengal, a catchment area of more than five times the bundh area is considered most suitable (Saha, 1977), whereas in Madhya Pradesh a ratio of 1:2.5 is considered essential (Dubey and Tuli, 1961). In Bankura district of West Bengal, most of the dry



bundhs are fed with water from storage tanks, constructed in the upland area.

Fig. 7.2 Dry bundh

Bundh breeding being practiced since a century has been given a greater importance. Since last three decades particularly after it has been reviewed in Madhya Pradesh, it has gained importance to such an extent that in some of the states like West Bengal, Rajasthan and Andhra Pradesh, besides rivers, the contribution of spawn production from bundhs is quite significant, particularly the spawn from dry bundhs as this source yields 100% pure spawn. It is known for its simplicity and mass production at one time.

7.3 Management of Bundh breeding

Site selection

The efficiency of the bundhs depends on many factors. The following criteria may be kept in mind when designing bundhs for fish breeding.

1. Extensive upland area from where, with heavy rains, considerable amount of rain water carrying soil and detritus enters the main pond.

2. The pond should have extensive shallow marginal areas which serve as ideal spawning grounds.

3. The soil should be of gritty nature which is considered to be the most suitable for the breeding of fishes.

4. Increase in oxygen contents of water which is due to the vast and shallow area of the pond.

The land should provide a place where a good sized pond can be made with a small dam. The place with a flat area surrounded on three sides by steep slopes should be selected. The fourth side, where the area drains out, should be as narrow as possible. The side slopes should constrict to shorten this up the construction area or axis of the dam.

Catchment area

A water shed with more than fifteen hectares of hard land for every hectare of water surface in the pond is considered essential. If the soil is retentive in nature, then forty hectares of watershed for each hectare of surface water is a better proposition. The fields must not erode. If the water shed is found either too big or too small even then it may be possible to correct the situation by using diversion terraces. .If water is more, excess watershed may often be cut off and the water disposed off elsewhere. If more water is needed, a diversion terrace will increase the effective water shed.

Embankment

The embankment must be constructed at the low level side. The slopes must be built on each side of the dam. On the lower side the slope should be 20%, i.e., two feet on horizontal distance for each foot of vertical rise. The upper or pond side slope requires more attention. If the fill material has a very high proportion of clay, it may safely be built to the 2 to 1 dimension. If it is loamy or silty or with any sand or gravel in it. this slope should be broadened out to 3 to 1. For one hectare pond, a minimum of 4 feet width is desired at the top and a free board of 2 feet is essential.

A spillway and sluice are a must in the bundhs also. The spillway or flood outlet is a surface drainage way that will carry surplus water during heavy rains. Without this, the whole dam may be lost by overlapping in some sudden monsoon cloudburst. It must be placed around one end of the dam in hard ground. When required the pond can be emptied completely with the help of sluice gates. Spillway and sluice should be provided with strong iron netting, so that the fishes may not escape from the breeding bundh.

Factors responsible for spawning

Hora (1945) stated that heavy monsoon and flood are the primary factors responsible for spawning of Indian major carps. The strong current is necessary to influence the breeding intensity of carps. Mookherjee (1945a) observed that a low depth of water is quite sufficient for fish breeding. Das and Dasgupta (1945) believed that the molecular pressure of water particles and silt on the body of natural breeders has a stimulating effect for spawning in conjunction with rising temperature. Dasan (1945) reported that monsoon floods from the hills, having a peculiar smell, specific chemicals and physical properties, were responsible for breeding of fishes in the bundhs. The availability of shallow ground was also considered to be a factor for spawning (Khan, 1947). According to Saha (1957), temperature has no specific influence on spawning, but cloudy days accompanied by thunder storm and rain seems to influence the spawning. Mookherji (1945) stated that pH and oxygen content of water do not influence spawning in fishes. Bundhs having highly turbid waters with a distinct red colour, low pH between 6.2-7.6, 5-8 ppm of dissolved oxygen, low total alkalinity and 27-290 C temperature provide favourable conditions for spawning in bundhs.

Fish breeding techniques

Rohu, catla, mrigal, common carp, silver carp and grass carps are used to breed in bundhs. 100% pure seed can be produced in bundhs. Besides, more seed can be produced at a time. Once the bundhs are constructed, they can be used for many years to get more profits.

The brooders are collected in May and stocked in storage tanks where they are kept sex wise till the first monsoon showers. As soon as water accumulates in the bundhs, a selected number of these breeders are introduced into these bundhs and a constant vigil is maintained. In the olden days no importance was given to maturity, sex ratio, etc. The techniques were improved later and the breeding was done with a better understanding of sex, ratio and number of breeders. Fully ripe females and males 1:2 in number and of 1:1 weight were introduced into the bundhs on rainy days. Successive spawning could also be achieved as many as 5 times in one season.

In the modern techniques few pairs of females and males are being injected with either pituitary, or HCG or ovaprim extract and are released in the bundhs. This process, “sympathetic breeding in dry bundhs” has been used in West Bengal. By this method of partial hypophysation all the limiting factors for spawning like rain, thunder, storm and current of water can be bypassed. It is reported that about 160-200 million spawn of major carps has been produced. Recently at Mogra, the farmers have created a cement pond of about 75* x 25'. The bottom of the pond is pucca, but divided into two portions possessing a gradual slope. When water is filled into the pond, the first part possesses about one meter depth of water an4 lower one has about 2 meters depth. The owners called it as West Bengal bundhs. The bottom is filled with 6" of fine river sand. Before releasing them into the pond, the male and female breeders are partially hypophysed. It is reported that 160-200 million spawn of major carps has been produced here.

Fish in bundhs generally commence to breed during the early hours of the morning and continue to breed throughout the day. Catla prefer deeper waters, when compared to rohu or mrigal, which breed in shallow waters varying in depth from 0.5-1 metre. In wet bundhs, the brooder stock may be maintained throughout the year or replenished prior to the monsoons. The brooders are generally not injected with pituitary extracts but are stimulated to breed due to the current of rainwater from the catchment area, like in the case of dry bundh breeding,

Collection and handling of eggs

As soon as breeding commences, arrangements for collection and hatching of eggs are made. The eggs are collected by pieces of nylon net or mosquito netting, cloth or gamcha after lowering the water level and hatched in the double walled hatching hapas, ordinarily fixed in the bundhs. Collection of all the eggs is impossible, especially in case of wet bundhs, due to its larger areas. About 70% of eggs can be collected .from the bundhs. In Madhya Pradesh, the hatching of eggs is carried out either in double-walled hatching hapas fixed in the bundh itself or in rectangular cement hatcheries measuring 2.4 x 1.2 xO.3 m. However, in West Bengal, the eggs are kept for hatching in specially dug out small earthen pits with mud plastered walls. The hatchlings are lifted from the pits by dragging muslin cloth pieces after 12 hours of hatching and are transferred to similarly prepared bigger earthen pits. The survival rate is about 35-40% in the hapas. It can be increased to 97% by using modern hatcheries.

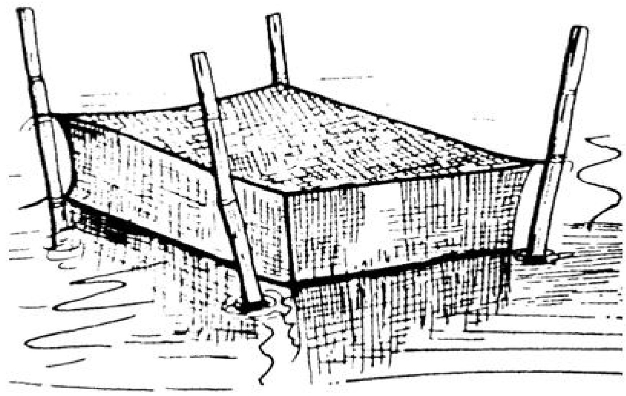


Fig. 7.3 A double hatching hapa

Improved features of dry bundhs

The dry bundhs can be improved keeping in view the following points:

1. Selecting shallow sloping depressions and undulating terrain of sandy soils with maximum catchment areas.
2. Constructing a small earthen bundh at the far end of the depression opposite to the catchment area so that water could be retained for a certain period. A maximum depth of 2 meters of water is maintained in the bundhs and a fine meshed wire netting protects any overflow water.
3. Constructing a battery of 10-20 rectangular cement hatcheries measuring 2.4 x 1.2 x0.3m.
4. Constructing a small double storied building which could serve as an observation tower cum store cum shelter.

7.4 Advantages and Disadvantages of Bundh

Advantages

1. Since major carps generally breed almost at any place in the shallow bundhs, it may be advantageous to prepare spawning grounds at different levels so as to get them flooded at different water levels in the bundh.

But, it is necessary to have the spawning ground away from the direction of the current.

2. A few storage tanks, cement cisternae or earthen ponds can also be provided adjacent to the bundhs to store the breeders temporarily prior to their introduction in the bundh.

Disadvantages

The problems encountered in bundh breeding are:

1. Sometimes it is difficult to coordinate the collection and hatching of large quantities of eggs at a time, particularly in the case of wet bundh breeding.
2. During egg collection from wet bundh, often unwanted fish spawn, and, predatory insect larvae, etc. are also collected.
3. In most cases, the hatching rate of eggs and survival of hatchlings upto the spawn stage have been poor, even when the fertilization rate of eggs was high. This could be improved by using modern hatchery techniques.
4. Presence of fairy shrimps (Streptocephalus sp. and Branchinella sp.) is in large numbers in dry bundhs particularly when breeding is late, i.e., three weeksof water accumulation during the collection of eggs. They can be controlled by sqjplying bleaching powder at the rate of 1 ppm on the first day of water accumulation,
5. Most of the dry bundhs primarily belong to the government. These are tasically meant for drinking water and irrigation purposes. Fish breeding in these bundhs is, therefore, a secondary activity. No control on the inflow and outflow af waters for fishery activities is possible.
6. The brood fish are mainly collected from the wild habitats for dry bundh breeding. Gillnets or cast nets are used for catching the brood fish thereby causing injuries to the brood fish.
7. Brood fish may carry some infection or injury.
8. When the rains are heavy after spawning is over the influx of water is so strong that much of the gonadal products are destroyed by mechanical injury.
9. Before the release of brood fish or at the time of spawning and development of the spawn, adequate attention is not paid to monitoring the water quality as regards dissolved gases, toxic substances and predatory organisms.
10. In the late monsoon with accumulation of more waters, some dry bundhs start overflowing, thus increasing the risk of loss of seed from the bundh.

11. In the post-monsoon months with receding water level, the fmgerlings are" exposed to the risk of predation by the birds.
12. In some dry bundhs having a uniformly flat basin, when the water is reduced to critical level, seed collection becomes difficult and there may be mortality due to rise in temperature and turbidity in shallow sheets of water caused by repeated netting operations.
13. Late harvest of fish seed with decreased amount of water further aggravates the problem of poaching.
14. The early major carps are voracious in their feeding habits. If adequate food is not made available to them they become cannibalistic, especially if there is a noticeable difference in the size groups.This is especially true when brood fish-are released in batches.
15. Often, when the dry bundh is supporting a good number of fish seed, water is drained out for irrigation purposes. This may also cause loss of sizeable stock from the dry bundh.
16. In most cases the spawn is allowed to stay uncared for in the dry bundh under natural conditions. If in excess, the silt, predatory insects and copepods cause heavy damage to the developing eggs and subsequently to the juvenile fishes.
17. When spawning occurs the water may recede to critical levels thereby exposing a large amount of eggs in the peripheral areas of dry bundh thus causing large scale mortality of spawn.

Economics

In an experiment in Nain Thallia, about 20 million eggs were produced per hectare. In Midnapore and Bankura. 75 lakhs of spawn was produced at a time, and 160-220 million spawn produced in a season. With the increasing pace in the creation of a large number of bundhs, it is necessary to mention that spawn production through dry bundhs, is quite economical. Many crops of seed can be easily obtained from one bundh in a season of 4 months. By utilising the rain water which would otherwise have been waste water, we can produce carp seed and reap good profits.

The bundhs are not only useful for fish breeding but also useful to culture fish after breeding. If the water is available for at least 6 months, those bundhs can be utilised to culture the fish. The fish seed of cultivable fishes can be introduced in the seasonal rain-fed bundhs and can be cultured for six months. Without providing supplementary feed and inorganic manures the yield can be about 1000kg/ha/6 months. By providing supplementary feed and inorganic manure the yield can be increased to about 2500kg/ha/6 months. It indicates that the bundhs are useful for both breeding and culture, and are highly profitable.

Short Answer Type Questions

1. What is bundh breeding?
2. Mention the types of bundhs in bundh breeding?
3. What is wet bundhs?
4. Write any two advantages of bundh breeding?
5. Mention any two disadvantages of bundh breeding?

Long Answer Type Questions

1. Describe the wet and dry bundh breeding?
2. Explain the fish breeding techniques and factors responsible for spawning in bundh breeding?

UNIT -8

Induced Maturation in Shrimp

Structure

8.1 Introduction

Spawners for hatchery production of prawn seeds were always collected from the commercial fishing grounds where they are known to mature and spawn. The collection of these spawners from the sea has been a serious problem as their availability is not only seasonal and uncertain but their procurement and transport expensive. The researches carried out at the NPCL of CMFRI have made it possible to mature and develop the spawners from the farm reared prawns. Adult prawns taken out from the grow-out ponds of the farm are subjected to unilateral eyestalk ablation and treated in special broodstock development pools where they attain full ~gonadial development and become ready to spawn. Using this technique several generations of the Indian White prawn Penaeus indicus, that have not gone to the sea during any phase of their life cycle, have been grown in the NPCL farm.

8.2 Induced Maturation in Shrimp

The important problem of shrimp farming is the shortage of pure and healthy shrimp seed. Most of the farmers depend on seed collection from natural resources. Obviously the availability of seed collected from natural sources is restricted to some areas and is seasonal. Further, the seed collected thus will be a mixture of economic and uneconomic seed. The separation of which is rather very difficult especially in early stages. Therefore, it is important to have shrimps hatcheries for ensuring the supply of adequate quantity of healthy seed to shrimp farmers. A pre-requisite for the effective production of shrimp seed is the availability of spawners in good conditions. The mature spawners are collected from the sea and are made to spawn in the fields and laboratory.

The shrimps are transported to the hatchery in 300liters containers. These shrimps are acclimatized to the hatchery conditions. After getting, the brooders keep them in ponds or tanks for spawning. If wild spawners are scare, the brood stock can be developed at the hatchery site for eye-stalk ablation technique. The shrimp breeders are most essential for shrimp hatchery unit. The development of the shrimps in hatcheries is mast important to attain self-sufficiency in seed requirement. Now-a-days healthy shrimps are selected from the culture system for breeding with the help of modern techniques. Moreover, breeding of prawn in captivity is that it involves considerable labour and cost. The process is time consuming and highly elaborates. Eye-stalk ablation technique is used for induced maturation in shrimps.

Eye-stalk ablation

Previously the mature spawners collected from the sea were made to spawn in the laboratory by a technique known as eye-stalk ablation. At present, the shrimps are selected from the culture system. With the perfection of the technique of eye-stalk ablation, the production of shrimp seed is increased enormously. No eye-stalk ablation is necessary in case of males. However, predation during moulting is pronounced if normal males are released with female with one or both eyes removed.

The egg production is a cyclic phenomenon. It is supposed to be controlled by hormones produced by the neuro-secretary centres of brain. The centre and thoracic ganglia produce gonado stimulating hormone (GSH), with promotes vitellogenesis. The X organ in the sinus gland complex situated on eye-stalk close to cornea produces a hormone known as gonad inhabitor hormone (GIH), which inhibits vitellogenesis. Based on this phenomenon the eye-stalk ablation technique has been developed to make the shrimps to mature in captivity.

Panonse (1943) was the first scientist to try ablation of the eye-stalk and to get ovarian development in Leander sarratus. Maturation and spawning of Penaeus monodon has been induced first time in India in brackish water ponds at Bakkah fish farm West Bengal.

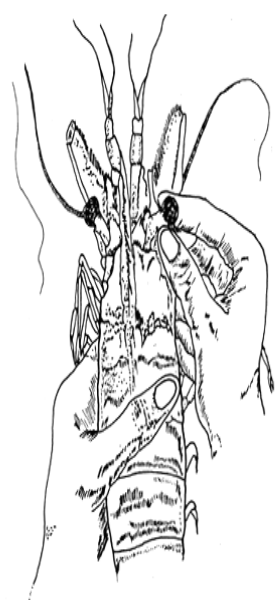
The culturable varieties of shrimp are generally collected either from sea pr from brackish water culture system. Usually the shrimp nearing maturity are selected for eye-stalk ablation. They are acclimatized in the laboratory in well aerated sea water prior to the removal of eye-stalk.

Methods of eye-stalk ablation

The removal of eye-stalk is done by more than one method. These are as follows.

1. Pinching of the eye-stalk is done with the help of forefinger and thumb nails.
2. Squeezing out the contents.
3. Crushing the eye-stalk.
4. Cutting the eye-stalk with bent scissors.
5. Serving the eye-stalk with a razor.
6. Ligation of eye-stalk with a thread.
7. Cauterization with electro-cattery apparatus.

a. Incision of eye



b. Press

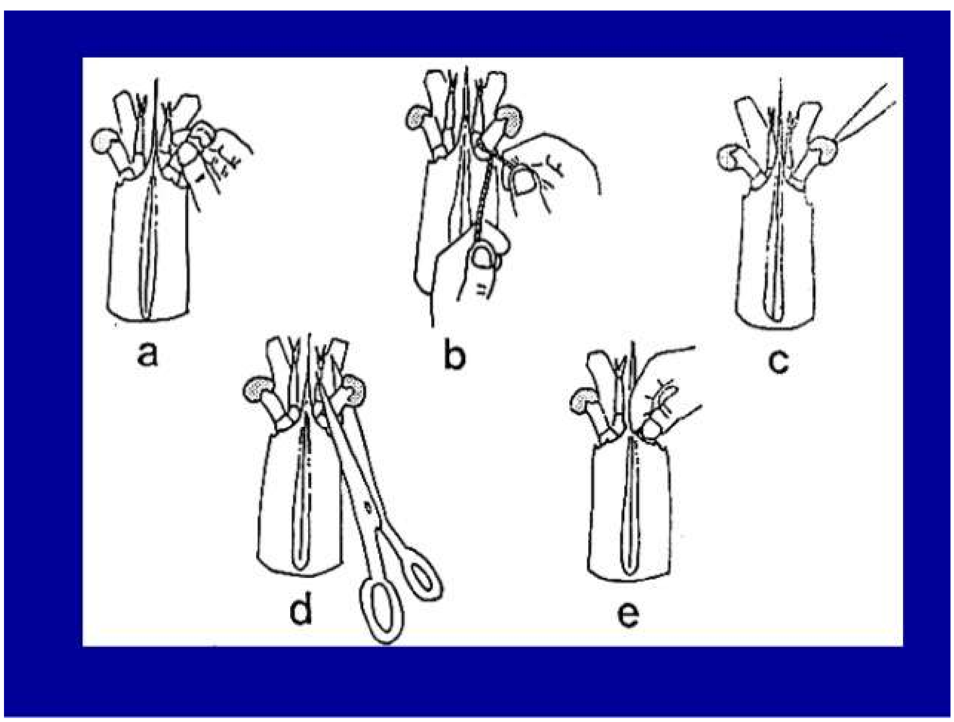


Fig. Eyestalc abilation techniques

Improved techniques of Caterisation followed recently ensure a higher survival rate of the spawners. The electro-catery apparatus which are used for this technique and only removes the eye-stalk but also seals the cut end so that the loss of blood during this process is minimized to obtain cent percent survival. In other methods loss of blood occurs, leading to weakness, and mortality.

Usually only one eye is ablated because bilateral eye-stalk ablation increases the mortality percentage. Single eye-stalk is removed and eye ablated shrimps are kept in the maturation pools along with a few males. Generally for every male four females are kept in the maturation pool. After Caterisation, care is taken to maintain optimum water condition during maturation. The optimum levels are as follows.

Salinity	-	28-35ppt	pH	-	8 - 8.2
Temperature	-	28-32^{O}C	O_2	-	4 – 5.5ppm

Within a week the females get matured. If the females are impregnated the male shrimps are to be removed from the pool.

8.3 Induced maturation technology

Operational details

Large sized *P.indicus* (over 140 mm in size) caught from the grow-out ponds are acclimatised in 32-34 ppt settled and filtered seawater kept in one ton capcity plastic pools for a day. After acclimatization the females are selected and one eye'! stalk of each of them is removed by using an electro-cautery apparatus. Mortality caused by the procedure is negligible. The cauterised females and half the number of acclimatised males are transferred to the maturation facility for gonadial maturation. The facility consists of 10 ton capacity circular seawater tanks fitted with sub-gravel biological filters with air-lift recirculation arrangement for maintaining the quality of the seawater. The biological filter converts the toxic ammonia excreted by the prawns into relatively harmless nitrates and maintains water quality.

The pH of the seawater is adjusted to remain at 8.2. The prawns are fed ad libitum with fresh clam meat. Under these conditions the females mature within 3-5 days after eyestalk removal and then they are transferred to the spawning tanks of the hatchery. About 75% of ablated females develop mature ovaries and spawn viable eggs.

Production

40 females and 20 males of *P.indicus* are kept in a 10 ton capacity broodstock pool. On an average 30 spawners will be ready fot spawning in 3-5 days and each spawner will produce not less than 1,00,000 nauplii i.e. 3 million nauplii from each pool. If daily production is required the number of brood stock pools should be increased to 5 or 6. At present, NPCL has 3 brood stock pools.

Inventory and cost

The maturation facility is to be considered as part of a hatchery meant to produce prawn seeds. The special inventory required for the maturation facility for a daily production of 3 million nauplii consisting of pools, filters, compressors,pumps, chemicals and testing equipments will cost around Rs. 0.5 million; the land and building will cost **25** around Rs. 0.5million and contingencies including salary component, labour, maintenance, feed, seawater pumping cost, etc. will cost around Rs.0.5million; totalling to about Rs.1.5 million. However this cost can be considerably reduced when the project is undertaken as part of a hatchery project.

Estimated cost of production

It is difficult to estimate cost of production in view of the fact that the broodstock pools form part of a hatchery utilizing many of its general facilities. However the production cost per spawner may not exceed Rs.5.

Prospects

A maturation facility, as an integral part of the hatchery, ensures a steady supply of spawners and helps efficient planning of hatchery operations to produce prawn seeds on a large scale. In a developed state it may be possible to sell spawners to nearby hatcheries or even sell newly hatched nauplii to those having only rearing facilities.

6.4 Physiological changes after induced maturation

Physiological changes after induced maturation.

1. Sinus gland produces GIH and MIH (moulting inhibiting hormones) which inhibits goandial maturation and moulting. GIH acts opposite to GSH. When eye-stalk is ablated only GSH remains in the body which promotes vitellogenesis.

2. Declining levels or MIH might have produced conductive conditions for the actions of the moulting hormone (MH). Eye-stalk ablation accelerated moulting. Frequency in both the sexes has resulted in shortening of intermoult period. Destalking also increases the frequency of berried moults.

3. The growth of body also increased in destalking shrimps. Growth of males is faster than females.

3. The egg production also increased in ablated prawns. Sometimes in *M. malcomsonii* this increase is almost double.

5. Growth acceleration, frequent moulting and increased egg output are all energy demanding processes. To acquire this extra energy, the ablated shrimps have to be hyperphagic or efficient converters.

6. Glycogen decreases in heptapancease and muscles in ablated shrimp in contrast to control.

7. Ascorbic acid levels are increased in destalked shrimps. Ascorbic acid is involved in oxidation-reduction reactions. Its higher levels may be due to increased demand of the tissues for oxidation-reduction process to meet the increased rate of oxygen uptake. Bilateral extripation of the eye-stalk increases the normal oxygen consumption as much as 60%.

8. Cholesterol levels are also higher in ablated shrimps. The increase may be due to mobilization glycogen to lipid or due to the formation of new tissues when the cholesterol content increases.

The ovary and other organs of Decapoda have been extensively documented (Bell and Lightner, 1988; Zhao et al., 1998; Deng, 2000), while the morphology and function of the shrimp oviduct have not been well studied. The oviduct of penaeid shrimp is considered to play a role not only in carrying the mature eggs from the ovary to the gonopore during spawning but also in the secretion of some molecules (Talbot and Helluy, 1995; Yu and Lu, 2005). The possible substances secreted from the oviduct may play various physiological roles in the female reproductive system, such as lubrication of the oviduct, participation in oocyte maturation, and induction of capacitation of sperm stored in the female seminal receptacle.

Short Answer Type Questions

1. What is eye stalk ablation?
2. What is the use of biological filters in what is X-organ?
3. What is X-Organ?
4. Write the optimum levels of salinity and temperature of water during maturation of shrimp?
5. What is cauterization what its use?
6. Mention any two methods of Eye-stalk ablation?
7. What are GIH and GSH in shrimps?
8. Write any two physiological changes after induced maturation in shrimp?

Long Answer Type Questions

1. Describe induced maturation technology in shrimp?
2. Explain the methods of eye-stalk ablation?
3. Write the physiological changes after induced maturation in shrimp?

Unit-9
Prawn Hatchery Management

Structure

9.1 Introduction :-

In India about 2.2 million ha. Of Brackish water fish and prawn cultivable land is available. So far only 50,000 ha. Of the above land is concerted into fish and prawn culture farms, which was facing already scarcity of prawn seed from natural sources. For a full fledged extension of Brackish water aquaculture in the above said total available land, the basic requirement is steady supply of young prawn larvae. The estimated prawn seed required for all the stocking available 50,000 ha. Of Brackish water area in our country (which is under culture at present) is worked out as 600 crores if prawn seed for four crops (at a stocking density rate of 30,000/ha.). The development of prawn hatchery has most important role for intensive prawn farming in India, since limited numbers of prawn seed can be obtained directly from natural resources.

A person should know the following aspects.

1. Site selection 2. Hatchery Facilities and equipment. 3.Brood stock selection. 4. Egg collection and 5. Hatching and identification or larvae 6. Larval rearing techniques 7. Harvest of (fry) post larvae 8. Diseases.

9.2 Criteria for the selection of site

Selection of site plays very important role for running a hatchery successfully, for selecting a suitable site, consider the following aspects. A. Brood stock source B. Location C. Climate D. Sea water quality and supply E. Power Supply F. freshwater supply G. Transportation facilities.

Brood stock supply: It is ideal for hatcheries to be near the source of wild spawners and brood stock. Wild spawners (mother Shrimps) is usually caught with a shrimp trawl, trawling time is usually kept limited, so as to avoid stress on mother prawns. Only sprawners with late maturing or mature ovaries are selected for hatchery. If wild sprawners are scarce, the brood stock can be developed at the hatchery site by eye-stalk ablation techniques.

Location: the penaeid hatchery should be located near the sea shore where clean water can be pumped easily and economically. The site must be free from pollution that is away sources of Agricultural. Biological and Industrial wastes.

Climate: The prospective hatchery must be located in areas relatively dry from November to April and wet during rest of the year. This type of climate will help in providing optimum temperature (28 – 30 C)

Sea water quality: Sea water for hatchery must have salinity range from 30 ppt to 35 ppt, which must be free from any type of pollution.

Power supply: Continuous power supply is essential during the entire larval period for running Air blower/aerator, pumps, lights and other domestic equipment used in the hatchery. Better to have a stand by generator in case of power failure. According to CMFRI (1985) report a 10 KVA 3 phase generator operated by 16H.P. diesel motor is necessary tor in a 35 million of PL 5 per year.

Fresh water supply: Continuous freshwater supply is necessary in the hatchery for lowering salinity when acclimating post larvae, to reduce the salinity from 35ppt to 30ppt, for washing and for the uses in the hatchery.

Transportation facilities: The hatchery should be connected with food transportation facilities with railway or road for seed lifting and to transport of materials and other required things for hatchery.

Hatchery facilities and equipment: Prawn hatchery should have complete facilities and necessary equipment for successful operation. It should have suitable tanks for larval and post larval rearing, Algal or phytoplankton and Zooplankton culture, air and sea water supply systems.

Tanks for rearing of larvae and post larvae: Larval tank capacity varies from 1 to 20 tones. For economical operation, a larval rearing tank should have a water capacity of 3-5 tons, while a postlarval (nursery) rearing tank should held 6-10 tons, both at 1 m depth, one 3 ton larval tank can hold from 1,50,000 to 3,00,000 nauplii obtained from a single spawner.

Algal culture (or) phytoplankton tanks: Small and shallow tanks of not more than 1 ton capacity and about 0.5 m deep are in use for algal or phytoplankton culture. This is because adequate light is necessary for faster algal growth the tanks may also be mad of bamboo and plastic materials.

Aeration supply: Aeration is most essential in a hatchery to provide oxygen in the culture water and to keep larvae and food in suspension. It is may be commonly supplied by an electric blower/a compressor, or a portable aerator.

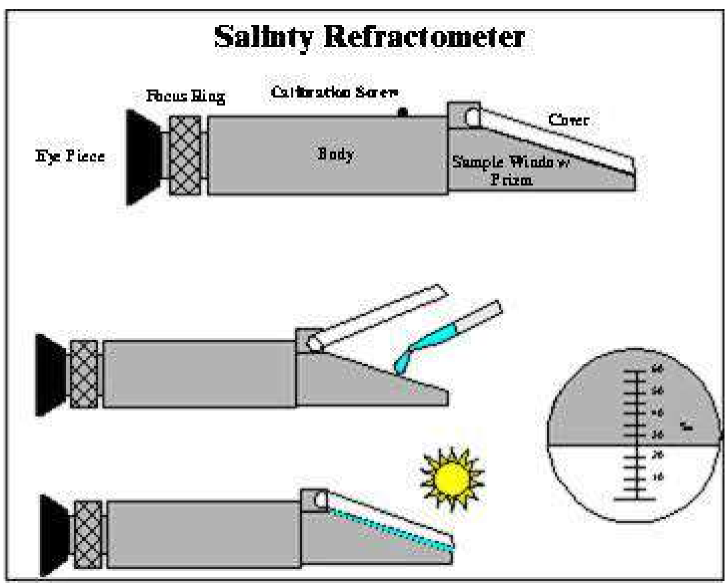
According to CMFRI (1985) report to run a 35 million PL5 capacity per year, which requires a 5 H.P. Air blower capable of delivering 160 cu.m of air/ hour. At a pressure of 0.3 kg/cm.

Sea Water Supply: Using a single suction line laid a few feet above the sea bed. The intake pipe opening should be fitted with screen to prevent fish and other unwanted organisms from being sucked in. Pumped water directed to the hatchery where it may be thoroughly filtered before use. This filtered sea water should be free from turbidity, debris and other undesirable marine organism. This filtered water should pumped to the overhead tank. These overhead tanks serve as a desiltation tank PVC or brass pipes used for the distribution of sea water from the overhead storage tank.

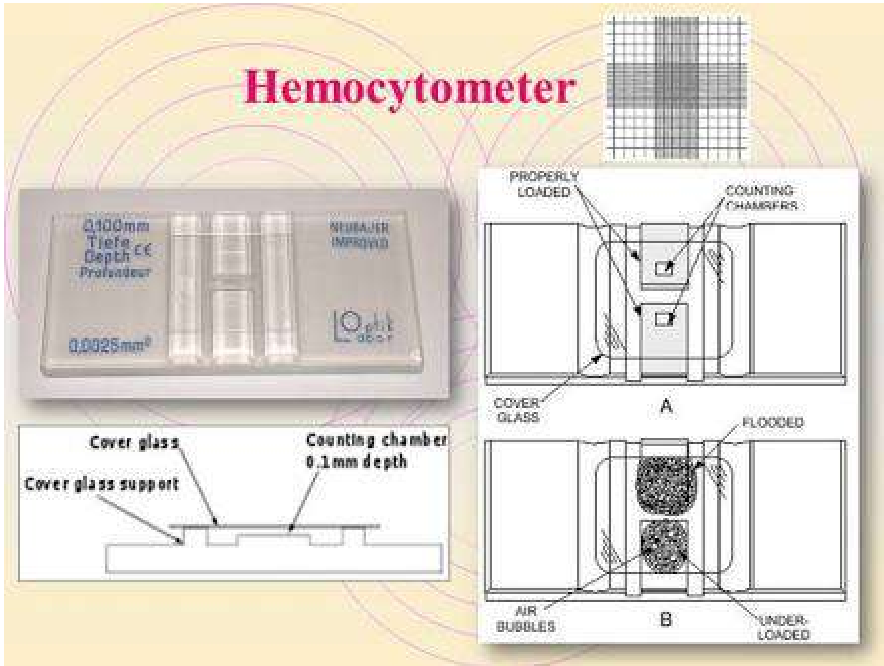
Building: A concrete building is advised for hatchery. Building (shed) can be constructed by using inexpensive and locally available materials such as Nipa, Coconut and palmirah lumbs can be used tic instruct building to house larval rearing tanks. Nursery tanks may be placed outdoors and covered individually with plastic sheet or canvas provide areas for monitoring, storage and for technicians quarters, for round the clock availability.

9.3 Hatchery equipment: The basic equipment needed in a hatchery are:

Refractometer/Hydrometer: Required for monitoring the salinity from time to time in larval tanks and in the water storage tanks.



Thermometer: Thermometer is required for monitoring the temperature of the water in the larval tanks.



Heamocytometer: Heamocytometer is required for counting algal cells.

Refrigerator: For storing stock cultures of Algal and other feeds for larval and post larval stages.

Microscope: Required for monitoring the conditions of larval and feed density

Air Diffusers: Air diffuser stones are used for serration in the larval tanks.

Scoopnets: Used for scooping larval of fry from tanks or from harvesting box.

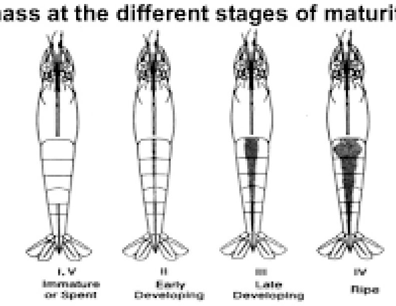
Harvest box: to use for harvest of fry (post larvae).

Drainers: Drainers various types and mesh sizes for draining the water, during the water exchange.

Glass beaker: Beaker or any other transparent container of 200 ml to 1 lt. for counting, feeding and checking of the condition of larvae.

9.4 Brood stock selection: In the selection marine prawn brood stock, only gravid female (female prawn carrying full of riped eggs) will be selected, since mating already take place in the sea. The brood stock selected by technicians from the wild catch, for which the following desirable characteristics. The prawn should have a clear outline of the ovary when observed from the back. The matured ovary can be seen as three knobs in the anterior part of the abdomen. The ovary should extend until distal part of the abdomen. An ovary which does not reach the distal part of the abdomen is considered to have spawned partially. The colour of the ovary is in dark green/light yellow/light green, which differs from prawn to prawn. The sprawning success of the middle size group (20 cm in length and 80 Gms in weight) is very good. 70 prawns of brood stock are put in 200m tank for spawning.

Fig. 2. The appearance of the ovarian mass at the different stages of maturity.



Egg collection and cleaning: After spawning the eggs have to be taken out from the spawning tank. At the same time the eggs also cleaned by washing thoroughly, to remove the rose colour substance. This rose cleaning material comes along with eggs during spawing. If proper cleaning is not attended very soon the larvae get infection. The broodstock may be checked after spawning, dead females and spawners should be removed. The aeration in the spawner tank should be adjusted so as to weakly bubble the water. The egg collection time usually occurred in nights though it depends on the spawning condition of the brood stock. The number estimation after sucking up the eggs using an air hose, put this method needs judgment by experience.

9.5 Rearing and Identification of larvae: fertilized eggs are hatched into oval shape free swimming larvae known as Nauplius. One middle size female releases 3, 00,000 eggs and percentage of hatching is estimated 80%.

Larval Rearing :-

From the Spawning tank sample of eggs are counted to determine the number of eggs spawned for female in normal condition, fertilized eggs hatched within 12 to 15 hours the hatching rate is measured by assessing the number of hatched nauplii. Nauplii are then transferred directly into the 40 ton tanks if the number of nauplii is between 0.5 million to 1 million they are then reared directly in the large tank up to the 25th post larval day. On the other hand, if the number of nauplii is less than 0.5million, they are stocked in 2.5 ton indoor tanks at density of 100 to 150 larvae/lt. The larvae are reared either to the third mysis stage (M3) or one day old (PL1) post larvae. They are then transferred to the outdoor 40 ton nursery tanks for further nursing.

1. **nauplius**: After hatching the newly hatched nauplii are stocked at a density of 100 to 150 nauplii per liter in the 2.5 ton larval rearing tons with fresh filtered sea water filling upto ¾ th of tank capacity no feed is required at the nauplii stage since the nauplius still utilizes its yolk as food . Prawn larvae moults repeatedly and metamorphose in the following manner. The first larval stage, Nauplius stage undergo five moultings to reach Nauplius VI Stage (NI to B VI) of course in some species it is different.

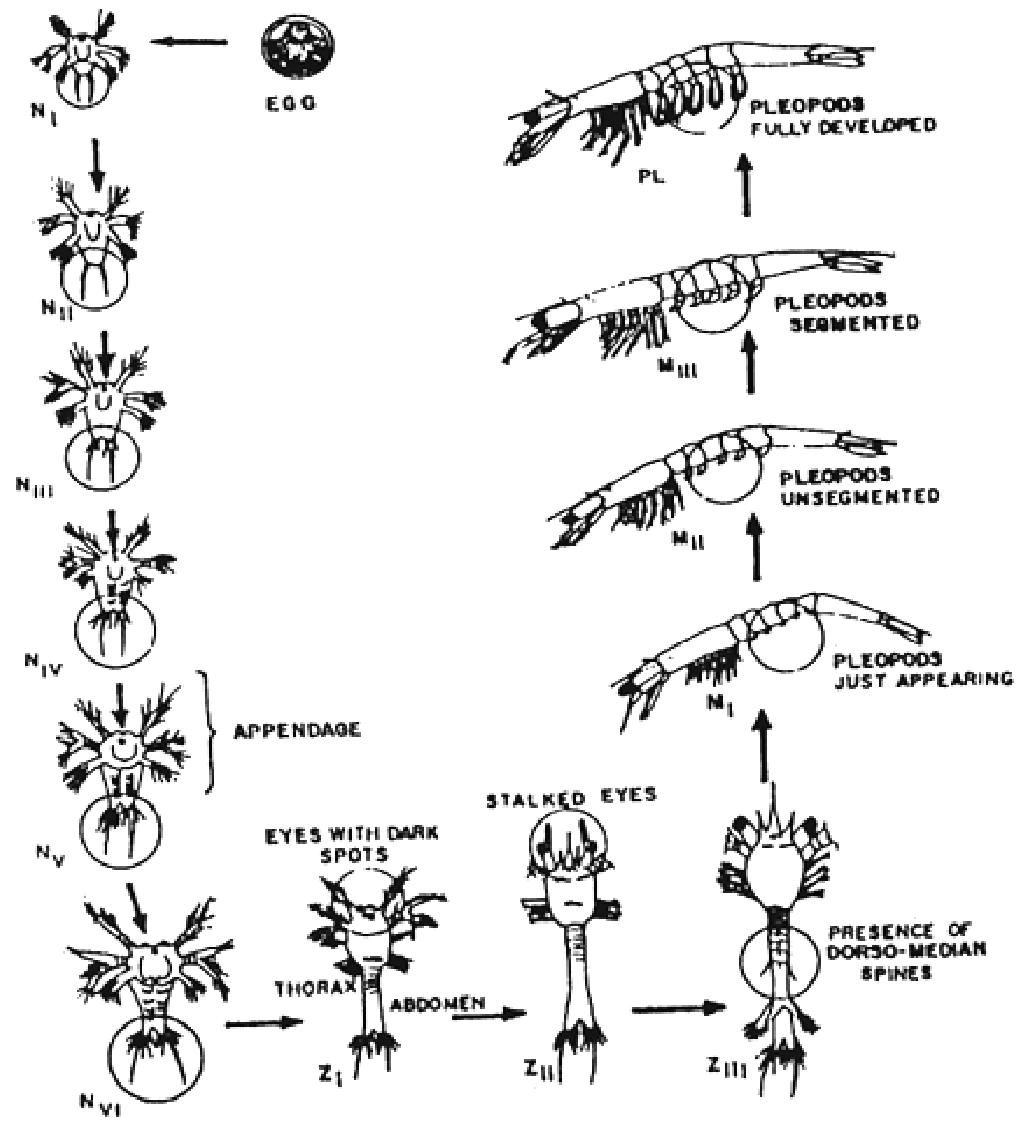
2. Zoea stage :-The larvae at this stage starts feeding on external food and feed on minute and easily digested microscopic algae such as skeletonema costatum, chatoceros etc. Zoea second larval stage after completing nauplius, has three sub stages, Zoea I to Zoea III, third stage Mysis also has three substages, Mysis I to III, and the last stage postlarvae stage in which there is no substages. For the cycle from hatching to reach postlarvae stage, it takes about 12 to 20 days.

3. Mysis stage:- The larvae at this stage will start feeding on rotifers or the brine shrimp. Nauplii required depends on the density of shrimp larvae being reared. Each mysis larve consumes about 100 to 200 rotifers or about 20 to 50 artemia nauplii per day.

4. Postlarvae stage:- Early post larval stages (p1-p6) are fed with brine shrimp nauplii at a rate of 100-200 per postlarvae per day. Once the post larvae reached the 6th day is fed with finely minced mussel or cockle meat are larval pellet feed. While Artemia feeding is stopped at p9. Beyond this stage the larvae are fed solely on minced mussel or cockle meat 3 to 4 time daily.

Apperance of appendages in zoes, Mysis and post Larvae stage is as follows
Page No. 349

Fig. Shrimp larval stages



Identification characters of shrimp larval stages:-

Zoea Stage

1. Eyes are sessile, body distinct as head, thorax and tail.
2. Eyes protrude.
3. Appearance of dorsal median spines and uropod development

Mysis Stage

1. Pleopods not fully developed.
2. Pleopods buds make appearance.
3. Pleopods segmented.

Post larval stage

Pleopods with serri, in this stage all characters resembles with adult prawn except sexual organs.

9.6 Artemia Culture

The brine shrimp (Artemia) is in the phylum Arthropoda, class Crustacea. Artemia are zooplankton, like copepods and Daphnia, which are used as live food in the aquarium trade and for marine finfish and crustacean larval culture.

There are more than 50 geographical strains of Artemia. Many commercial harvesters and distributors sell brands of various qualities. Approximately 90 percent of the world's commercial harvest of brine shrimp cysts (the dormant stage) comes from the Great Salt Lake in Utah. However, the lake's cyst production is heavily influenced by freshwater inflow, and the supply varies dramatically. The cost of good quality cysts fluctuates with supply and demand; buyers might expect to pay $12 to $40 or more per pound (1/2 kg). Normally 200,000 to 300,000 nauplii might hatch from each gram of high quality cysts. This publication describes the process of hatching Artemia cysts for use as larval food for cultured species, and the benefits of Artemia as a food source.

Background

Artemia are extremely euryhaline, withstanding salinities from 3ppt to 300ppt. They can even survive short periods of time in freshwater, but cannot reproduce in it. Artemia survive temperatures ranging from 15 to 55^{o}C (59 to 13 ^{o}F). They have two modes of reproduction. Sometimes nauplii (first Artemia swimming stage) hatch in the ovisac of the mother and are born live.

However, when the body of water where adult Artemia are living begins to dry up and salinities rise, embryos are encased in a hard capsule, or cyst, so that they are protected and can hatch later when conditions are better. The cyst is 200 to 300 micrometers in diameter, depending upon the strain. Its external layer is a hard, dark brown shell. Dry conditions cause the encysted embryo to enter a dormant state, which allows it to withstand complete drying, temperatures over 100^{o}C (212^{o}F) or near absolute zero, high energy radiation, and a variety of organic solvents. The dehydrated cyst can be stored for months or years without loss of hatchability. Only water and oxygen are required to initiate the normal development of the Artemia embryo, but it does help the hatch rate to maintain the temperature above 25^{o}C (77^{o}F) and place a light near the eggs. The durable, easily hatched cyst makes Artemia a convenient, constantly accessible source of live feed for the finfish hatchery operator. Artemia cysts are best stored in a tightly sealed container in a cool, dry environment and, if possible, vacuum packed.

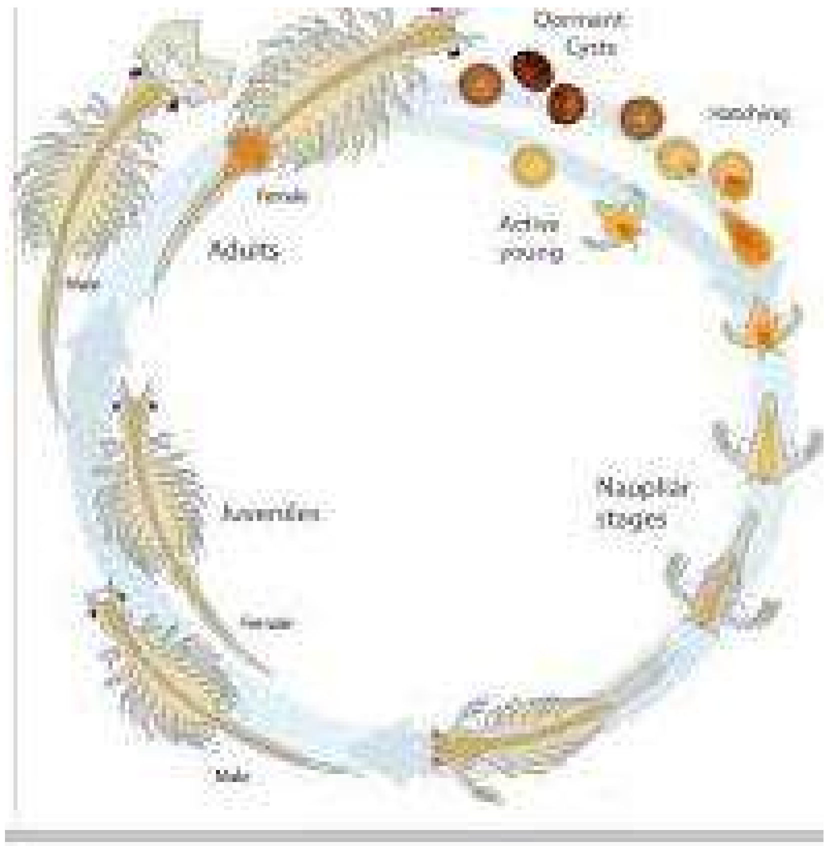


Fig. life stages

Artemia

Within 15 to 20 hours after being placed in seawater at 28^{o}C (82^{o}F), the shell breaks and the pre nauplius in E-1 stage appears (Fig. 1a). For the first few hours, the embryo hangs beneath the cyst shell in what is called the umbrella stage. The newly hatched Artemia relies on its yolk sac for nutrients because its mouth and anus are not fully developed. The pre-nauplius E-2 stage (Fig. 1b) is then released as a free-swimming nauplius (Fig. 1c) called an Instar 1 nauplius.
In this stage it is brownish orange because of its yolk reserves. It uses specially modified antennae for locomotion and later for food filtering.

Approximately 12 hours after hatch it molts into the second larval stage (Instar II) and starts filter feeding on microalgae, bacteria and detritus. The Artemia nauplius can live on yolk and stored re - serves for up to 5 days or through the Instar V stage (Fig. 1d), but its caloric and protein content diminish during this time. The nauplius progresses through 15 molts before reaching adulthood in approximately 8 days.

Optimum conditions for hatching Artemia cysts:-

The optimal conditions for hatching Artemia are: 1) temperature above 25^oC (77^oF), with 28^oC (82^oF) being optimum; 2) salinity of 5ppt (1.030 density); 3) heavy, continuous aeration; 4) constant illumination (example: two 40- watt fluorescent bulbs for a series of four 1-liter hatching cones); and 5) a pH of about 8. Stocking density is set by adding no more than 5 grams of cysts per liter of water. Good circulation is needed to keep the cysts in suspension. A container that is V-shaped or cone-shaped is best (2-liter bottles work well; glue a valve on the bottle cap and invert it). The best container is a separation column, found in any lab supply, although it is more expensive. Un hatched cysts, empty shells and hatched nauplii can be easily removed separately. The hatching percentage and density are usually a function of water quality, circulation, and the origin of the cysts.

Preparation and use of Artemia

There are seven tasks involved in feeding Artemia to larvae.

1. Determine the weight of Artemia cysts required to feed the larvae in a tank of known volume.

2. Hydrate and decapsulate cysts (decapsulation is optional, but recommended).

3. Incubate cysts.

4. Separate cysts from shells and debris (not necessary if cysts were decapsulated).

5. Count the hatched Artemia.

6. Calculate the number of Artemia remaining in the rearing tank from the previous feeding.

7. Calculate the number of Artemia nauplii required by the larvae and transfer them to the rearing tank.

Be careful with step number 6, as remaining nauplii may have little nutritional value and may need to be flushed out of the system.

Details of each of the tasks will be discussed in the following small scale example. Materials and equipment needed are:

•Artemia cysts

•Two 250-ml (8.5-fluid ounce) beakers

•Distilled water

•Household bleach

•Sodium hydroxide (NaOH)

•1-liter settling column

•Low-pressure air supply (aquarium pump)

•Seawater or equivalent (salinity of 5 to 32 ppt)

•Siphon tube (approximately 4 feet long) or a valve at the bottom of the cone.

•1-ml pipette

•10-ml pipette

9.7 Culture of diatoms:-

Introduction:-

Unicellular marine microalgae (Figure 12) are grown as food for the various stages in the hatchery culture of commercially valuable shellfish. Until recently living algae constituted the sole food source for bivalve larvae and juveniles. This is now beginning to change as the result of recent research into the development of suitable non-living and artificial diets. However, the production of live algae will remain a critically important aspect of successful hatchery management into the foreseeable future, if only as a live food supplement to innovative foodstuffs.

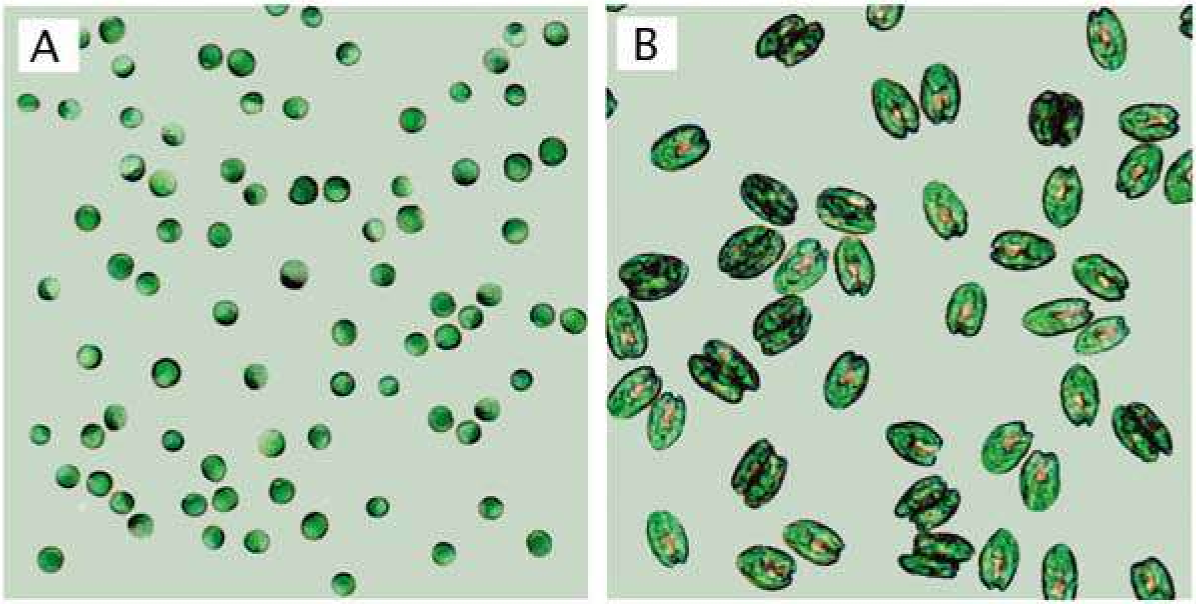


Figure 12: Photomicrographs of two algal species commonly cultured in hatcheries, *Isochrysis* sp. (**A**) and *Tetraselmis* sp. (**B**) showing the relative difference in cell size.

Flagellate and diatom species, among the microalgae, are primary producers at the base of the marine food chain. They manufacture organic cellular components from the uptake of carbon dioxide and nutrients contained in seawater using light as the energy source in a process called photosynthesis. They are normally cultured in hatcheries in suitably treated natural seawater enriched with additional nutrients, which include nitrates, phosphates, essential trace elements, vitamins and carbon dioxide as the carbon source. Synthetic seawater may be used but it is prohibitively expensive except at the small laboratory scale.

The need to culture microalgae arises because the natural phytoplankton content of seawater used in the hatchery is insufficient to support optimum growth of high densities of larvae and juveniles reared. Particularly in the culture of larvae, the water treatments used will remove almost all of the natural phytoplankton which then needs to be replaced from cultures of preferred, high food value species. In this context, and in the provision of suitable food rations for breeding stock and juveniles, few of the very many naturally occurring algae are of good food value to bivalves and not all of these are amenable to artificial culture on a sufficiently large scale. A list of the more commonly used species in bivalve hatcheries is given in Table 1. Parameters of cell size and composition are also shown.

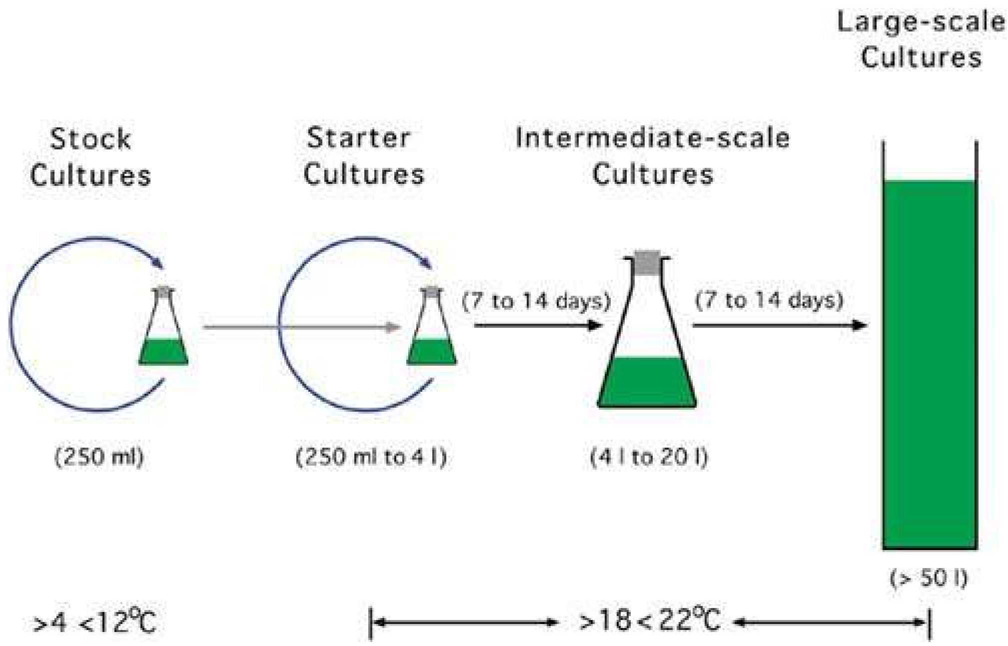
Table 1: The cell volume, organic weight and gross lipid content of some of the more commonly cultured algal species used as foods for bivalve larvae and spat. Species marked * are of relatively poor nutritional value.

The culture of algae accounts for about 40%

Species:	Median cell volume (μm^3)	Organic Wt. (μg 10^{-6} cells)	Lipid %
Diatoms:			
Chaetoceros calcitrans	35	7	17
Chaetoceros gracilis	80	30	19
Thalassiosira pseudonana	45	22	24
Skeletonema costatum	85	29	13
*Phaeodactylum tricornutum**	40	23	12

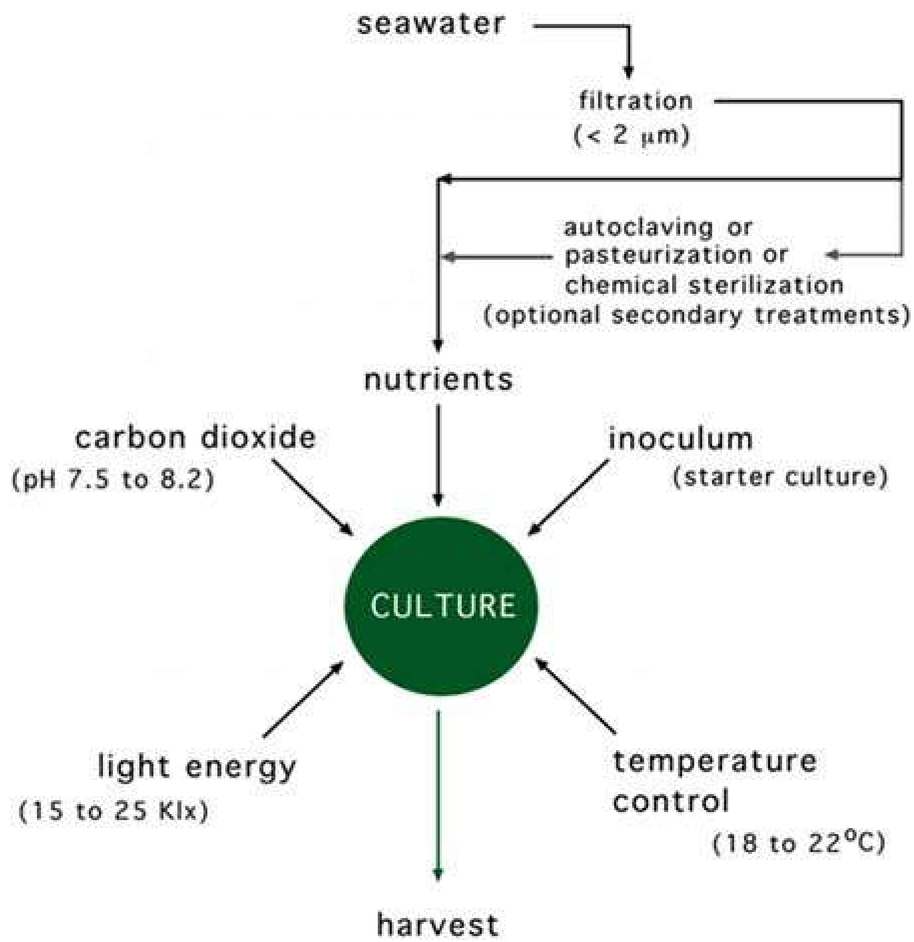
of the costs of rearing bivalve seed to a shell length of about 5 mm in a hatchery. For example, 1 million juvenile Manila clams or Pacific oysters of 5 mm shell length will consume 14,00l of high density, cultured algae each day at the optimum rearing temperature of 24°C. Smaller daily volumes are required to feed brood stock and larvae.

The basic methods of algal culture have changed little over the years and the various steps in the process leading to production-scale cultures are introduced in Figure 13. Hatcheries have either opted for indoor, intensive culture with artificial illumination, usually external to the culture vessels, or outdoor, extensive culture in large tanks or ponds utilizing natural light. The intensive techniques are satisfactory in terms of reliability and productivity but are expensive in terms of capital outlay and labour, while the extensive methods tend to be less reliable and, sometimes not very productive. Both methods will be considered together with the essential infrastructure and methodologies. A schematic diagram of the process of culturing algae is given in Figure 14 and a floor plan of a hatchery showing the area allocated to algal culture.



Steps in the production of algae.

Stock cultures (250 ml or less) remain in isolation under light and climate control (low temperature) and are only used to inoculate starter cultures when necessary. They are not aerated nor is carbon dioxide added. Starter cultures (250ml to 4lml in volume) are grown quickly for 7 to 14 days at higher temperatures and light intensity with a supply of carbon dioxide enriched air. When ready, a small portion of the volume is used to start a new starter culture and the main portion to begin an intermediate-scale culture. Intermediate scale cultures (usually of between 4l to 20l ml in volume) may be used as food for larvae or to start a large-scale culture. Large-scale cultures are generally of a minimum of 50l and are frequently much greater in volume.



The process of algal culture showing the various required inputs. Whether secondary seawater treatment is necessary or not depends on the extent to which the water is initially filtered.

Maintenance of Stock and Starter Cultures

Stock cultures, otherwise known as master cultures, of the preferred species are the basic foundation of culture. They are normally supplied as mono specific (uni-algal) cultures from reputable culture collections maintained by national institutions or research laboratories. Since they are valuable, they are normally kept in specialized maintenance media, for example, Erdschreiber, or alternatively in F/2 media, or on nutrient enriched agar plates or slopes, under closely controlled conditions of temperature and illumination. A special area or room off the algal culture room is usually allocated to this purpose.

Stock cultures are used only to provide lines of starter cultures (also known as inocula) when required. Every effort should be made to minimize the risk of contaminating the stock and starter cultures with competing microorganisms. The sterile procedures described below should be followed to ensure that contamination does not occur.

Stock cultures are kept in small, transparent, autoclavable containers. For example, 500ml borosilicate glass, flat-bottomed boiling or conical flasks fitted with a cotton wool plug at the neck, suitable for containing 250ml of sterile, autoclaved medium, are ideal. The composition and preparation of Erdschreiber medium is given in Table 2. Alternate media suitable for the purpose are Guillard's F/2. Proprietary algal culture enrichment products for addition to suitably treated seawater can also be used according to the manufacturer's instructions. Stock cultures are also often maintained in seawater agar medium impregnated with suitable nutrients in Petri dishes or on slopes in test tubes.

Stock cultures are best kept in a cooled incubator at 4 to 12°C (according to preference), illuminated by two or more 8-watt (W) fluorescent lamps that provide a light intensity of 450lux measured at the culture surface. Alternatively they can be kept in cool conditions close to a north-facing window (out of direct sunlight), or in a cool room illuminated by fluorescent lamps. The objective is not to allow rapid growth , but to maintain the cultures in good condition. The cultures are not aerated nor is carbon dioxide introduced.

3.2.1 Procedures for the management of stock cultures

It is necessary to sub-culture stock cultures at monthly intervals to maintain them in a vigorous and healthy state. Following removal of the cotton wool plug from a stock culture flask and flaming the neck of the flask with a Bunsen burner (or butane torch), an inoculum of 20 to 50ml is decanted into another sterile flask containing autoclaved medium. The plug is inserted after flaming of the neck of this new flask. Species name and the date are indelibly marked on the flask, which is then returned to the incubator. The original stock culture can be kept for a few weeks in the event that the new stock culture fails to grow. The stock culture transfer procedure is best performed in a cabinet that has been sterilized by ultra-violet light to further reduce the risk of contamination. Details of the transfer procedure are given in the accompanying box.

Short Answer Type Questions

1. What is nauplius?
2. How aeration done in hatchery?
3. Write the use of refract meter and Heamocytometer in shrimp hatchery?
4. How can you identify the maturity of shrimp?
5. Name the larval stages of shrimp?
6. Write the identification characters of Zoea?
7. What is Artemia?
8. What are the optimum conditions for hatching of Artemia cysts?
9. Write two examples of microalgae?
10. Write live feed used in shrimp hatchery?

Long Answer Type Questions

1. Describe the criteria for the selection of site for shrimp hatchery?
2. Explain the equipment used in shrimp hatchery?
3. Write short note on

a) Shrimp brood stock selection b) Shrimp egg collection and cleaning
c) Identification of larval stages

4. Describe the Artemia culture?
5. Describe the Diatom culture?

FISHERIES

I YEAR

PART B – VOCATIONALSUBJECTS
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PAPER– I TAXONOMY, ECOLOGYAND BIOLOGYOF FISHES

PERIODS/WEEK: 04 **PERIODS/YEAR:135**

S.No	NAME OF THE UNIT	No. of Periods	Weightage in marks	Short answer questions	Essay/ Problem questions
1.	Introduction to Taxonomy, Ecology and Biology Of Fish and Prawn	10	0 4	2	-
2.	Identification of Fish, Classification and General characters of fish and Prawn	16	10	02	1 .
3.	Ecosystem and Limnology of , Pond, Reservoir, River, Estuarine , Marine, abiotic and biotic factors. energy flow, food chain and web, Trophic levels and ecological pyramids, productivity,	14	10	2	1
4.	Soil – Types, abiotic and biotic factors	10	8	1	1
5.	Bio-geochemical cycles- Gaseous, Sedimentary cycles and Aquatic pollution and its effect on Fisheries	14	10	2	1
6.	Exoskeleton and endskeleton of fish and prawn . exoskeleton,	17	10	2	1
7.	Digestive System and Physiology of fish and prawn .	10	8	1	1
8.	Respiratory and Circulatory system of fish and prawn.	14	10	2	1
9.	Excretory and Reproductive system of Fish and Prawnn	14	10	2	1
10.	Nervous system and Endocrine System of Fish and Prawn.	16	10	2	1
	Total	**135**			

FISHERIES
I YEAR
PART B – VOCATIONAL SUBJECTS
BLUE PRINT

PAPER – II PRINCIPLES OF FISHERIES AND AQUACULTURE

PERIODS/WEEK: 04 **PERIODS/YEAR:135**

S.No.	Name of the Unit	No. of Periods	Weightage in marks	Short answer questions	Essay/ Problem questions
1	Introduction of aquaculture - History, Scope, Present status of Fisheries in India and A.P. ,	10	8	1	1
2	Types of aquaculture - Freshwater, Brackish water, Mariculture	5	4	2	-
3	Culture System a) Open systems (Reservoir and large tanks) b) Semi-closed systems (Cages, Pens) c) Closed Systems (Ponds) d) Recirculatory systems	14	8	1	1
4	Cultivable fauna in aquaculture - Criteria for selection of fish, cultivable fishes, prawns, Lobsters, Crabs, Molluscs	15	10	2	1
5	Cultivable flora in Aquaculture – Azolla, Spirulina	10	8	1	1
6	Fish Biotechnology , Cryopreservation of gamets, Transgenic fish, Hybridization	13	10	2	1
7	Aquarium fabrication & maiontenance Study of acquarium fishes and prawns, Breeding of aquarium fishes.	13	10	2	1
8	Fishing craft and gear :- Types of craft and gears, gear material,fabrication and maintenance of gears.	20	16	2	2
9	Fishing methods – Electric fishing, Line fishing, Trawling , purse seining, gill netting, use of electronics in fishing	20	16	2	2
10	Fisheries Institutions – State & Central Government Institutions, Extension Services	15	10	2	1
	Total	**135**			

FISHERIES
I YEAR
PART B – VOCATIONAL SUBJECTS
BLUE PRINT
PAPER – III SEED PRODUCTION TECHNOLOGY

7PERIODS/WEEK: 04 **PERIODS/YEAR: 135**

S.No.	NAME OF THE UNIT 135	No. of Periods	Weightage in marks	Short answer questions	Essay/ Problem questions
1	Introduction – Importance of seed, present status of fish, prawn and shrimp seed production.	8	8	2	1
2	Life cycle of fish, prawn, shrimp and crab,	18	10	2	1
3	Seed resources in India – fish and shrimp seed resources	15	10	2	1
4	Seed procurement:- –Fish seed collection From natural resources. Influencing factors, Disadventages,Identification of major carp Seed. Seed transportation	22	16	2	2
5	Induced breeding in fishes :- Brood Stock Managemen Induced breeding agents – Hypophysation,HCG..,Obaprim/ovatide stripping, technique.	22	16	2	2
6	Fish hatchery management:- Types ohatcheries. chines hatchery-components and operation ,D-variety, Jar hatchery.	20	10	2	1
7.	Bundh Breding: Types of Bundhs managements Adventages and disadventages.	10	08	1	1
8.	Induced mature in prawn: Brood stock management, maturation technique,physiologi-Cal changes after induced maturation.	10	08	1	1
9.	Prawn Hetchery management:- Principles of prawn hatchery equipment, brood ,stock, selection,egg collection and larval raring. Culture of Artemia,Diatoms.	8	8	1	1
	Total	**135**			

FISHERIES

MODEL QUESTION PAPER

I –Year

PAPER - I TAXONOMY, ECOLOGY AND BIOLOGY OF FISHES

Time: 3 Hours **Max. Marks: 50**

SECTION-A

Note: (i) Answer all the Questions
(ii) Each Question carries 2 marks **10X2=20**

1. Define Digestion?
2. What is Fin Formula?
3. What type of nutrients found in the soil?
4. What is Eco-system?
5. Define Osmoregulation?
6. How many types of scales are found in fishes?
7. Define Taxonomy?
8. What are Gonadotrophic hormones?
9. What are the sources for aquatic pollution?.
10. How the accessory respiratoryorgans are useful for the fishes?

SECTION-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks **5X6=30**
(iii) Draw the Diagram

11. Describe the Digestive system of fish?
12. Describe the general characters of prawn?
13. What is the Composition of fish blood?
14. Give the mechanicism of excretion in fishes?.
15. Explain the structure and functions of fish heart?
16. Write the Life cycle of Prawn.?
17. discuss the Nitrogen cycle?
18. Explain the energy flow in Pond eco system?

FISHERIES
MODEL QUESTION PAPER
I –Year
PAPER - II PRINCIPLES OF FISHERIES AND AQUACULTURE

Time: 3 Hours **Max. Marks: 50**

SECTION-A

Note: (i) Answer all the Questions (ii) Each Question carries 2 marks **10X2=20**

1. Define the Aquaculture.
2. Name the Indian major carps?
3. How Azolla is useful for Aquaculture?
4. What is Brackish Water?
5. Give an examples of closed aquaculture system?
6. Name any four types of fishing nets?
7. Define Fisheries?
8. Name any four Or-nmental fishes
9. Define Cryopreservation?
10. What is Trawling?

SECTION-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks **5X6=30**
(iii) Draw the Diagram

11. Write an essay on Transgenic Fishes
12. Describe the biology of tigershrimp?
13. Describe the maintenance of acquarium?
14. Discuss the culture of spirulina?
15. How the fishing gear is protected?
16. Describe the role of electric fishing?
17 Describe the different types of fishing crafts?
18. Describe the fisheries research institutions in India?

FISHERIES
MODEL QUESTION PAPER
I –Year
PAPER - III SEED PRODUCTION TECHNOLOGY

Time: 3 Hours **Max. Marks: 50**

SECTION-A

Note: (i) Answer all the Questions (ii) Each Question carries 2 marks 10X2=20

1. Define Fecundity/
2. What is Bandh breeding?
3. What is induced maturation of shrimp
4. Write various stages of fish seed?
5. Define Hatchery?
6. What is the use of Artemia and Diatoms in aquaculture?
7. What are the Larval stages of prawn?
8. Name any two artificial induced harmones used in breeding of carps?
9. What are the components of Chines Hatcheries?
10. What are the components of shrimp hatchery?

SECTION-B

Note: (i) Answer any five Questions (ii) Each Question carries 6 marks 5X6=30
(iii) Draw the diagram

11.Describe the advantages and disadventages of bandh breeding?
12. Describe the present status of fish and prawn seed production
13.Describe the Life Cycle of Shrimp?
14.Describe the Eye-stalk ablation technology?
15. Describe the management of Chines hatchery?
16.What are the modes of seed transportation? Write the reasons for seed mortality?
17. What is induced breeding explain methodology with Ovaprim?
18 Discuss the management of B-81 hatchery?