DNR COLLEGE (A) BHIMAVARAM

DEPARTMENT: AQUA CULTURE

SEMESTER II

PAPER 2 BIOLOGY OF FIN FISH AND SHELL FISH

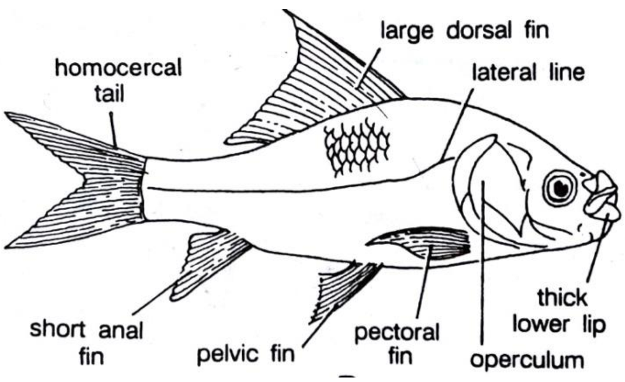
* Fish General Characters*

Definition: Fishes may be defined as aquatic cold blooded ectothermic vertebrates with a streamlined body, skin with or without scales and gills and fins for aquatic respiration and locomotion respectively.

The study branch of fishes is called **Ichthyology**.

Salient Features of the Fishes

1. Aquatic, ether freshwater or marine ectothermic vertebrates.
2. An exoskeleton of scales is usually present in fishes, but few species are even naked secondarily.
3. Integument contains mucous glands and chromatophores.
4. Skeleton is less massive than that of terrestrial vertebrates.
5. Organs of respiration are gills throughout life but accessory respiratory organs may also be present.
6. Gills are borne by true gill-arches. They are open outside by gill-slits, which are covered by operculum in teleostomi.
7. The gill-slits are usually five pairs but never more than seven pairs.
8. Lateral line system is well developed. It is sensitive to water current and changes in pressure and vibrations.
9. Endoskeleton is cartilaginous or bony.
10. There is no middle ear, only internal ear is present.
11. Eyelids and tear glands absent.
12. Fleshy muscular tongue is absent.
13. Visceral skeleton is well developed.
14. Locomotion by muscular contraction assisted by paired and unpaired fins which are supported by fin rays of dermal origin.
15. Paired visceral arches are present.
16. The kidney is of mesonepheric type.
17. Ten pairs of cranial nerves are present.
18. The gonads possess true gonoducts.
19. Unisexual organisms.
20. Development is indirect.



COMMERCIALLY IMPORTANT PRAWNS

1. Hippolysmata Ensirostris:
Hippolysmata Ensirostris is distributed in India (along the coasts) Myanmar, Sri Lanka and Sumatra

Maximum size – 80 mm

Fishery importance in India – Good fishery in Bombay and Godavari estuary areas.

2. Palaemon Styliferus (Rushna Chingri):
Distribution – Pakistan to Malay Archipelago. In India, present along the northern regions of both coasts.

Maximum size – 90 mm

Fishery importance in India – One of the most important fisheries of the Gangetic Delta.

3. Palaemon Tenuipes:

Distribution – India (northern regions of both coasts) to New Zealand through Malaysia.

Maximum size – 80 mm

Fishery importance in India – Another important fisheries in Bombay and Gangetic Delta.

4. Macrobrachium Malcomsonii:
Distribution – India and Myanmar. Present in the peninsular rivers of India and migrates into brackish waters during breeding season.

Maximum size – Male-230 mm Female-200 mm

Fishery importance in India – Fairly good fishery during monsoon in North-East Coast.

5. Macrobrachium Rosenbergii (Golda Chingri):
Distribution – Wide distribution, it extends from the Indo-Pacific zone up to Indo- China. In India common in lakes and estuaries.

Maximum size – 320 mm

Fishery importance in India – Very good fishery during the monsoon and post-monsoon months, particularly in Kerala.

6. Macrobrachium Rude:
Distribution – India (South-West Coast and East Coast), East Africa, Madagascar and Sri Lanka.

Maximum size – 130 mm

Fishery importance in India – Good seasonal fishery in Orissa. Bengal and Andhra Pradesh.

coast.

7. Metapenaeus Affinis:
Distribution – Found along the coasts of India. Indian seas to Malaysia, parts of Indonesia to Hong Kong and Japan.

Maximum size – 180 mm

Fishery importance in India – Very important fisheries along both the coasts. Juveniles are caught from estuaries.

8. Metapenaeus Monoceros (Honne Chingri):
Distribution – Along the entire coastline of India. Present in Mediterranean and Indian seas to Malaysia.

Maximum size – 180 mm

Fishery importance in India – Important fishery of commercial importance.

9. Penaeus Indicus (Chapda Chingri):
Distribution – All coastal waters of India. Found in India, Sri Lanka, Gulf of Aden, Madagascar, East Coast of Africa, Malaysia, Indonesia, Philippines, New Guinea and Northern Australia.

Maximum size – 230 mm

Fishery importance in India – Most important commercial species along all Indian Coast and also in estuaries.

10. Penaeus Monodon (Bagda Chingri):
Distribution – In India more common along the East Coast (Bengal and Orissa) and all along West Coast. It is present from South Africa to Southern Japan.

Maximum size – 320 mm

Fishery importance in India – Very important commercial species particularly in Bengal and Orissa. Present in West Coast but not as dominant as in the east.

11. Penaeus Semisulcatus (Hende Bagda):
Distribution – Widely distributed in Indo-West- Pacific in India, Malaysia, Indonesia, Australia (Northern and North-Eastern). New Guinea, Philippine Islands to Southern Japan. Common on the East Coast of India.

Maximum size – 250 mm

Fishery importance in India – Small fishery in East Coast. Very common in the 'bheri fisheries' of West Bengal due to its tolerance to wide salinity range.

12 Solenocera Hextii:
Distribution – Bay of Bengal (65 to 276 fathoms) and along entire West Coast in India.

Maximum size – 140 mm

Fishery importance in India – Fairly good fishery in West Bengal, Orissa and T. Nadu. Caught in large numbers (December to April) in Thiruvanantapuram coast.

CLASSIFY MOLLUSCANS WITH SUITABLE EXAMPLES

MOLLUSCA - DEFINITION

Molluscs (also know as mollusks) are soft-bodied, bilaterally symmetrical, segmented, coelomate animals; usually shelled having a mantle, ventral foot, anterior head, and a dorsal visceral mass.

Phylum Mollusca Classification

Mollusca (mollusks) are classified into 6 classes according to their symmetry and the characters of food, shell, mantle, gills, nervous system, muscles, and radula.

Class 1. Monoplacophora (Gr., monos, one+ plax, plate+ pherein, bearing)

- Body is bilaterally symmetrical and segmented.
- Mantle dome-shaped.
- The shell comprises a **single piece** or valve.
- Flattened limpet-shaped shell with spirally coiled Protoconch.
- Head without eyes and tentacles.
- Mantle encircles the body as a circular fold of the body.
- Foot broad and flat, with 8 pairs of pedal retractor muscles.
- Gills external. 5 pairs of gills in pallial grooves.
- 6 pairs of nephridia, two of which are gonoducts.
- Radula in a radular sac; intestine much coiled.
- Heart of 2 pairs of auricles and a single ventricle.
- Nervous system with longitudinal pallial and pedal cords.
- Sexes separate **(dioecious)**
- Examples: *Neopilina galatheae*.

Gastropoda (Gr., gaster, belly + podos, foot)

- Marine, freshwater, terrestrial and few parasitic on echinoderms.
- Body unsegmented, asymmetrical typically with univalve, **spirally coiled**
- Head distinct bearing tentacles, eyes, and mouth.
- The foot is ventral, broad, flat and muscular forming the creeping sole and often bearing dorsally a hard piece, the **operculum** on its posterior end.
- **Torsion** (coiling) of body mass at sometimes in development.
- The mantle is a collar-like fold of body wall lining the body leaving a space, the **mantle cavity**, between itself and the body.
- The buccal cavity contains an **odontophore** with a radula bearing rows of chitinous teeth.
- The digestive system comprises muscular pharynx, long esophagus, stomach, long coiled intestine, and anteriorly placed anus.
- Respiration by **gills (ctenidia)** in most forms, through the wall of the mantle cavity in some forms and in many by
- The open circulatory system and heart is enclosed in a pericardium.
- The excretory system comprises metanephridia which are paired in primitive forms and reduced to a single nephridium in most forms.
- The nervous system comprises distinct cerebral and pleural besides buccal, pedal, parietal and visceral ganglia.
- Sexes separate (dioecious) in most forms while in some forms united.
- The development includes **trochophore** and **veliger**
- Examples: *Crepidula* (slipper shell), *Pila* (apple snail),

Pelecypoda (Gr., pelekus, batchet+ podoa, foot)

- Aquatic, mostly marine, some freshwater forms.
- The body is bilaterally symmetrical and laterally compressed.
- Bivalve shells hinged together and mid-dorsally.
- Head is not distinct; pharynx, jaws, radula, and tentacles
- The foot is ventral, muscular which is ploughshare.
- **Mantle** bilobed, consisting of paired, right and left lobes.
- **Gills** or **ctenidia** are paired, one on each side.
- The coelom is reduced to a dorsally placed pericardium.
- The alimentary canal is coiled with large paired digestive glands.
- The heart is contained within the pericardium and comprises a median ventricle and two auricles.
- The excretory organ is paired nephridia or kidneys opens at one end into pericardium at the other end to the exterior.
- The nervous system consists typically of 4 pairs of ganglia i.e. cerebral, pleural, pedal and visceral.
- Cerebral and pleural of each side usually fused into a single Cerebro-pleural ganglion.
- Sense organs are statocyst and osphradia.
- Sexes are separate or united.
  - Mostly filter-feeding. Development is accompanied by **metamorphosis** which usually includes a **trochophore larva.** Examples: *Unio, Pecten, Ostraea*

* SENSE ORGANS IN CRUSTACEANS*

The sense organs include eyes, statocysts, tactile organs and olfactory setae.

Eyes:

The prawn bears two compound eyes. Each eye is a collection of a large number of visual elements called ommatidia and is borne on a movable stalk.

Structure (Fig. 25.13):

1. The outer convex transparent cuticular covering of the eye is known as cornea. The cornea is divided into a large number of square facets, each corresponding to a single ommatidium. The ommatidia are arranged regularly along the radii of the eye.

2. Each ommatidium is a complete visual unit, made up of cells arranged in end- to-end position along the long axis. Beneath the corneal facet is a pair of flat corneagen cells of epidermal origin which secrete a new cornea when the old one is lost during moulting.

3. Beneath the corneagen cells lie four tall cells—the cone cells—the inner borders of which give rise to a refractive crystalline cone.

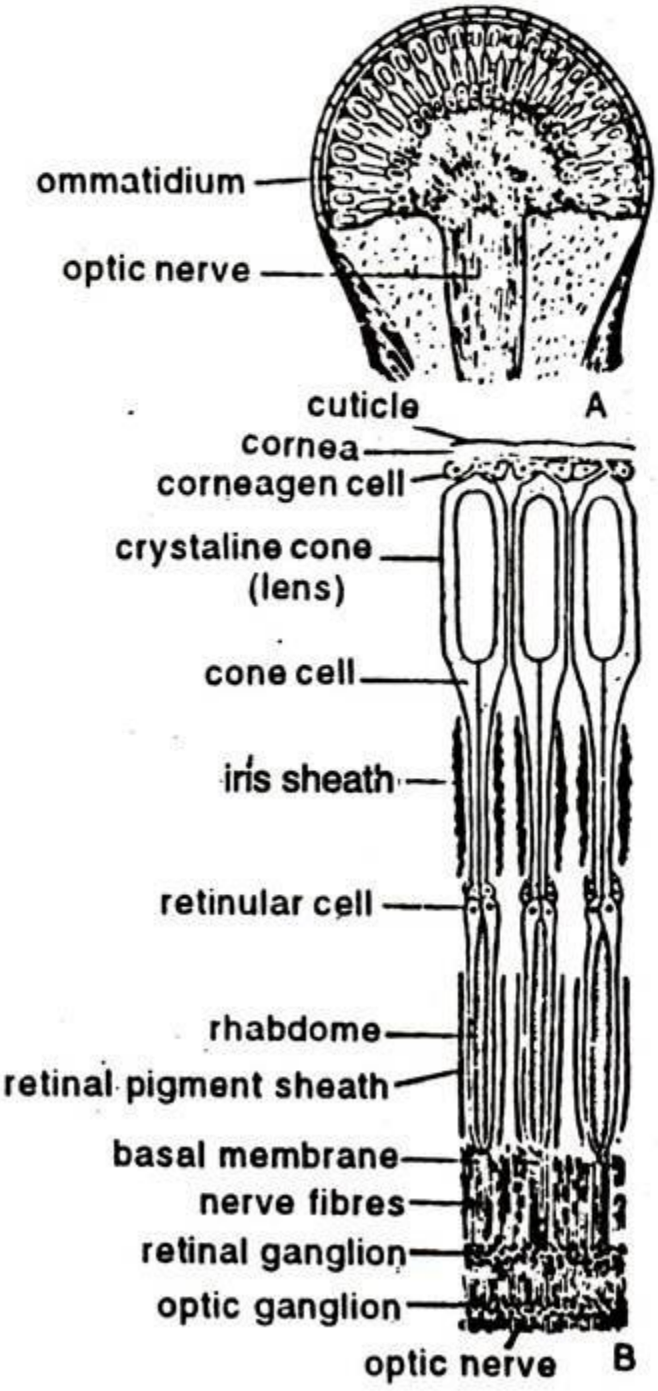


Fig. 25.13. Macrobrachium sp. Eye.
A. Vertical section. B. The same magnified showing three ommatidia

. The basal part of the ommatidium is made of spindle-shaped, transversely striated structure, the rhabdome, which is surrounded by seven elongated cells, the retinular cells. The rhabdome with the retinular cells are known as the retinula bearing a pigment, guanine, the nature of which is said to be of melanin.

5. The optic nerve breaks up into branches and innervate the retinular cells.

6. Each ommatidium is separated from its neighbours by a partition of pigment cells, the chromatophores.

These are arranged in two groups:

a. The distal group surrounding the lens and the cone cells constitute the Irish sheath.

b. The proximal group surrounding the retinula constitute the retinal sheath. The pigment sheaths can extend or retract under the influence of light. In bright light, they are extended and in weak light they are retracted.

Vision in Prawn:

In prawn, two types of visions are found. At daytime, when the intensity of light is high, the vision is of mosaic type. In the night, or dim light, when the intensity of light is less, the vision is of superimposed type.

1. Mosaic vision:

In bright light, the pigment sheath is extended and any jay, of light which falls obliquely on the ommatidium is absorbed by the pigment sheath. Almost parallel rays falling on each ommatidium from an object, reach the rhabdome and an image of a point of the object is formed.

Therefore many images of the many points of the object are formed. Such an image is known as apposition image. By the apposition-of those points of images in a number of ommatidia an erect image of the object is formed. In such a vision, any slight change of the object is quickly detected. Here, the sharpness of the image is dependent upon the number of ommatidia involved and the degree of their separation.

2. Superimposed vision:

In dim light, the pigment sheath is retracted and greater portion of the ommatidium is uncovered. Any ray of light striking obliquely on the sides of the ommatidium passes to the next and, in doing so, becomes refracted to reach the next ommatidium.

In such a case, an overlapping of points of lights occur and a superimposed image is formed, which is not sharp. The crystalline cones, capable of adjusting accordingly, act in unison and behave as a single unit and the whole of the retinal portion act as a single retina.

Statocysts of Prawn:

Statocysts are the balance organs. They are a pair, one in each antennule, located in the cavity of the precoxa or the basal segment.

1. A statocyst is a sub-spherical cuticular sac (Fig. 25.14A) attached to the inner surface of the dorsal wall of the precoxa and opens to the exterior through a narrow pore.

2. Sensory setae are arranged in the sac in the form of an oval ring.

3. Each seta has a swollen base and a pointed shaft bearing fine bristles (Fig. 25.14B).

4. Sand grains are present in the space surrounded by the setae.

5. The setae receive fine branches of statocyst nerve, which is a branch of the antennulary nerve.

During movement the sand grains are displaced with the change of position and press against certain setae, which helps the animal to correct its position.

Tactile Sense Organs:
They are present along the margins of the appendages, abundant in antennae and flattened portion of pleopods.

A tactile seta (Fig. 25.14C) consists of:
1. A hollow base or shaft connected to the appendage.

2. A tapering blade bearing double linear rows of tiny barbs is attached to the distal end of the shaft.

The sense organs carry sense of touch.

Olfactory Setae:
A seta is located on the small, middle feeler, between the two long feelers of an antennule.

It has:
1. A two-jointed shaft, proximally attached to the integument by a flexible membrane.

2. The free end of the distal segment is bluntly rounded and covered with a thin membrane (Fig 25. 14D).

3. Innervated by nerve fibres from the olfactory branch of the antennulary nerve.

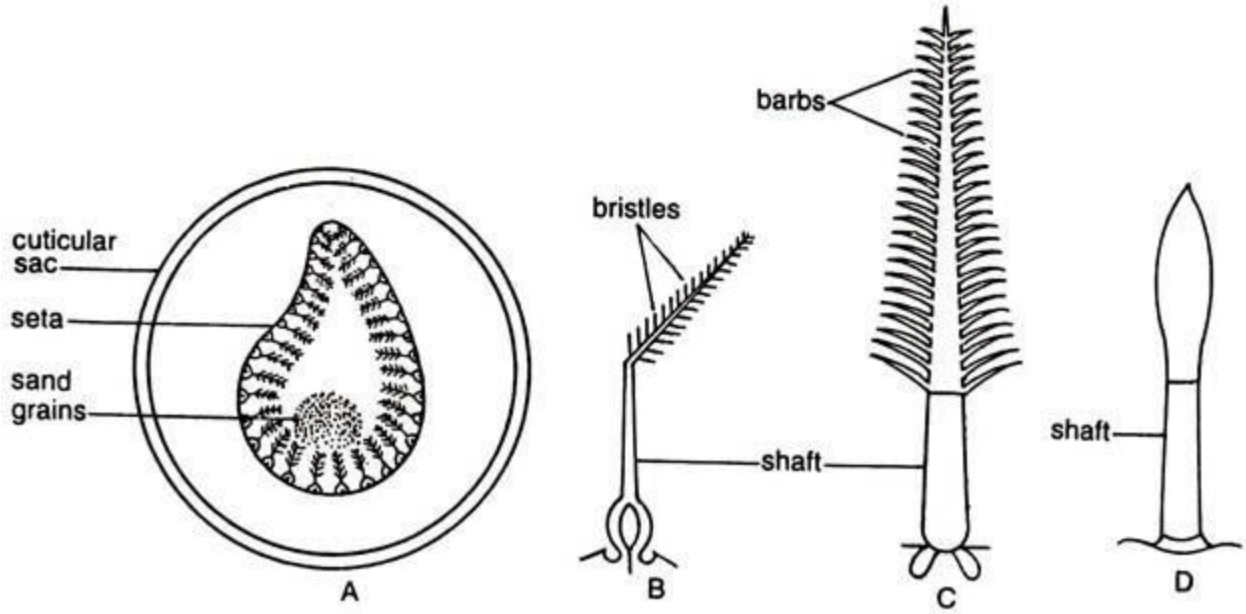


Fig. 25.14. Macrobrachium sp.
A. Statocyst. B. A statocystic seta. C. A tactile seta. D. An olfactory seta

SWIM BLADDER IN FISHES

INTRODUCTION:

Swim bladder, also called **air bladder**, buoyancy organ possessed by most bony fish. The swim bladder is located in the body cavity and is derived from an outpocketing of the digestive tube. It contains gas (usually oxygen) and functions as a hydrostatic, or ballast, organ, enabling the fish to maintain its depth without floating upward or sinking. It also serves as a resonating chamber to produce or receive sound. In some species the swim bladder contains oil instead of gas. In certain primitive fish it functions as a lung or respiratory aid instead of a hydrostatic organ. The swim bladder is missing in some bottom-dwelling and deep-sea bony fish (teleosts) and in all cartilaginous fish (sharks, skates, and rays).

- ROLE IN FISHES:

1. The normal gaseous content of the swimbladder of fresh-water fishes near the surface is approximately that of the atmosphere. The composition varies with the species, pressure, temperature, amounts and kinds of dissolved gases, and with the seasons of the year.

2. When fishes are placed in water containing little or no oxygen the oxygen in the swimbladder diminishes; indicating that the swimbladder may act as a reservoir on which the blood may draw for oxygen in times of need. A perch is enabled to go into water of low oxygen content without asphixiation.

3. The effect of increased pressure in the surrounding water is to increase both the percentage of oxygen and carbon dioxide in the swimbladder.

4. If carbon dioxide is increased in the medium in which perch are living, the volume of the fishes is changed and the fishes automatically rise in the water. This response would be of adaptive value, causing the fish to move out of deeper water containing larger amounts of carbon dioxide into the safer zones above.

5. The primary function of the swimbladder of most of the fresh-water fishes is hydrostatic.

6. Perch apparently possess no voluntary muscular control over the size of the swimbladder.

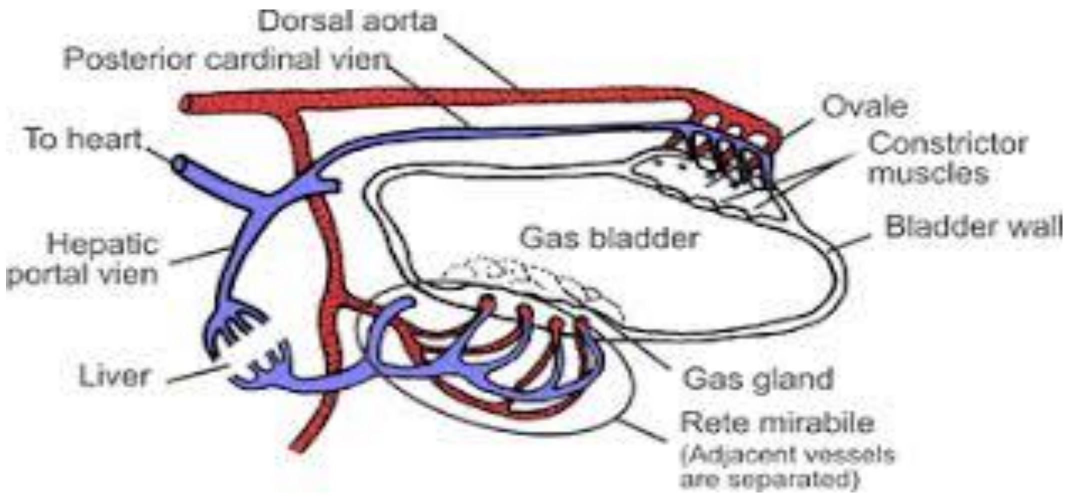
7. Under conditions where high oxygen percentages were found in the swimbladder, a higher tension of the gases existed than in the blood. This indicates an active secretion.

8. Under conditions where fishes are not changing their depth rapidly, the gases in the swimbladder are probably kept constant by simple diffusion of gases from the blood.

9. A "rete mirabile" partially surrounds the walls of the swimbladder and furnishes a rich supply of blood. It is apparently the means by which the gases are transferred from the blood to the swimbladder.

10. The mechanism by which gas is secreted into the swimbladder can apparently be explained on a chemical and physical basis. The writer's experiments show that the hydrogen ion concentration of the swimbladder gland is increased by external stimulation. This indicates the secretion of a substance by the gland which may aid in the secretion of gases into the swimbladder. The apparent secretion of oxygen is believed to be brought about by (*a*) an increased flow of blood because of the dilatation of the capillaries and (*b*) an increased tension of the oxygen due to the local dissociation of oxygen from oxy-hemoglobin.

11. The swimbladder is a mechanism which enables the fish to actively maintain its stability in the midst of changing external conditions.



SENSE ORGANS IN MOLLUSCANS

The **sensory organs of gastropods** (snails and slugs) include olfactory organs, eyes, statocysts and mechanoreceptors.[1] Gastropods have no sense of hearing.

Olfactory organs

The upper pair of tentacles on the head of the edible snail *Helix pomatia* have eyes, but the main sensory organs are sensory neurons for olfaction in the epithelium of the tentacles.

In terrestrial gastropods the most important sensory organs are the olfactory organs which are located on the tips of the 4 tentacles.

Some terrestrial gastropods can track the odor of food using their tentacles (tropotaxis) and the wind (anemotaxis).

In opisthobranch marine gastropods, the chemosensory organs are two protruding structures on top of the head. These are known as rhinophores.

An opisthobranch sea slug *Navanax inermis* has chemoreceptors on the sides of its mouth to track mucopolysaccharides in the slime trails of prey, and of potential mates.

The freshwater snail *Bithynia tentaculata* is capable of detecting the presence of molluscivorous (mollusk-eating) leeches through chemoreception, and of closing its operculum to avoid predation.

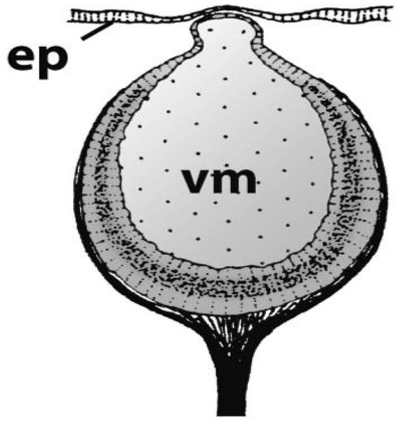
The deepwater snail *Bathynerita naticoidea* can detect mussel beds containing the mussel *Bathymodiolus childressi*, because it is attracted to water that has cues in it from this species of mussel.[5]

Eyes

In terrestrial pulmonate gastropods, eye spots are present at the tips of the tentacles in the Stylommatophora or at the base of the tentacles in the Basommatophora. These eye spots range from simple ocelli that cannot project an image (simply distinguishing light and dark), to more complex pit and even lens eyes.Vision is not the most important requirement in terrestrial gastropods, because they are mainly nocturnal animals.[1]

Some gastropods, for example the freshwater Apple snails (family Ampullariidae) and marine species of genus *Strombus*[8] can completely regenerate their eyes. The gastropods in both of these families have lens eyes.

Morphological sequence of different types of multicellular eyes exemplified by gastropod eyes:

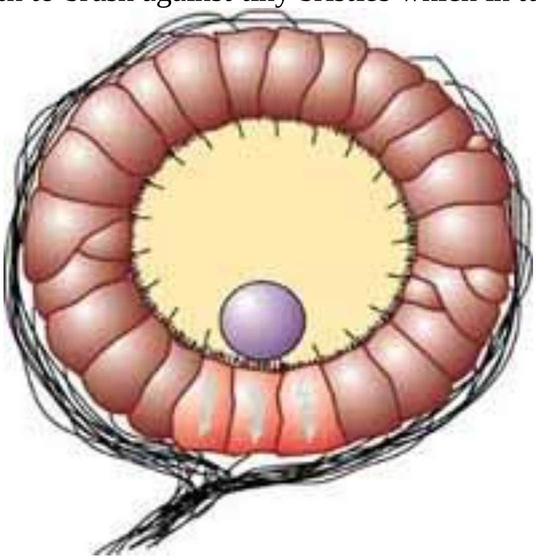


Statocyst

Statocysts (ss) and statolith (sl) inside the head of sea snail *Gigantopelta chessoia*.

The **statocyst** is a balance sensory receptor present in some aquatic invertebrates, including bivalves,[1] cnidarians,[2] ctenophorans,[3] echinoderms,[4] cephalopods,[5][6] and crustaceans.[7] A similar structure is also found in *Xenoturbella*.[8] The statocyst consists of a sac-like structure containing a mineralised mass (**statolith**) and numerous innervated sensory hairs (setae). The statolith's inertia causes it to push against the setae when the animal accelerates. Deflection of setae by the statolith in response to gravity activates neurons, providing feedback to the animal on change in orientation and allowing balance to be maintained.

In other words, the statolith shifts as the animal moves. Any movement large enough to throw the organism off balance causes the statolith to brush against tiny bristles which in turn send a



message to the brain to correct its balance.

UNIT-2

* NATURAL FISH FOOD*

INTRODUCTION:

A variety of natural fish food organisms are found in a water body, which depend on the nutritive nature of the water body.

The natural food provides the constituents of a complete and balanced diet.

The demand of natural food varies from species to species.

Fishes fees on natural food present in all tropic levels.

Natural feed have high protein and fat content which promote the growth of the fish.

Plankton :

Plankton includes plants and animals that float along at the mercy of the sea's tides and currents. Their name comes from the Greek meaning "drifter" or "wanderer." There are two types of plankton: tiny plants--called phytoplankton, and weak-swimming animals--called zooplankton. Some are babies that will grow into strong-swimming, non-planktonic adults. Others will remain plankton for their entire lives. All jellyfish, and the Ocean sunfish are such feeble swimmers that they too are included as plankton. Most of the plankton in the ocean are plants

Phytoplankton :

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton are buoyant and float in the upper part of the ocean, where sunlight penetrates the water. Phytoplankton also require inorganic nutrients such as nitrates, phosphates, and sulfur which they convert into proteins, fats, and carbohydrates.

The three most important types of phytoplankton are:

Diatoms. These consist of single cells enclosed in silica (glass) cases. Each case is made of two interlocking parts with fine holes, through which nutrients and wastes pass. These photosynthetic organisms live in the ocean, with some species common in fresh waters. About 620 species of marine diatom are known to live around New Zealand. Of the freshwater species, only 2% are unique to the country.

Dinoflagellates. This name refers to two whip-like attachments (flagella) used for forward movement. They include photosynthetic members as well as predatory species. About 230 marine species have been described in New Zealand. When masses of red-brown dinoflagellates gather in surface waters they create what is known as a red tide.

- Desmids. These freshwater photosynthesisers are closely related to green seaweeds. They resemble little green cylinders or miniature barbells, and are common in lakes and rivers.

Zooplankton:

Planktons consisting of animals is called zooplankton.

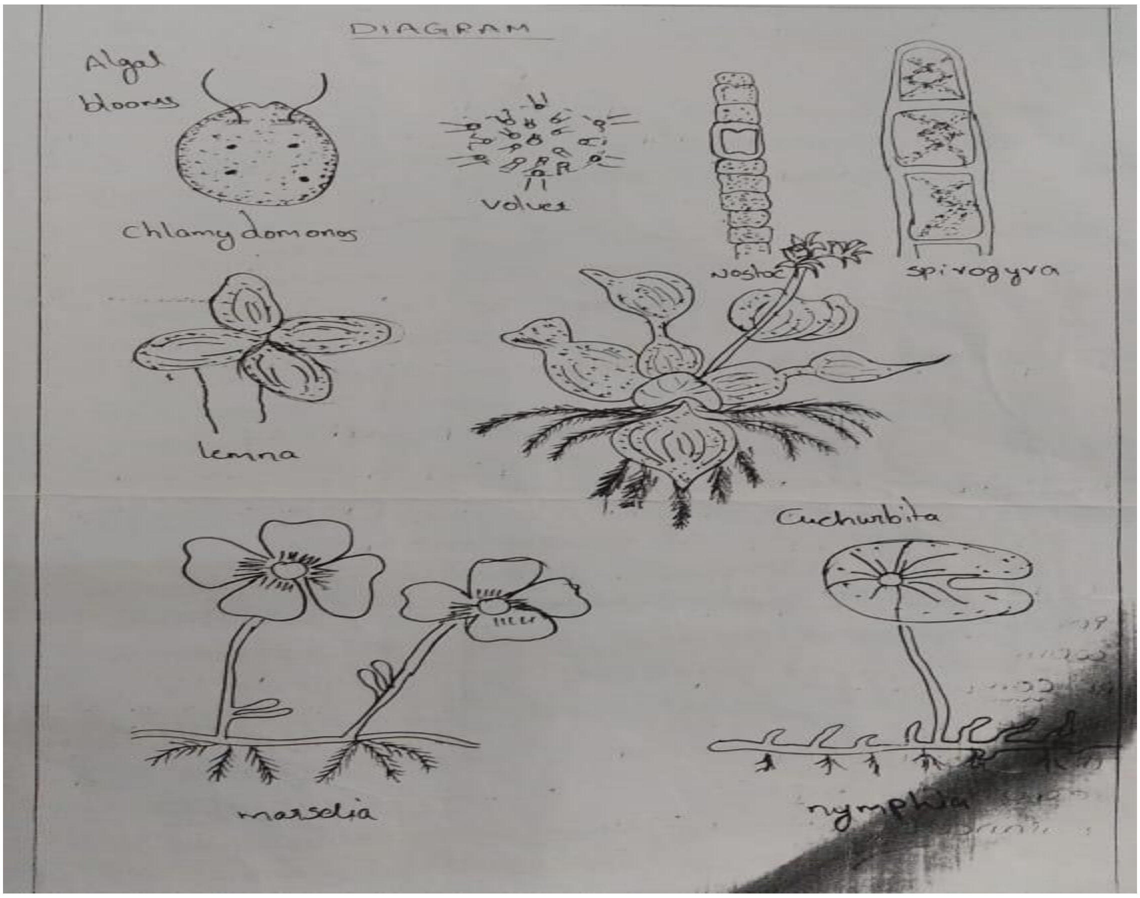
Zooplankton feed on algae and bacteria and finally fishes consume zooplankton.

Annelids: They have **a long and segmented body**. Annelids are bilaterally symmetrical. They are triploblastic. Also, they exhibit organ system grade of organisation, showing organ differentiation.

Insecta: many fishes depend on insectsand their larvae cat fish, murrels, often prey upon insects . hemiptera, dipthera, coeloptera dominate fish food among the insects. Larvae of may flies, dragon flies, chirosomal larva,are also taken by fishes.

Mollusa: molluscan are taken by carnivorous and omnivorous fishes. They are found at the bottom of the water body. Hence bottom dwelling fishes consume them.

Fishes: carnivorous fishes consume fishes, fry , eggs and fingerlings. Murrel singhala shark feed on other fishes. Some fishes are cannibalistic. Fishes even feed on prawns. Some fishes like punctata , labeo , gambna , zoomus are consumed by large fishes.



Scale method

A: Cycloid and ctenoid scales are equally serviceable for determination of age . A knowledge of scale structures and its development is very useful in the interpretation of the growth zones .A scale presents a certain pattern of sculpturing on its surface which can be easily studied under a binocular microscope,or after projection on to a screen.Using a microprojector or on making permanent records by the colloid impression method.The following markings are discernible ;focus circuli ,grooves radii and annuli. Focus is the central small clear area,it may displaced from the central of scale due to unequal growth of the anterior and posterior parts of the scale in case in which wide overlapping of scales occurred .Circuli are concentric marks around the focus . These appear as ridges running parallel to each other and at more or less regular intervals or spacings .Grooves with ridges of circuli and are responsible for the regular spacings between them. Radii are grooves disposed radially i.e. running from focus to the margin of the scale . Radii cut the circuli as these fall in their path. Annuli appear in ageing fish , as wide . Circular troughs , their number depending upon the age in the years of the individual .Each trough carries a few incomplete and narrowly spaced as compared to the circuli outside it which are complete and more widely spaced .

In the light of scale development, foucus represents the original size of the scale when it was first formed in the young of the fish . With development ,scale grows in size by the addition of material of the scale pheripheral to the focus. The grooves and the circuli are the marks of growth-activity and secretion pattern of the osteoblasts as the secrete the material of the scale around the focus .

Annuli are valid as year marks for the purpose of age determination of the individual ,provided:

1.The calculated age from scale study shows correlation with thesize of the individual

2.The caluculated age groups from scale study corresponds with length-frequency distribution of the individuals in showing the coinsideing modes .

3.The assessed age from the scale method agress with the age determined by other methods

True annuli may form abnormal pattens under abnormal growth .

Scale method using annuli for age determination cannot be applied to species inhabiting regions with more or less uniform temperature conditions. An unusually high temperature may produce " annulus" similar to the annukus produced in winter due to low temperature , scales from individual of advanced ages are difficult to interprete due to crowding of the annuli.

Fish inhabiting temperate regions show clear rings which are true year marks.this is because throught such regions in the northern and southern continental parts of the world, the period of poor growth or no growth occurs only once a year and the two seasons, summer , the period of faster growth and winter the period of slow or no growth have sharp differences of temperature. The readings of age determination based on annuli are therefore must reliable for temperate fish.

On the other hand, in tropics where temperature is uniform throughout the year , day light is fairly constant and fish spawn several times , vide fluctuations in food and chemical compostion of water occur due to rains and floods , formation of annulus may not be an annual feature. fish inhabiting tropical regions show growth rings which do not necessarily represent year marks. The growth rings may be laid down more than one per year depending upon how many times growth is retarded or stopped in a year.

* OTOLITH METHOD*

Otoliths (ear stones) are found in the head of all fish other than sharks, rays and lampreys.

These pearly white stones are about the size of a pea, and can be found in the fish's skull just below the rear of the brain. They aren't attached to the skull, but rather float beneath the brain inside the soft, transparent inner ear canals.

There are 3 pairs of otoliths in each fish, including 1 large pair (the sagittae) and 2 small pairs (the lapilli and the asteriscii).

The largest pair is usually used for determining age. The smaller pairs are about the size of the tip of a pin. However, despite their size, the smallest pair (the lapilli) is most often used for daily ring ageing.

We've used many parts of fish to determine their age, including:

- bones
- scales
- otoliths
- fin rays

These and other bony parts of fish often form yearly rings (annuli) like those of a tree. However, otoliths generally provide the most accurate ages, particularly in old fish.

Reading thin otoliths

The easiest way to read an otolith is to take a slice, or cross section, out of the otolith with a special saw and then count the rings under a microscope. However, unless you have access to a low-speed diamond-bladed saw in a laboratory, you won't be able to age the otolith this way.

If the otolith is thin enough, it may be possible to count the annuli without having to prepare the otolith first. Try measuring the thickness of the otolith:

- if it's 1 mm or less, or if the thickness is less than 1/8 that of the total length, you may be able to read it
- if you can see alternating light and dark zones, you're probably looking at annuli

They probably won't be as clear as those in a cross section, but they should look roughly similar.

where the otolith breaks with pliers, and an otolith that's broken too far from the centre line can't be aged.

Reading otoliths

You can read the otolith once it's cool. To do this:

- take the otolith half and embed the non-cracked tip in the clay so that the cracked surface faces up
- spread a drop of vegetable or cedar oil over the whole cracked surface
- put the clay holding the otolith under the microscope and focus at a magnification of about 10X
    - if a lot of soot is visible, try rubbing it with an old cloth or on a whetstone, and then add another drop of oil

The annuli should be visible as thin but prominent brown or black lines. Keep in mind that not every line is a yearly ring. So count only those rings or groups of rings which are most prominent.

If no dark lines are visible, try re-burning the otolith. In general, the annuli nearest the centre are furthest apart, and contain the most non-yearly lines. Later annuli (those nearest the edge), such as would be seen in an old fish, tend to be closer together and more regular in spacing. As a result, otoliths from older fish tend to be easier to age than those from younger fish.

Length frequency method

Organisms generally increase in size (length, weight) during development.

The key factors that influence the growth of fish are the quantity of food available, the number of fish utilizing same food source, temperature, oxygen and other water quality factors besides the size, age and sexual maturity of the fish.

Every animal in its life exhibit growth both in length and in weight and the relationship between these two has both applied and basic importance.

The length-weight relationship is one of the standard methods that yield authentic biological information and is of great importance in fishery assessments.

It establishes the mathematical relationship between the two variables, length and weight, and helps in assessing the variations from the expected weight for the known length groups.

This is particularly useful for computing the biomass of a sample of fish from the length-frequency of that sample.

The parameter estimates of the relationship for a population of fish can be compared to average parameters for the region, parameter estimates from previous years, or parameter estimates among groups of fish to identify the relative condition or robustness of the population.

Relationship between length and weight is required for setting up yield equation and sometimes it may be useful as a character to differentiate “small taxonomic units”.

It also helps in converting one variable into another. Of the two, length is easier to measure and can be converted into weight in which the catch is invariably expressed.

The length weight relationship also provides means for finding out the “condition factor” and the seasonal changes in the condition factor are useful to determine the biological changes in the fish.

The relationship between weight (W) and length (L) in fishes has the form: W=aLb

Unit – 3

BUNDH BREEDING

A: **Bundh breeding**

Bundhs are special types of perennial and seasonal tanks or impoundments where riverine conditions are simulated during monsoon months. The bundhs are ordinarily of two categories, viz., a perennial bundh commonly known as “Wet bundh” and a seasonal one called “Dry bundh”.

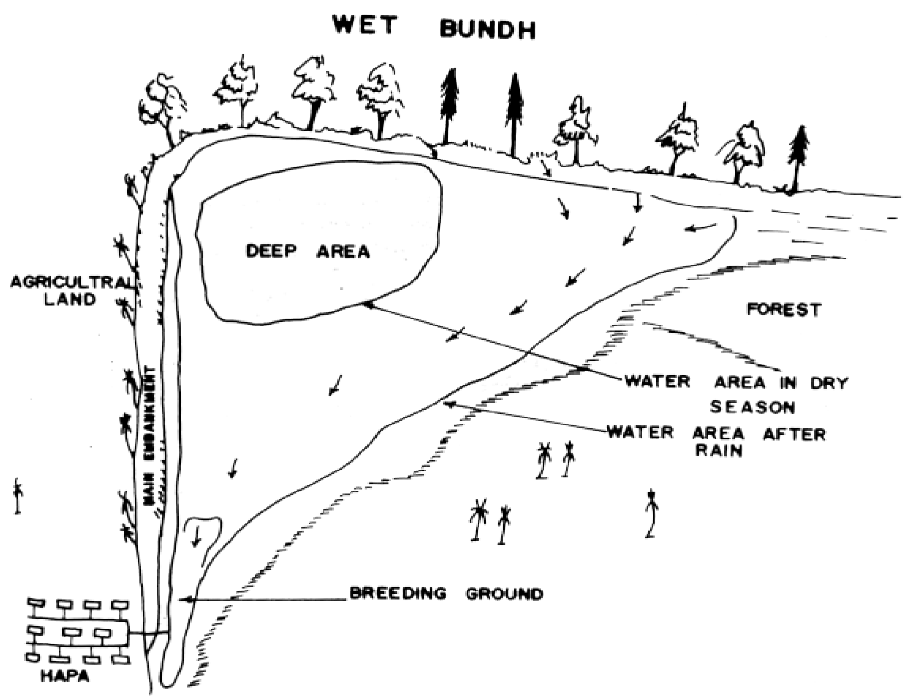
WET BUNDH

A typical “Midnapore type” of wet bundh is generally located in a gradual slope of a catchment area with an inlet towards the high land and an outlet at the opposite side towards the lower end to regulate the inflow and outflow of water respectively during heavy showers.

The wet bundh contains a deeper area which retains water throughout the year and where adequate stocks of brood fishes are maintained. During heavy rains, a major portion of the bundh is submerged and excess water, if any, is drained through the outlet which is guarded by bamboo fencing (locally termed as “Chhera”). The shallow areas of the bundh (moans) serve as breeding ground for fishes present in the bundh.

The wet bundh varies in shape and size from place to place. Generally, the ponds covering a water body of 1–2 ha with catchment area ranging from 20–100 times are considered as wet bundhs, but a bundh could be as large as 300 ha.

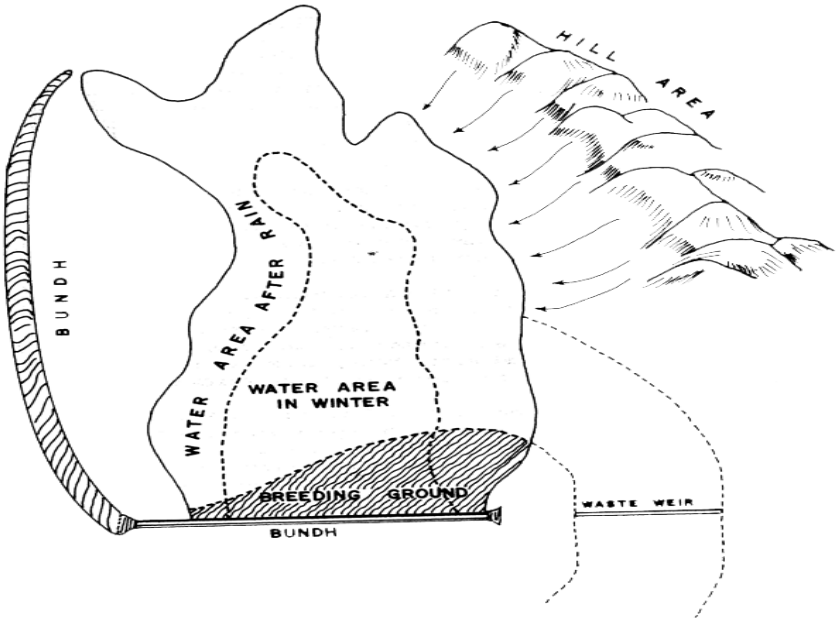
Bundh for Breeding (Wet Type)



DRY BUNDHS

This type of dry bundh consists of only one shallow depression (or one shallow pond) and a catchment area located in a gradual slope. The upper high land area is considered as a catchment area. The shallow depression or pond is enclosed by embankments on three sides which impounds freshwater from the catchment area during the monsoon season. There should be provision for an outflow for drawing excess water from the pond during heavy rains. The outlet is guarded by fine bamboo fencing. Such bundhs remain more or less dry during the greater part of the year. In the West Bengal Province of India, a catchment area more than five times the size of the bundh is considered most suitable (Saha et al., 1957), whereas in Madhya Pradesh the recommended ratio is 1:25 (Dubay and Tuli, 1961). Dry bundhs of Madhya Pradesh are comparatively bigger in size (0.2 to 2.5 ha) than those of West Bengal (0.1 to 0.5 ha).

In a modified bundh, adjacent ponds are constructed along the gradient of the catchment area (Moitra and Sarkar, 1973, 1975). The upper one where the premonsoon rain water is collected from upland catchment area serves as a "reservoir" and the lower one is used for breeding purposes. A deeper tench is dug along the lower extremity of the breeding bundh so that the breeders can take shelter before and after spawning. The reservoir and breeding bundhs are arranged in a sequence along the gradient so as to facilitate the flow of water which is controlled through a system of sluice gates. Premonsoon rain water is collected from the catchment area to fill up the reservoir. The water-holding capacity of the reservoir is generally more than that of the breeding ground bundh.



Collection of eggs: Egg collection is taken as soon as the embryo starts twitching movements. To collect eggs, the water level of the bundh should be lowered by opening the outlet. Eggs are generally netted by a piece of thin cotton cloth (gamcha) or a piece of mosquito netting cloth. In such areas a series of earthen pits are constructed with water flow facilities. Fertilized eggs are allowed to hatch in these pits and the spawn are collected after three days. Spawn are usually sold at the bundh site

* BREEDING PLACES AND BREEDING HABITS IN FISHES*

A: fishes breed effectively intheir natural areas of living such as rivers , streams , water falls , lakes , ponds , tanks, reservoirs and seas . The scope for collecting large quantities of spwan is more in

these natural surroundings.

Because of the high demand for fish seed due to establishment of fisheries on industrial sector , efforts are made in the direction of producing fish seed by artificial methods

Fishes breeding in ponds and tanks:

Tilapia mossambicus , cyprinus carpio , osphronemus gouramy , channa punctatus , clarius batraches , anabus testudinius , etropus suratensis , heteropneustes fossilis , trichogaster pectoralis etc...

Fishes breeding in rivers , streams , irrigation canals , waterfalls , reservoirs etc:

Catla catla , labeo rohita , cirhinus mrigal , hypopthalmycthyes molitrix , labeo calbasu , labeo bata, ctenopharyngodon idella , labeo gonius , salmotrutta , eel Anguilla , viza corsula , chanos .

Fish breeding in marine and brackish water areas:

Lates calcarifer , mugil cephalus , chanos , mackerels .

BREEDING HABITS:

Mating and egg laying, which follow the preliminary 'acts of courtship and nest building, have been observed by the present writer under na.tural conditions.

The breeding male, which is larger in size than the female, haR its body and fins vividly coloured in different beautiful shades giving it a brilliancy seldom found under normal conditions.

The female is less attractive and is of a dark dull colour.

Eggs are mid in batches and during the intervals between the laying of the successive batches of eggs the female remains quietly in one place a few inches away, usually at the bottom, in a completely exhausted condition.

The lllale is very active apd busies himself With the work of substituting fresh bubbles of air in place of those lost from the bubble nest by taking occasional gulps of air and blowing it on to the under side of the nest.

Once 01' twice it goes near the female and 'noses' it so as to create excitelnent.

Finding no response from the female it goes under the nest and after making a brief survey inspects the mud for any egg that might have fallen down by accident.

The exact procedure by which stray eggs at the bottom are brought up to the nest could not be clearly seen, though it was observed that the male remains at an angle at the bottom pJ;obing the mud for eggs. Probably the eggs' are blown up.

While the male is thus engaged the female begins to show signs of activity as if awakened from slumber and the male quickly noting the changed disposition of its mate approaches and touches it with confidence and the latter quickly responds to the invitation of the male and accompanies it to the underside of the nest where both make a few circles and exhibit some sort of a playful love chase for a few seconds.

Suddenly the male bends round in an arch converting its body into a ring around the female which remains motionless and submissive.

During this act the head of the male touches its tail, and the vent of the male comes into close apposition with that of the f~male.

Simultaneously with this both turn over describing a semi-circle so that the female now remains with the ventral side up. They remain quiet in this condition for about 10 to 15 seconds.

The beautifullcoloured pelvic fins of the male stand erect in a conspicuous manner and the anterior portion of the dorsal fin shows some sign of movement.

The male now relaxing its grip moves to one side and the female with the ventral side still up, before resuming the normal position, sends up a stream 9f about 10 to 15 eggs, which are shot up towards the mass of air bubbles by the force of the ejection and there they float with the other eggs.

Mter this act the female steadies herself slowly with signs of complete exhaustion, just like a half dead fish that has lost its equilibrium.

While the female rests at a side the male is busy looking after the nest and the eggs. This act is repeated a number of times till roughly about 3QO eggs are laid.

The combined weight of the eggs submerges a portion of the comparatively large mass of air bubbles, but the dorsal surface of the nest projects like a dome above the surface of water.

INDUCED BREEDING AND COLLECTING PITUITARY GLAND

Induced breeding is a technique where organism is stimulated by particular hormone or other synthetic hormone or by providing condition, introduced to breed in captive condition. It is called hypophysation.

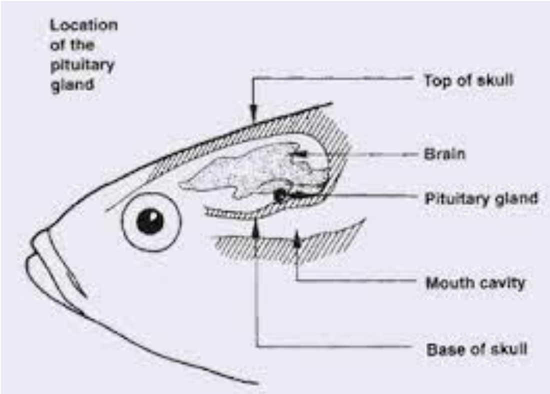
HYPOPHYSATION: The pituitary gland secrete several hormones – which are most important for breeding. The technique of breeding the fish by administrating pituitary gland extract injection in to the body of both the matured male and female fishes is known as induced breeding or hypophysation. After the injection the carps become excited lay eggs in the pond water and subsequently fertilization takes place Steps involved in hypophysation.

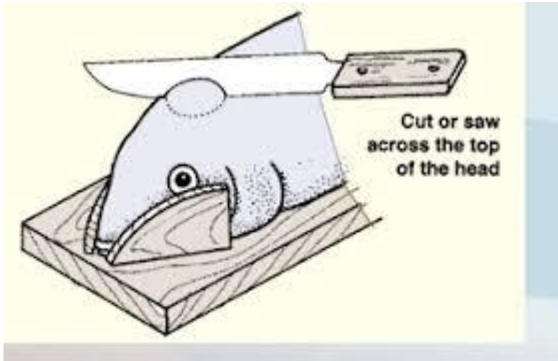
1. Collection of Pituitary gland
2. Preparation and Preservation of gland extract
3. Selection of breeders for injection
4. Determination of dose for injection
5. Site of injection
6. Breeding
7. Hatching and management of spawns

Collecting Pituitary Gland: Pituitary gland is a very important in fish breeding. This gland is located under brain. The hormones secreted from pituitary gland control the tasks of any other glands. Among the all secreted hormones from pituitary gland Growth hormone and gonadotropin hormone will have great influence in the growth and tasks of sexual organs. Because of this Pituitary gland used as inducing agent for artificial breeding of fish. gonadotropin hormone will have great influence in the growth and tasks of sexual organs.

From the matured fishes of both sexes either belonging the same species or a closely related the pituitary glands are collected. It is preferred to collect the pituitary gland from freshly killed fishes. In the fish markets, where the head of the cut fishes are available the pituitary glands can be taken out from the posterior end of the cranium through the foramen magnum after cleaning the brain tissue.

At first cut the upper section of scalp with saw. Then remove the skull and there is gray fatty material over the brain. Clean the gray material with cotton. This will make the surface of brain clearly visible. Now elevate the brain and keep it to the back side.

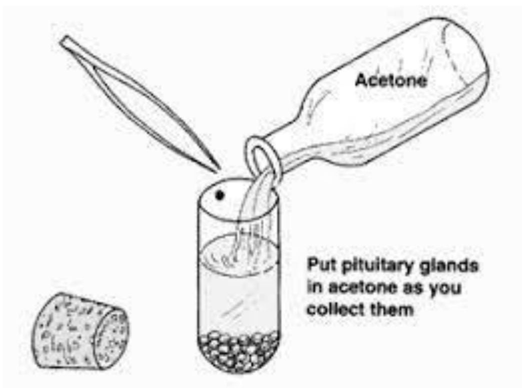


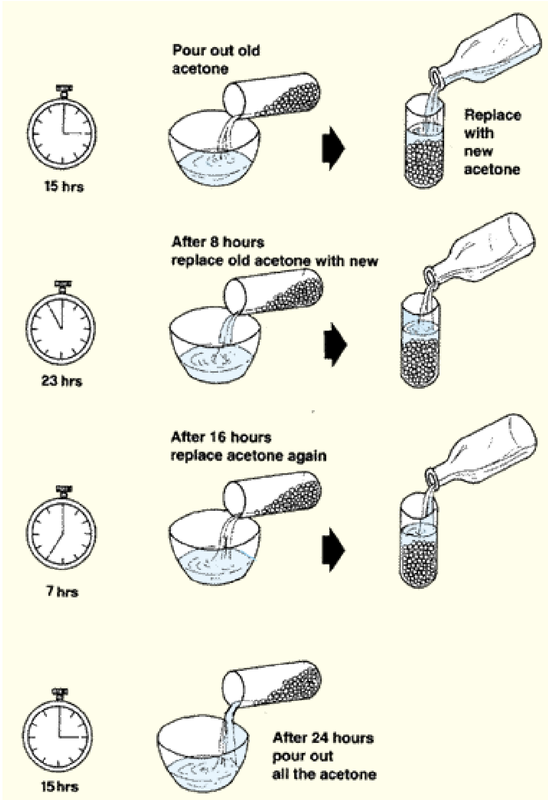


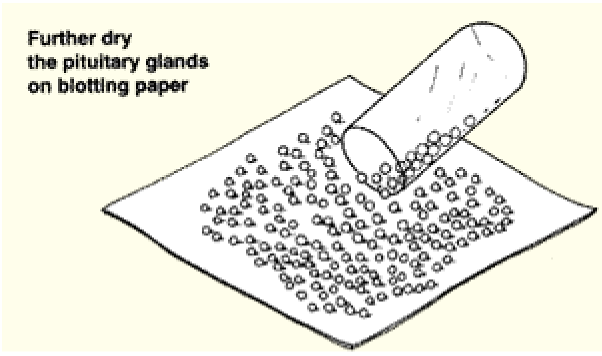
Be very careful during elevating brain so that pituitary gland with membrane can't get mixed with brain. Pituitary gland of carp fish is separated with brain by a thin membrane. Raise the pituitary gland carefully with tongs or needle from the hole and keep in Petri dish of 100% ethanol. Clean the muscle and blood from pituitary gland by keeping it intact.

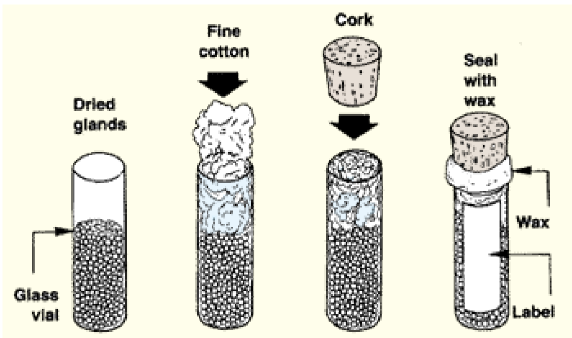
Preparation of Pituitary extract: Immediate after the collection of the pituitary glands are kept in absolute alcohol for dehydration. After 24 hours, the alcohol is changed for further dehydration and de fattening. The glands are then weigh (varies from 7 to 19 mg.) and preserve in fresh alcohol in dark colour glass bottles. At the time of injection to carps the required quantity of pituitary glands are taken out and the alcohol is allowed to evaporate.

The gland are homogenized with 0.3 percent of saline . The homogenate is centrifuged. The tissue debris is centrifuged off and the supernatant containing the hormone is drawn into a syringe for injection. If pituitary extract is to be stored for a longer period the glycerine or trichloro acetate acid may be used instead of saline.









Preparation of extract – calculation: If you are planning to use dried pitutary glands with 34 Females (average weight 2 kg two injections each) and 17 males (average weight 1.5 kg one injection each) you will require the following quantities of dried glands.
Femalesfirstinjection 34 X 2 kg X 0.3 mg/kg = 20.4 mg

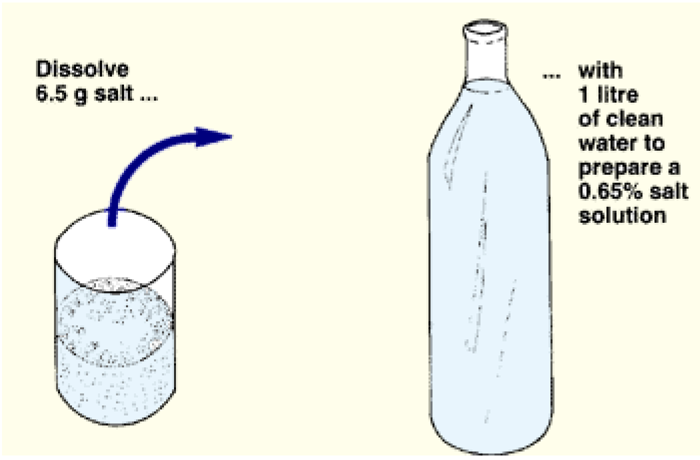
Femalessecond injection 34 X 2 kg X 3.5 mg/kg = 238.0mg

Malesfor one injection 17 X 1.5 kg X2.0 mg/kg = 51.0 mg

Total forinjections = 309.4 mg Allow10 percentsafety margin = 31.0 mg

Total weight of dried glands needed = 340.0 mg

Preparation of extract for injection: The gonadotropic hormones which are injected to induce ovulation and/or spawning are extracted from the pituitary glands, either immediately on collection or after a certain storage period. Proceed as follows.



Prepare a 0.65 percent salt solution (saline): dissolve 6.5 g of common kitchen salt in 1 litre of clean water. You may use either boiled and filtered water or distilled water. Use clean glassware and mix well. Keep this solution in a corked glass bottle.

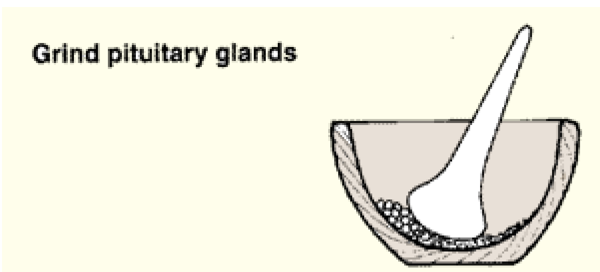
Calculate how much salt solution you require, according to the manuals referred to above.

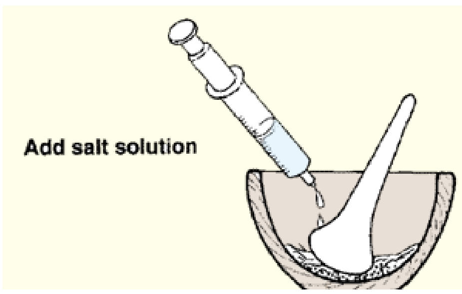
Calculate how much salt solution you require, according to the manuals referred to above.

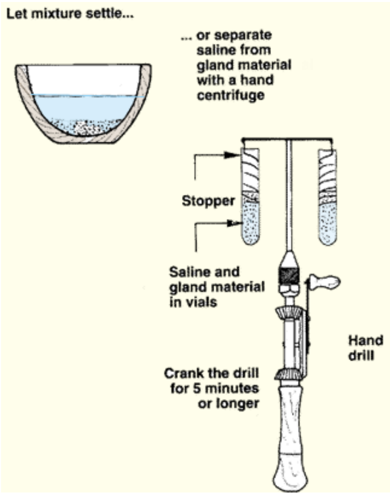
Measure the required volume of 0.65 percent salt solution and pour it in the mortar, over the gland mash/powder. It is best to use a syringe to measure such small volumes.

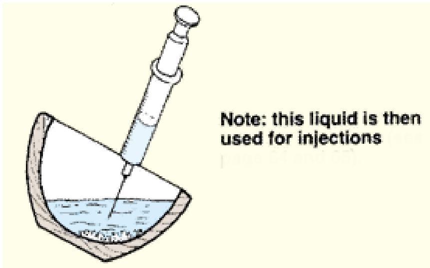
(f) Mix the saline and gland material well to extract the gonadotropic hormones from the gland tissue into the liquid.

(g) Let it settle, or better still, use a small hand centrifuge to separate the upper (supernatant) liquid from the pieces of gland material.



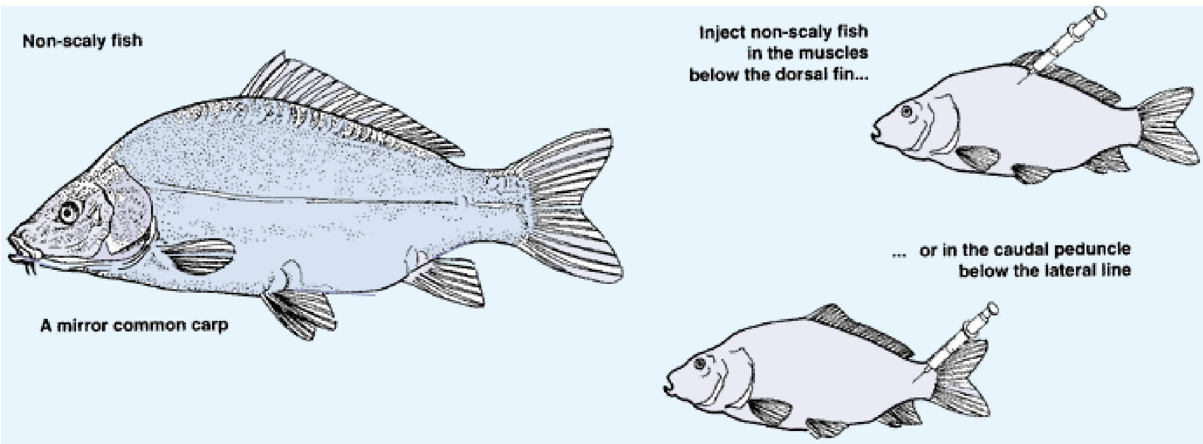


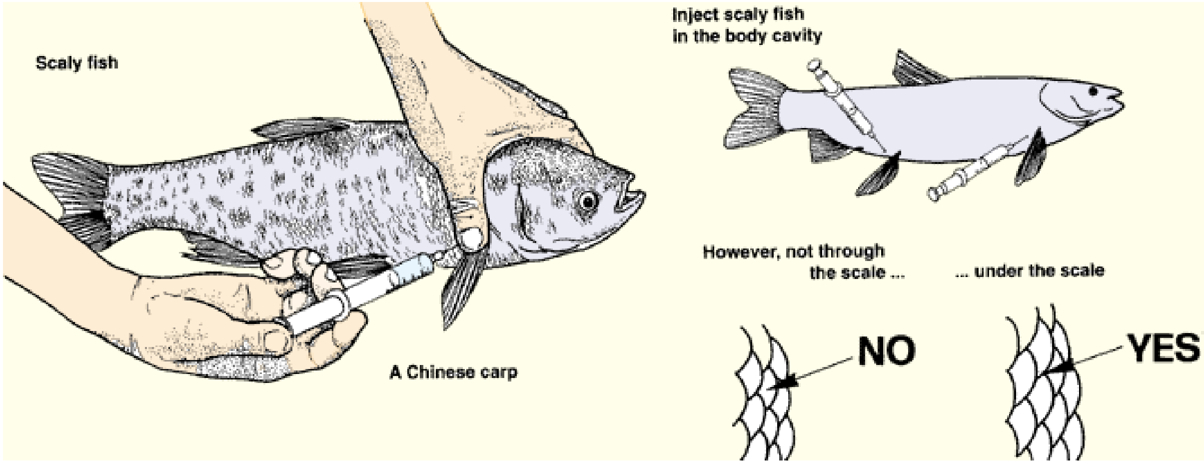




Selection of Breeders: The potential breeders, each weighing above 1 kg, are reared properly prior to breeding season. Health and maturity status are periodically examined. Medium sized fully ripe and healthy fish is preferred for induced breeding. The weight should be 1 to 5 kg. • Healthy male and female breeders should be kept in spawning pools and provide with supplementary food.

Injection of Pituitary Extract: • To ensure higher success rate of fertilization it is important to coincide time of ovulation with the release of milt of male fish. • For this purpose usually ratio of female and male 2:1 is maintained in every set. • Dose of pituitary extract to be given is decided according to age, sex, weight and state of maturity .





• Injection of the carps is to be done outside of the water lying on a piece of sponge which is used only to avoid the injury of the carps.

• During the rainy season, the extract of the pituitary gland is injected in the muscle of the matured carps just before evening (suitable cold climate).

• Pituitary extract is introduced in the muscle of the caudal peduncle/ near the dorsal fin of the female carp.

• The injection should not be done on the lateral line sense organ of the carp. The needle of the syringe is introduced between the scales with an angle of 45° with the body.

• Then the two female and one male carps are placed in a breeding hapa for spawning.

Description of Hapa:

• The breeding hapa is a rectangular case of fine netting.

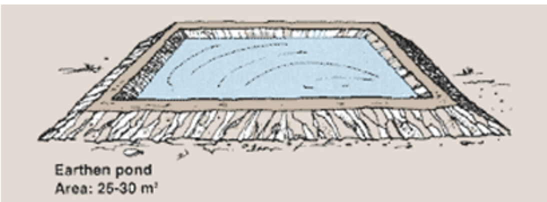
• For larger fishes its size is 8′ x 3′ x 3′ , but for the smaller fishes it is 5’x 3’x 3′.

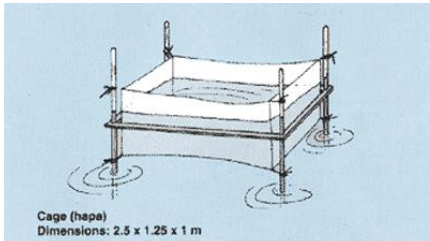
• It is held on four bamboo poles, one at each corner of the rectangular case.

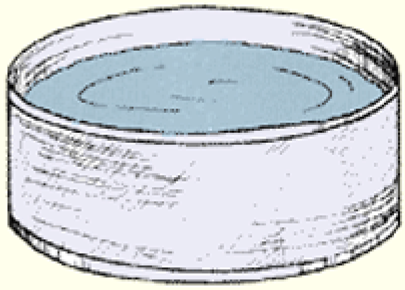
• The roof of the hapa may be open or closed.

• The hapa is made of mosquito net cloth so that laid eggs and milt cannot escape out.

• Three-fourth part of hapa is summarized in water whereas upper one-fourth part remains in air.







Fibre glass tank
Dimensions: 3 m (diameter) x 1 m (depth)

B2.3. Describe induced in shrimp.

Maintenance of brood stock resources hatchery ponds, selection of brooders , breeding and spawning , fertilization , development , phsycio-chemical factors regulating the larval growth and metamorphosis ,larval feed etc are cheif inputs for production of prawn seed .

Maintenance of brood stock resources:

1. Breedres can be stocked and maintained by culturing immature prawns in breeder ponds.

2. Large prawns can be collected from fresh or brackish water ponds for breeding.

3. Egg releases from the young ones around 5-7 months age .

4. Male and females can be easily identified as prawns exhibit sexual dimorphism.

5. Male with petasama on first abdominal segment and female with thelycum between 4^{th} and 5^{th} walking legs .

Hormonal regulation of gonadal activity

1. Similar to vertebrates in prawn also some hormones initiate reproduction by maturing gonads .

2. Hormones release from brain and thoracic ganglia regulate multiplication of yolk cells and maturity of gonads.

3. Medulla terminals of optic peduncle, x-organ sensory papilla ,x-organ is sinus gland of optic stalk near brain region-organ formed by a pair of glands near the antero – thoracic region ,ovary, androgenic gland of male and female prawns are the main endocrine glands of the body .

4. Hormones from x-organ suppress the gonadal maturity. By removing one of the optic stalks. Prawns quickly attain sexual maturity and release eggs. This is Ablation.

5. Ablation can be done in three ways.

i. Removal of optic stalk with eye
ii. Tying the optic stalk at its base.
iii. Damaging optic stalk tissue by making a wound in the eye.

6. Ablation done soon after moulting in matured prawns initiate spawning in 3-5 days.

Selection and transport of breeders:

Fully grown and sexually mature brooder prawn male measuring around 200mm and 65gm of weight are selected.

1. Generally female attain maturity only in their natural environment whereas male can attain maturity even in ponds where water salinity alters.
2. While on transport to decrease mortality prawns are immobilised by tying with thread or by giving sedatives. This facilitates easily transport with less oxygen consumption and less injuries.
3. Selected breeders are given chemical bath with 20ppm oxy tetra cyclin , erythromycin , perfurin for half hours.

Hatchery tanks:

1. Plastic tubes or fibre tubes which are lined internally black are selected to place breeders.
2. Into these tanks male and eye stalk ablated female in 1:1 ratio are released around 60 *100 cubic meters tanks and the tanks are covered with mosquito net or muslin cloth.
3. Water in the hatchery resembles in all properties to sea water , the only difference is it filtered.
4. After the transfer mating occurs between 80-180 at nght time around 12:3o o' clock.
5. Male and female come close to each other and lie to ventral side. Male releases spermatophores into thelycum with the help of petasma and leaves off female.
6. After sometime female releases ova at the same time sperm come out of thelycum and fertilisation occurs.
7. A mature female releases 70,000 eggs into water in 3-5b mins.
8. Spawning occurs at the night time 60cm above the bottom of the pond.
9. From the fertilised eggs within 12-16 hours first larva called nauplius larva is released.
10. After each yield hatcheries should be cleared with bleaching powder detergents fresh water and then filled with marine water.

* PEARL OYSTER BREEDING*

In case of pearl oyster, every mature female produces several millions of eggs, while every mature male produces trillions of sperms. Such high fecundity is provided for the high mortality of eggs, larvae and young ones due to predation and diseases.

Hatchery Establishment:

The hatchery establishment comprises facilities for good sea water supply, aeration, maturation and spawning of oysters, live algal production for food, larval and spat rearing

Maturation and Spawning of Pearl Oysters:

For production of larvae in the laboratory, both natural spawning and induced spawning are undertaken. Fully mature oysters are then brought from the natural beds or from the farm and placed in the hatchery along with other matured oysters.

The fully mature oyster starts spawning spontaneously and in all cases the male initiate spawning. When this single oyster starts spawning, the chemical substance present in the gametes induces other oysters to follow, resulting in mass spawning in the tank.

However, through physical or chemical stimulation the mature oysters are further induced to spawn at the required time. When pearl oysters are placed in this buffer solution at pH 9.0 for 1-2 hours and then transferred to normal water, they spawn with a success rate of about 78%.

Another chemical stimulation with satisfactory spawning response is obtained when oysters are injected with 0.2 ml of N/10 Ammonium hydroxide at the base of its foot. Mature oysters can also be made to spawn on thermal stimulation when they are maintained at 24°C for a day and then the temperature is raised gradually to 32°C.

Rearing of Larvae:

The tiny veliger larvae in the hatchery take about 16-20 days to metamorphose into the adult pearl oyster. Healthy larvae are separated and reared in filtered and sterilised sea water in fibreglass tanks.

They are fed once a day with adequate supplies of microalgal food. The sea water is changed every alternate day after removing the larvae on a sieve. To prevent bacterial and fungal diseases, antibiotics are added to the larval rearing medium.

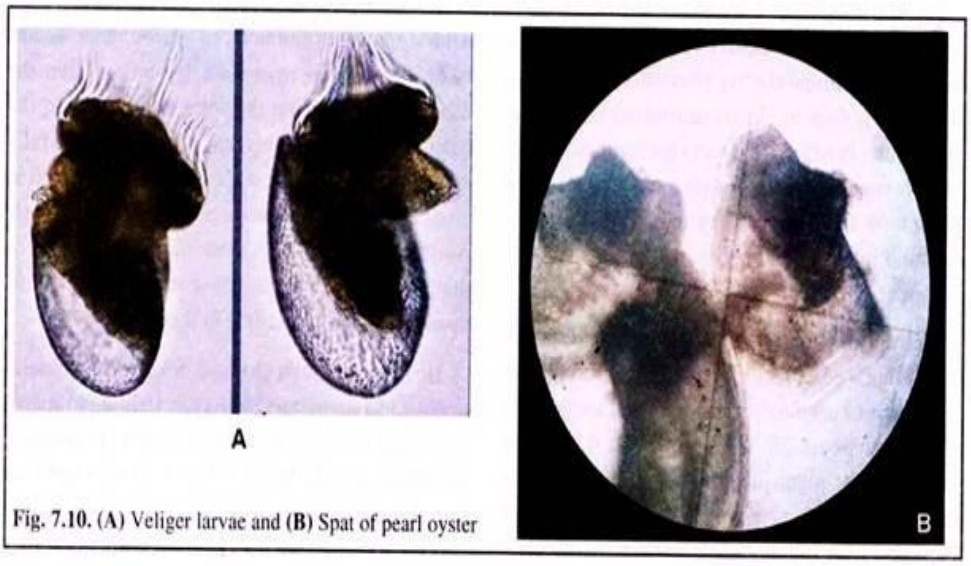


Fig. 7.10. (A) Veliger larvae and (B) Spat of pearl oyster

The veliger larva reaches the umbo stage within 9 to 10 days. The umbo stage larva swims freely and with the development of foot, reaches the Pedi- veliger stage. It soon settles down on a substratum. The brief free-swimming period of larval life comes to an abrupt halt.

It then attaches itself to the substratum by secreting the adhesive byssal thread. The larva through a series of morphological changes metamorphoses and attains the shape and form of adult. It attains a size of this transformed young oyster is called ‘spat’ (Fig. 7.10B). The spat terminology is used till it reaches a size of about 2 cm shell height. The spat and also the adults discard the bunch of byssal threads, move a bit away from the original spot by the help of foot and refix itself on a new spot by secreting fresh threads. Only 300 µm.

(e) Spat Rearing:
The spat initially are too small and fragile for transplantation to the farm. It needs rearing in the hatchery till it reaches a size of about 3 mm in a month. At this initial phase of spat rearing, good sea water, aeration and adequate amount of external algal food should be provided.

The spat consumes a variety of algae and diatom species. When the spat reaches 3 mm, they are carefully collected from the tanks, placed in fine-meshed velon screen nets with a protective covering and transplanted to the farm.

When the oyster reaches 25 mm, they are taken out and grown in regular baskets. The young oysters fall prey to a number of predators. So areas where preys are abundant should be avoided or these enemies should be periodically removed and destroyed.

(a) Farm Site:

The site of pearl oyster farms are selected in sheltered and protected areas of the sea, where the depth should be about 10 m and silting should be minimum. It should be seen that the salinity does not fall below 15 ppt, as this would lead to mortality. Prolonged low salinity condition may occur at the time of heavy precipitation of rain and heavy discharge of rivers in the adjoining area of the farm.

Area rich in phytoplankton should be selected as they are food for the spat. But care should be taken that this bloom is not noxious. A mild water current of 2 knots would help bring in fresh food and at the same time help in removal of metabolic wastes, faecal matters and other farm droppings.

(b) Farming Techniques:

At the onset of culture the technique used was simple, comprising collection of oysters (preferably females) from the natural beds by engaging divers and broadcasting them on the seabed in a protected area near the shore. In such type of practice, the oysters suffered heavy mortality due to covering of silt and sand and also due to predation.

Subsequently, the technique developed was to grow the oysters in the water column which would be well above the bottom. This type of culture came to be known variously, such as off-bottom culture, hanging culture, suspended culture, long-line culture and raft culture. To give the oysters protection from predators, they are placed in nets, cages and baskets.

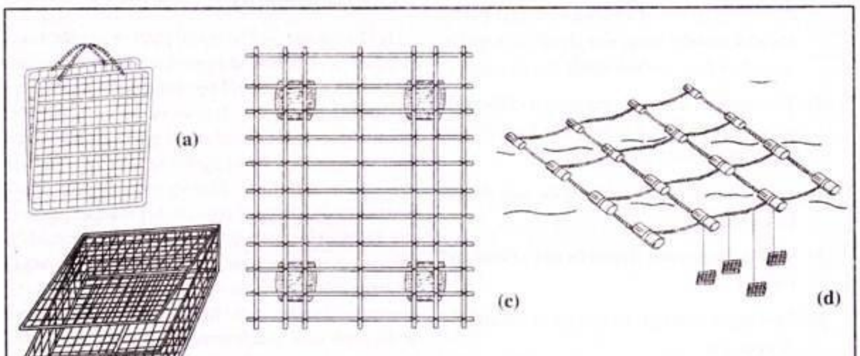


Fig. 7.11. Structures used for pearl oyster farming — (a) Frame net; (b) Cage; (c) Raft and (d) Long-line.

Choice of Site:

Depending upon the site available, it is important to choose the right technique of farming. In case of calm bays raft culture should be selected, while for turbulent sea long-line culture is ideal. In case of moderately deep lagoons, underwater platforms are best suited.

Hydrographic Conditions:

(1) Depth:

For rearing pearl oyster, depth is an important factor. Quality pearls are produced in deeper waters (beyond 10 m). In the Gulf of Mannar, better quality pearls are produced by oysters in deeper beds (at 15-20 m depths) compared to those produced in intertidal areas. Fouling and boring problems do not occur at depths below 10 m.

(2) Bottom:

Muddy bottom should be avoided. Sea bottom should preferably be gravelly or an admixture of sand.

(3) Water Current:

Water current should be mild (about 1 knot) and would be sufficient to carry dissolved oxygen and food material. Strong current should be avoided as it results in stunted growth of oysters.

(4) Change of Culture Ground:

Repeated culture in the same ground often results in accumulation of biological wastes on the sea bottom, resulting in deteriorative quality of pearl production. Moreover, diseases and mortality of pearl oysters may occur.

(5) Temperature:

The suitable range of temperature is between 18-25°C. During winter when temperature drops to about 10°C, the oysters undergo hibernation. However, in the

Indian seas, temperature is high throughout the year and higher growth rate is observed in the winter months. At lower temperatures fine layers of nacre are deposited which improve the lustre of the pearls.

(6) pH:
The pH of the sea water should be between 7-8. In the farm of Tuticorin (presently named Thoothukudi), the annual range of pH is 7.7-8.3.

(7) Salinity:
Salinity in the Gulf of Mannar generally varies between 30 and 35 ppt. Heavy rain in the sea does not bring about any noticeable change in salinity. However, during monsoon heavy discharge of freshwater from rivers, considerably lowers the salinity of coastal waters. Prolonged spells of low salinity cause oyster mortality.

(8) Calcium:
Calcium is required for the formation of shell and pearl. Oysters derive calcium from sea water as well as from the body fluids via the mantle. The normal calcium level in sea water is 400 mg/1. In Tuticorin Bay, salinity ranges from 316 to 454 mg/1. Low calcium level would lead to formation of thin shells and poor quality pearls.

(9) Nutrient Salts:
Nutrients such as phosphates, nitrates and silicates are essential for good growth of phytoplankton which forms the food of oysters.

(10) Trace Elements:
The composition of trace elements (quality and quantity) influences the colour of pearls. Pink coloured pearls contain more sodium and zinc, while copper and silver are responsible for gold- and cream-coloured pearls.

Food of Pearl Oysters:
Several groups of phytoplankton, particularly diatoms and flagellates, form the main food of pearl oysters. The chemical composition and amount of phytoplankton determine the quality of pearl. Blooms of certain diatoms and Dinoflagellates sometime result in toxicity and may lead to death of oysters. Therefore, areas which witness such toxic blooms should be avoided for construction of pearl oyster farms.

Enemies of Pearl Oyster:
In maintenance of pearl oyster stock, one of the major problems encountered are the enemies of pearl oyster. They can be classified as biofouling, boring and predator organisms

Predators:

In farms the major predators of pearl oysters are the gastropods such as Cymatium cingulatum and Murex virgineus, who cause serious damage (kills an oyster per day). These gastropods are seasonal devastators. Crabs such as Charybdis sp., Atergatis sp., Leptodius sp. and Thalamita sp. also prey upon the pearl oysters.

These gastropods and crabs when young (small in size), enters into the baskets through the meshes and grow by preying upon the young pearl oysters. Prevention methods have to be taken through periodic inspection, removal and killing of these predators.

Fig. 7.14. Predators of pearl oysters

Shell Bead Production:

The shells of various freshwater mussels are used as raw material for production of shell bead. The shell bead manufacturing industry in Japan is highly specialised where the shells from different countries are imported. Here, the shells are cut, ground and processed into spherical shell beads of 2 to 8 mm diameter. They are then supplied to several countries where they are used as nuclei for pearl culture practices.

In India, the sacred chank shell (Xancus pyrum) is used as raw material for nuclei making. From the coastal waters of Tamil Nadu, Kerala and Gujarat, several thousands of Xancus are fished annually and sent to West Bengal, where the cottage shell industry makes bangles and rings from them. However, more than 70% of the shell mass is wasted and often used in making lime.

From these shell waste, thick shell bits are sorted out and then ground into spheres. It is then polished and used as nuclei for cultured pearls. Shell beads are also produced from the shells of giant clam, Tridacna sp., which occur in Andaman and Nicobar Islands. However, freshwater mussels of large size with thick shells are hardly found in India.

* INDUCED BREEDING IN SHRIMP*

Introduction:

Induced breeding in shrimp involves manipulating environmental or hormonal factors to stimulate reproduction in a controlled environment, typically for aquaculture purposes. This method helps overcome challenges in natural breeding, such as seasonal constraints and low fertility rates. Here's an overview of the key aspects of induced breeding in shrimp:

1. Selection of Broodstock

- **Health and Quality:** Choose healthy and disease-free broodstock with good growth rates and desirable traits.
- **Maturity:** Ensure broodstock are sexually mature; females should have fully developed ovaries, and males should have mature spermatophores.

2. Environmental Manipulation

- **Water Quality:** Maintain optimal water conditions (temperature, salinity, pH, and dissolved oxygen).
- **Photoperiod:** Adjust the light-dark cycle to mimic natural conditions that induce spawning.
- **Temperature:** Slightly increase water temperature to stimulate spawning activity.

3. Hormonal Induction

- **Eyestalk Ablation:** This is a common method where one of the female shrimp's eyestalks is removed to reduce the production of gonad-inhibiting hormones, thus promoting ovarian development and spawning.
- **Hormonal Injections:** Administer hormones such as gonadotropin-releasing hormone (GnRH) or other synthetic hormones to induce maturation and spawning.

4. Spawning and Larval Rearing

- **Spawning Tanks:** Transfer induced females to spawning tanks with optimal conditions for egg laying.
- **Egg Collection:** Collect eggs after spawning and transfer them to hatching tanks.
- **Larval Rearing:** Provide proper nutrition and water quality management to rear larvae through various stages (nauplius, zoea, mysis, and post-larvae).

5. Feeding and Nutrition

- **Broodstock Diet:** Provide a high-quality diet rich in essential nutrients to ensure successful maturation and high-quality eggs.

- **Larval Diet:** Feed larvae with appropriate live feeds such as algae, rotifers, and Artemia nauplii.

6. Disease Management

- **Monitoring:** Regularly monitor for signs of disease and stress.
- **Prophylactics:** Use probiotics and other preventive measures to maintain health.
- **Biosecurity:** Implement strict biosecurity measures to prevent the introduction and spread of pathogens.

7. Record Keeping

- Maintain detailed records of broodstock selection, environmental conditions, hormonal treatments, spawning dates, and larval survival rates to optimize the breeding process over time.

Benefits of Induced Breeding in Shrimp

- **Controlled Reproduction:** Allows year-round breeding independent of natural cycles.
- **Genetic Improvement:** Facilitates selective breeding for desirable traits.
- **Higher Yield:** Increases the production of larvae and juveniles for commercial aquaculture.
- **Sustainability:** Reduces the reliance on wild-caught broodstock, promoting sustainable aquaculture practices.

Challenges

- **Technical Expertise:** Requires specialized knowledge and skills.
- **Initial Costs:** High initial investment in facilities and broodstock.
- **Risk of Disease:** Increased risk of disease outbreaks in high-density rearing environments.

Induced breeding is a critical technique in shrimp aquaculture, contributing to the industry's growth and sustainability by enhancing production efficiency and allowing for genetic improvement.

UNIT 4

PARENTAL CARE ON FISHES

Introduction:

Parental care in fishes is a fascinating and diverse aspect of their biology, showcasing a range of strategies to ensure the survival of their offspring. This care can be provided by either one or both parents and can include behaviors like guarding, cleaning, fanning, and even transporting the eggs or young. Here are the primary types of parental care observed in fishes:

1. Egg Guarding

- **Nesting Sites:** Many fish species, such as cichlids and sunfish, create nests where they lay their eggs. The parent, usually the male, guards the nest against predators and potential threats.
- **Cleaning:** Parents often clean the nest site and eggs to prevent fungal growth and to ensure the eggs are well-oxygenated.

2. Mouthbrooding

- **Oral Incubation:** Species like certain cichlids, arowanas, and some catfish carry their eggs and, later, their fry in their mouths to protect them from predators. This can be done by either the male or female, depending on the species.
- **Extended Care:** After hatching, the fry may continue to seek refuge in the parent's mouth when threatened.

3. Egg Carrying

- **Body Attachment:** In some species, like seahorses and pipefish, males carry the eggs attached to their bodies. In seahorses, the male has a specialized brood pouch where the female deposits the eggs, and he fertilizes and incubates them.
- **Clingfish and Other Species:** Some clingfish carry eggs on their ventral surface, and certain species of catfish attach eggs to their body surfaces.

4. Bubble Nests

- **Nest Building:** Species like bettas and gouramis build bubble nests at the water's surface. Males typically blow mucus-coated bubbles to form the nest and guard the eggs and young.
- **Oxygenation:** These nests help keep the eggs oxygenated, as the males frequently tend and repair the nest.

5. Brood Parasitism

- **Adoptive Care:** In some cases, fish like cuckoo catfish lay their eggs in the nests of other fish species, such as mouthbrooding cichlids. The host species inadvertently takes care of the parasitic eggs along with their own.

6. Guarding Free-swimming Fry

- **Shoaling:** Many species, such as some cichlids and catfish, guard their free-swimming fry. Parents keep their offspring close and protect them from predators.
- **Feeding:** In some cases, parents may help the fry find food or even chew food and spit it out for the fry to eat.

Examples of Parental Care Strategies

- **Cichlids:** Known for their diverse and complex parental behaviors, with some species practicing biparental care, where both parents are involved in guarding and raising the young.
- **Catfish:** Many species exhibit elaborate parental care, such as the armored catfish (Loricariidae), where males guard and fan the eggs to ensure oxygenation.
- **Gobies:** Some gobies guard their eggs laid in crevices or burrows, with males often taking on the primary role of egg protection.
- **Discus Fish:** Both parents produce a nutrient-rich mucus on their skin, which the fry feed on during the early stages of development.

Benefits of Parental Care

- **Increased Survival Rates:** Protecting eggs and fry from predators and environmental hazards significantly boosts the survival rates of offspring.
- **Enhanced Development:** Parental behaviors, such as fanning eggs to increase oxygenation, contribute to better development and health of the young.
- **Adaptation to Diverse Environments:** Parental care allows fish to exploit a wider range of habitats by mitigating the risks associated with those environments.

Challenges and Costs

- **Energy Expenditure:** Parental care requires significant energy and resources, which could otherwise be used for foraging or self-defense.
- **Increased Predation Risk:** Parents guarding nests or carrying young are more vulnerable to predators.
- **Reduced Reproductive Opportunities:** Time and effort spent on caring for current offspring may reduce the opportunities for producing additional clutches of eggs.

Parental care in fishes is a complex and adaptive behavior that enhances the survival of offspring in various environments. The diversity of strategies reflects the evolutionary pressures and ecological contexts that different fish species face.

* EMBRYONIC DEVELOPMENT OF FISHES*

Embryonic development in fishes is a fascinating and complex process that involves multiple stages from fertilization to hatching. While there are variations among different species, the general process can be outlined as follows:

1. Fertilization

- **External Fertilization:** Most fish species engage in external fertilization, where the female releases eggs into the water and the male simultaneously releases sperm to fertilize them.
- **Internal Fertilization:** Some species, such as sharks and rays, practice internal fertilization, where the male transfers sperm into the female's body using specialized organs.

2. Cleavage

- **Zygote Formation:** Once the egg is fertilized, it becomes a zygote and begins to undergo cleavage, a series of rapid cell divisions.
- **Blastomeres:** The zygote divides into smaller cells called blastomeres without an increase in overall size.
- **Blastula Stage:** Cleavage leads to the formation of a blastula, a hollow ball of cells surrounding a fluid-filled cavity called the blastocoel.

3. Gastrulation

- **Cell Movement:** Cells start moving and rearranging themselves to form the three primary germ layers: ectoderm, mesoderm, and endoderm.
- **Gastrula Stage:** The blastula transforms into a gastrula, with distinct layers that will give rise to different tissues and organs.

4. Organogenesis

- **Differentiation:** Cells begin to differentiate into specific types, leading to the formation of tissues and organs.
- **Neural Development:** The neural tube forms from the ectoderm, which will develop into the brain and spinal cord.
- **Somite Formation:** Mesodermal cells form somites, which will develop into the vertebral column, muscles, and other structures.

5. Yolk Utilization

- **Yolk Sac:** Fish embryos rely on the yolk sac for nutrition, which provides the necessary energy and nutrients for growth.
- **Absorption:** As development progresses, the yolk is gradually absorbed and utilized by the growing embryo.

6. Development of Key Structures

- **Heart:** The heart begins to form and beat early in development, ensuring circulation of nutrients and waste.
- **Gill Arches:** Gill arches develop, which will eventually form the gills or other structures depending on the species.
- **Eyes and Ears:** Sensory organs like eyes and ears start to develop, essential for the fish's survival post-hatching.
- **Fins:** Limb buds form and grow into fins, which will aid in swimming once the fish hatches.

7. Hatching

- **Final Stages:** As the embryo nears the end of its development, it becomes more active and ready for hatching.
- **Egg Shell Breaking:** The fish uses an egg tooth or other mechanisms to break out of the egg shell or membrane.
- **Free-Swimming Larva:** Once hatched, the fish enters the larval stage, where it will continue to grow and develop into a juvenile.

Types of Embryonic Development

- **Oviparous:** Most fish lay eggs that develop and hatch outside the mother's body.
- **Ovoviviparous:** Some species retain eggs inside the mother's body until they hatch, giving birth to live young.
- **Viviparous:** A few species give birth to live young that have developed inside the mother's body with direct nourishment from the mother, similar to mammalian development.

Factors Influencing Embryonic Development

- **Temperature:** Developmental rates are highly influenced by temperature, with warmer temperatures generally accelerating development.
- **Oxygen Levels:** Adequate oxygen is crucial for the proper development of embryos.
- **Water Quality:** Clean, pollutant-free water is essential to avoid developmental abnormalities and ensure healthy growth.

LIFE CYCLE IN SHRIMP

The life cycle of shrimp is complex and involves multiple distinct stages from egg to adult. Understanding these stages is crucial for effective shrimp farming and conservation. Here is a detailed overview of the shrimp life cycle:

1. Egg Stage

- **Spawning:** Female shrimp release eggs into the water, which are then fertilized by male shrimp. This can occur in the open sea or in controlled aquaculture settings.
- **Development:** The fertilized eggs are typically spherical and may be carried by the female (in some species) or left to develop independently in the water column.
- **Incubation Period:** The incubation period can vary depending on the species and environmental conditions such as temperature and salinity. This stage usually lasts a few hours to a few days.

2. Larval Stages

The larval development of shrimp includes several distinct stages, each characterized by different morphological features and behaviors. These stages are:

Nauplius

- **First Stage:** The nauplius is the first larval stage after hatching.
- **Appearance:** Nauplii are small, free-swimming, and characterized by a simple body structure with three pairs of appendages used for swimming.
- **Feeding:** They typically rely on yolk reserves for nutrition during the early nauplius stages.
- **Duration:** This stage lasts for a few days, during which the nauplii undergo several molts.

Zoea

- **Second Stage:** After passing through the nauplius stages, the shrimp larvae molt into the zoea stage.
- **Appearance:** Zoea larvae have a more developed body with noticeable eyes, thoracic appendages, and a segmented abdomen.
- **Feeding:** They start feeding on phytoplankton and small zooplankton in the water.
- **Movement:** Zoea larvae are strong swimmers and can actively move in the water column.
- **Duration:** This stage also involves multiple molts and lasts for several days to weeks.

Mysis

- **Third Stage:** The mysis stage follows the zoea stage.
- **Appearance:** Mysis larvae resemble miniature adult shrimp but still have some larval features. They have more developed appendages and a clearer body structure.
- **Feeding:** They continue to feed on plankton but may also start consuming larger particles.
- **Behavior:** Mysis larvae are more mobile and exhibit more complex behaviors.
- **Duration:** This stage lasts for several days and includes several molts.

3. Post-larval Stage

- **Transition:** After the mysis stage, shrimp enter the post-larval stage, where they start resembling juvenile shrimp.
- **Appearance:** Post-larvae look like small adult shrimp with fully developed appendages and a more defined body structure.
- **Habitat:** They start moving towards the benthic zone (the bottom of the water body) and seek out habitats like seagrass beds, mangroves, or other sheltered areas.
- **Feeding:** Their diet becomes more varied, including detritus, small invertebrates, and organic matter.
- **Duration:** This stage can last from a few weeks to several months, depending on the species and environmental conditions.

4. Juvenile Stage

- **Growth:** Juveniles continue to grow and molt, gradually increasing in size.
- **Habitat:** They inhabit areas with ample food supply and shelter from predators.
- **Feeding:** Their diet becomes more similar to that of adult shrimp, including a wider range of food items.
- **Duration:** The juvenile stage lasts until the shrimp reach sexual maturity, which can take several months.

5. Adult Stage

- **Maturity:** Adult shrimp are sexually mature and capable of reproduction.
- **Behavior:** They often migrate to deeper waters for spawning, especially in marine species.
- **Feeding:** Adult shrimp have a varied diet, including detritus, plant material, small invertebrates, and organic matter.
- **Reproduction:** The life cycle begins anew with the spawning of eggs.

Factors Influencing the Life Cycle

- **Temperature:** Higher temperatures generally accelerate development and growth rates.
- **Salinity:** Optimal salinity levels are crucial for the survival and development of different life stages.
- **Food Availability:** Adequate nutrition is essential for successful molting and growth.
- **Water Quality:** Clean, oxygen-rich water is necessary to prevent disease and ensure healthy development.

* LARVAL DEVELOPMENT OF FISHES*

Larval development in fishes is a critical phase in the life cycle, involving significant morphological and physiological changes as the fish transitions from the egg to the juvenile stage. This process varies among species but generally follows a series of well-defined stages. Here is an in-depth overview of the larval development of fishes:

1. Hatching

- **Emergence from the Egg:** Fish larvae hatch from eggs after a period of incubation. The timing of hatching depends on species-specific factors and environmental conditions such as temperature.
- **Yolk Sac Larvae:** Newly hatched larvae are often referred to as yolk sac larvae because they carry a yolk sac, which provides essential nutrients for the initial days of development.

2. Yolk Sac Stage

- **Nutrition:** The yolk sac contains proteins, lipids, and other nutrients that sustain the larva until it can feed independently.
- **Morphology:** Yolk sac larvae typically have undeveloped digestive systems and simple body structures. They are often translucent with visible internal organs.
- **Behavior:** They exhibit limited swimming ability and are often found near the spawning site, relying on the yolk sac for sustenance.
- **Duration:** This stage lasts from a few days to a couple of weeks, depending on the species and environmental factors.

3. Preflexion Stage

- **Depletion of Yolk Sac:** As the yolk sac is absorbed, the larvae begin to develop a more functional digestive system and start looking for external food sources.
- **Morphological Changes:** There is significant development in the head, mouthparts, and digestive tract. The larvae begin to form fin rays, but they are not fully developed.
- **Feeding:** The larvae transition to exogenous feeding, often consuming small planktonic organisms such as phytoplankton and zooplankton.
- **Behavior:** Increased swimming activity and the beginning of feeding behaviors are observed.
- **Duration:** The preflexion stage continues until the larvae have absorbed the yolk sac completely and start significant morphological differentiation.

4. Flexion Stage

- **Notochord Flexion:** This stage is characterized by the upward bending of the notochord at the caudal (tail) end, which is a precursor to the development of the caudal fin.
- **Fin Development:** Fin rays start to develop more fully during this stage. The dorsal, anal, and pectoral fins become more defined.
- **Feeding and Growth:** Larvae continue to grow rapidly and their diet may include larger plankton and small invertebrates.

- **Behavior:** Increased swimming capabilities and more complex behaviors are exhibited, including more active pursuit of prey.
- **Duration:** This stage lasts until the notochord flexion is complete and the caudal fin is fully developed.

5. Postflexion Stage

- **Completion of Flexion:** The notochord flexion is complete, and the caudal fin is fully formed.
- **Advanced Morphology:** Larvae resemble miniature versions of the adult fish, with more developed fins, scales beginning to form, and more complex internal organs.
- **Diet:** Their diet becomes more varied, often including larger prey items.
- **Habitat Shift:** Some species may begin to migrate to different habitats, such as moving from pelagic (open water) to benthic (bottom) zones.
- **Duration:** This stage continues until the larvae undergo metamorphosis into juvenile fish.

6. Juvenile Stage

- **Resemblance to Adults:** Juveniles closely resemble adult fish in morphology and behavior but are not yet sexually mature.
- **Growth:** This stage involves rapid growth and further development of scales, pigmentation, and reproductive organs.
- **Habitat Utilization:** Juveniles often settle in habitats that provide shelter and abundant food, such as coral reefs, seagrass beds, or rocky substrates.
- **Feeding:** Their diet expands to include a broader range of food sources, aligning more with adult feeding habits.
- **Duration:** The juvenile stage lasts until the fish reach sexual maturity, which can vary widely among species.

Factors Influencing Larval Development

- **Temperature:** Warmer temperatures generally speed up development, but extreme temperatures can be detrimental.
- **Food Availability:** Adequate and appropriate food is crucial for survival and growth during the larval stages.
- **Water Quality:** Clean water with optimal levels of oxygen, pH, and minimal pollutants is essential for healthy development.
- **Predation:** High predation rates can significantly impact larval survival, influencing behaviors and habitat choices.

* NEST BUILDING FISHES*

Nest-building fishes exhibit fascinating behaviors and strategies for constructing and maintaining nests, which serve various purposes such as courtship, spawning, and protection of eggs and young. Here are some examples of nest-building fishes and their nesting behaviors:

1. Cichlids

- **Description:** Cichlids are well-known for their diverse nesting behaviors, which vary among species and habitats.
- **Nest Types:** Cichlids build different types of nests, including pit nests, cavity nests, and substrate nests.
- **Materials:** Depending on the species, cichlids may use various materials such as sand, gravel, rocks, or plant matter to construct nests.
- **Nesting Sites:** Nests are often built in shallow areas with sandy or rocky substrates, near vegetation or other structures.
- **Parental Care:** Both parents are typically involved in nest construction, spawning, and guarding of eggs and fry.
- **Examples:** African cichlids, such as those from the genera Tilapia and Pseudotropheus, and South American cichlids like angelfish (Pterophyllum spp.) and discus (Symphysodon spp.), are known for their diverse nesting behaviors.

2. Sticklebacks

- **Description:** Sticklebacks are small, spiny-rayed fish found in freshwater and marine habitats worldwide.
- **Nest Construction:** Male sticklebacks build elaborate nests using plant materials, algae, and other debris.
- **Behavior:** They construct nests in shallow areas, often near vegetation or structures, using their mouths to weave and shape materials into a cup-like structure.
- **Parental Care:** Male sticklebacks court females and defend the nest site. After spawning, males guard the eggs until they hatch and may continue to protect the fry for a period.
- **Examples:** Three-spined sticklebacks (Gasterosteus aculeatus) and nine-spined sticklebacks (Pungitius spp.) are common examples known for their nest-building behaviors.

3. Anabantoids (Bubble Nest Builders)

- **Description:** Anabantoids, also known as labyrinth fish, include species such as bettas, gouramis, and paradise fish.
- **Nest Construction:** Male anabantoids are bubble nest builders. They create bubble nests at the water's surface using saliva and air bubbles.
- **Nesting Sites:** Bubble nests are often built under floating plants or other structures that provide cover.

- **Parental Care:** After spawning, the male fertilizes the eggs and gathers them into the bubble nest. He guards the nest and may retrieve any falling eggs or fry.
- **Examples:** Siamese fighting fish (Betta splendens), dwarf gouramis (Trichogaster spp.), and paradise fish (Macropodus opercularis) are popular examples of bubble nest-building anabantoids.

4. Catfish

- **Description:** Various catfish species exhibit nesting behaviors, with nesting strategies varying greatly among families and genera.
- **Nest Construction:** Some catfish species construct burrows or cavities in the substrate for spawning and rearing of young.
- **Materials:** Depending on the species, catfish may use sand, gravel, mud, or plant matter to construct nests.
- **Parental Care:** Both male and female catfish may be involved in nest construction, spawning, and guarding of eggs and fry. In some species, one parent may provide exclusive care while the other parent may abandon the nest.
- **Examples:** Corydoras catfish (Corydoras spp.), channel catfish (Ictalurus punctatus), and clown plecos (Panaque maccus) are examples of catfish species known for their nesting behaviors.

5. Perciformes (Wrasses, Damselfish, etc.)

- **Description:** Various perciform fish families, including wrasses (Labridae) and damselfish (Pomacentridae), exhibit nesting behaviors.
- **Nest Construction:** Nesting behaviors among perciform fishes vary widely. Some species construct depressions or pits in the substrate, while others create mounds or utilize crevices and coral heads.
- **Parental Care:** Depending on the species, parental care may involve both male and female fish guarding the nest, fanning the eggs, and protecting the fry.
- **Examples:** Bluehead wrasse (Thalassoma bifasciatum), sergeant majors (Abudefduf spp.), and clownfish (Amphiprion spp.) are examples of perciform fishes known for their nesting behaviors.

Benefits of Nest Building

- **Protection:** Nests provide shelter and protection for eggs and young from predators and environmental hazards.
- **Courtship and Reproduction:** Nest building often plays a role in courtship rituals and spawning behaviors, facilitating successful reproduction.
- **Parental Care:** Nest-building species typically exhibit parental care behaviors, which enhance the survival and development of offspring.
- **Habitat Modification:** Nest building can also have ecological impacts by modifying habitats and creating microenvironments that support biodiversity.

Challenges and Conservation

- **Habitat Loss:** Destruction of natural habitats, including spawning and nesting sites, threatens the survival of nest-building fish species.
- **Invasive Species:** Competition with invasive species and predation on eggs and fry can negatively impact nest-building populations.

- **Pollution:** Pollution and water quality degradation can disrupt nesting behaviors and affect the viability of eggs and young.
- **Overfishing:** Overfishing of nesting populations can disrupt reproductive behaviors and lead to declines in fish populations.

EMBRYONIC AND LARVAL DEVELOPMENT OF CRAB

The embryonic and larval development of crabs is a fascinating process that involves several distinct stages, each with its unique characteristics and behaviors. While there can be variations among different crab species, the general developmental stages are similar across many species. Here's an overview of the embryonic and larval development of crabs:

1. Egg Stage:

- **Fertilization:** After mating, female crabs produce eggs, which are fertilized externally by the male's sperm.
- **Egg Mass:** The fertilized eggs are often deposited in clusters or masses attached to the female's abdomen or carried by specialized appendages.
- **Incubation:** The eggs are protected and incubated by the female until they hatch into larvae.

2. Zoea Larvae:

- **Hatching:** Once the eggs hatch, they release larvae known as zoea. The hatching process may be triggered by environmental factors such as temperature or salinity.
- **Appearance:** Zoea larvae are typically small and transparent, with elongated bodies and relatively large eyes. They have long spines on their carapace and appendages.
- **Behavior:** Zoea larvae are planktonic, drifting in the water column and feeding on phytoplankton and small zooplankton.
- **Molting:** Like other crustaceans, zoea larvae undergo molting as they grow, shedding their exoskeleton to accommodate their increasing size.

3. Megalopa Larvae:

- **Metamorphosis:** After several molts, zoea larvae undergo metamorphosis into megalopa larvae. This process involves significant morphological changes.
- **Appearance:** Megalopa larvae have more developed appendages and resemble miniature versions of adult crabs. They still exhibit some larval features, such as a slender body and long abdomen.
- **Behavior:** Megalopa larvae continue to drift in the water column but may start to exhibit more benthic (bottom-dwelling) behaviors, such as walking along the substrate.
- **Feeding:** They feed on a variety of small organisms, including detritus, algae, and small invertebrates.

4. Juvenile Stage:

- **Settlement:** Megalopa larvae eventually settle on the substrate, where they undergo further development into juvenile crabs.
- **Habitat:** Juvenile crabs inhabit various coastal habitats, including rocky shores, sandy beaches, estuaries, and mangrove forests.

- **Feeding:** They are omnivorous, feeding on a wide range of prey items, including small invertebrates, algae, and detritus.
- **Growth:** Juvenile crabs grow rapidly, undergoing molting to accommodate their increasing size.
- **Maturity:** Depending on the species, crabs may reach sexual maturity within a few months to several years, at which point they can reproduce and complete the life cycle.

Factors Influencing Development:

- **Temperature:** Developmental rates are influenced by water temperature, with warmer temperatures generally accelerating development.
- **Salinity:** Optimal salinity levels are necessary for larval survival and development.
- **Food Availability:** Adequate food resources in the form of plankton and benthic organisms are crucial for larval growth and survival.
- **Predation:** Larvae and juveniles are vulnerable to predation by fish, birds, and other aquatic organisms, which can affect population dynamics.

* MENTION ABOUT ENVIRONMENTAL FACTORS AFFECTING REPRODUCTION AND DEVELOPMENT IN FISHES*

Environmental factors play a crucial role in the reproduction and development of fishes, influencing various physiological processes, behaviors, and life history strategies. Here are some key environmental factors that affect reproduction and development in fishes:

1. Temperature

- **Spawning Timing:** Temperature influences the timing of spawning in many fish species. Warmer temperatures often trigger spawning, while colder temperatures may delay or inhibit reproduction.
- **Embryonic Development:** Optimal temperature ranges are essential for the proper development of fish embryos. Deviations from these ranges can lead to developmental abnormalities or mortality.
- **Growth Rates:** Temperature affects metabolic rates and growth rates in fish larvae and juveniles, influencing their development and size at maturity.

2. Water Quality

- **Oxygen Levels:** Adequate oxygen levels are crucial for successful reproduction and development in fishes. Low oxygen levels, often associated with pollution or eutrophication, can impair spawning, embryonic development, and larval survival.
- **pH and Acidity:** Changes in pH levels and water acidity can affect reproductive behaviors, egg viability, and larval development. Acidification of water bodies due to factors like pollution or carbon dioxide absorption can have detrimental effects on fish populations.
- **Toxic Substances:** Exposure to pollutants such as heavy metals, pesticides, and industrial chemicals can disrupt reproductive processes, cause developmental abnormalities, and reduce survival rates in fishes.

3. Salinity

- **Anadromous and Catadromous Species:** Anadromous species, such as salmon, migrate from the sea to freshwater rivers to spawn, while catadromous species, such as eels, migrate from freshwater rivers to the sea to spawn. Changes in salinity levels along migration routes can impact spawning success and larval survival.
- **Estuarine Species:** Many fish species inhabit estuarine environments, where they are exposed to fluctuating salinity levels due to tidal influences. Adaptations to variable salinity regimes are essential for successful reproduction and development in these species.

4. Photoperiod

- **Seasonal Breeding:** Photoperiod, or day length, influences the timing of breeding and spawning in many fish species. Longer daylight hours in spring and summer often trigger reproductive behaviors, while shorter days in autumn and winter may inhibit breeding activity.
- **Migration Patterns:** Photoperiod cues play a role in regulating migratory behaviors in some fish species. Changes in day length can signal the onset of spawning migrations, particularly in species that migrate between freshwater and marine habitats.

5. Habitat Availability and Quality

- **Spawning Habitat:** The availability and quality of spawning habitats, such as suitable substrate, water depth, and vegetation, are critical for successful reproduction in fishes. Habitat degradation or loss due to factors like habitat destruction, pollution, and urbanization can negatively impact spawning success and larval survival.
- **Nursery Habitats:** Nursery habitats, including shallow coastal areas, mangroves, and seagrass beds, provide essential shelter and food resources for juvenile fish. Degradation or loss of these habitats can disrupt recruitment and population dynamics.

6. Predation and Competition

- **Predator Avoidance:** Predation pressure can influence the timing and location of spawning, as well as the choice of nesting or egg-laying sites, to minimize predation risk.
- **Intraspecific Competition:** Competition for resources, including mates and spawning sites, can influence reproductive behaviors and success in fish populations.

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PITUITARY GLAND IN FISHES

In fishes, the pituitary gland, also known as the hypophysis, plays a vital role in regulating various physiological processes, including growth, reproduction, metabolism, and osmoregulation. Here's an overview of the pituitary gland in fishes and its functions:

Anatomy of the Pituitary Gland in Fishes:

- **Location:** The pituitary gland is located at the base of the brain, just below the hypothalamus, in a region called the sella turcica.
- **Structure:** It consists of two main parts: the anterior pituitary (adenohypophysis) and the posterior pituitary (neurohypophysis). These parts have distinct functions and origins.

Functions of the Pituitary Gland in Fishes:

1. Anterior Pituitary (Adenohypophysis):

- **Growth Hormone (GH):** Regulates growth and development in fishes by stimulating cell division, protein synthesis, and tissue growth. GH also influences metabolism and energy utilization.
- **Prolactin (PRL):** Plays a role in osmoregulation, particularly in freshwater fishes, by regulating ion uptake and water balance.
- **Thyroid-Stimulating Hormone (TSH):** Stimulates the thyroid gland to produce thyroid hormones, which regulate metabolism and energy expenditure.
- **Gonadotropins (Gonadotropin-Releasing Hormone, GnRH):** Stimulate the development and function of the gonads (testes in males and ovaries in females), controlling reproductive processes such as gamete production and sex steroid synthesis.

2. Posterior Pituitary (Neurohypophysis):

- **Vasotocin (Vasopressin):** Regulates water balance and osmoregulation by controlling water reabsorption in the kidneys. Vasotocin helps fishes maintain proper hydration levels in varying environmental conditions.
- **Oxytocin:** Plays a role in reproductive behaviors, such as mating, courtship, and parental care. Oxytocin release may stimulate spawning behavior and facilitate egg laying or brood care.

Regulation of Pituitary Function:

- **Hypothalamic Control:** The pituitary gland is under the control of the hypothalamus, which secretes releasing and inhibitory hormones that regulate pituitary hormone release. These hormones travel through the bloodstream to the pituitary gland via the hypophyseal portal system.
- **Feedback Mechanisms:** Pituitary hormone secretion is often regulated by negative feedback mechanisms, where rising hormone levels inhibit further hormone release. This helps maintain hormonal balance and homeostasis in the body.

Importance in Reproduction:

- The pituitary gland plays a central role in regulating reproductive processes in fishes, including sexual maturation, gonadal development, and spawning behavior.
- Gonadotropins released by the anterior pituitary, such as follicle-stimulating hormone (FSH) and luteinizing hormone (LH), control gametogenesis (sperm and egg production) and stimulate the release of sex steroids (e.g., estrogen, testosterone) from the gonads.
- The release of gonadotropins is often controlled by hypothalamic gonadotropin-releasing hormone (GnRH), which is influenced by environmental cues such as photoperiod, temperature, and water quality.

Conclusion:

The pituitary gland in fishes plays a crucial role in regulating various physiological processes, including growth, metabolism, osmoregulation, and reproduction. Its functions are essential for maintaining homeostasis and adapting to environmental changes, ensuring the survival and reproductive success of fish populations. Understanding the endocrine control of pituitary function is valuable for fisheries management, aquaculture, and conservation efforts aimed at supporting healthy and sustainable fish populations.

FISH ADENOHYPOPHYSIS

The adenohypophysis, also known as the anterior pituitary gland, is a critical component of the endocrine system in fishes. It is responsible for producing and secreting several hormones that regulate various physiological processes, including growth, metabolism, osmoregulation, and reproduction. Here's a closer look at the adenohypophysis in fishes and its functions:

Anatomy and Structure:

- **Location:** The adenohypophysis is located at the base of the brain, just below the hypothalamus, within the sella turcica.
- **Histological Structure:** It consists of several types of cells organized into distinct regions or lobes, including the pars distalis (anterior lobe), pars intermedia (intermediate lobe), and pars tuberalis (tuberal lobe). The pars distalis is the largest and most functionally significant region in fishes.

Functions of the Adenohypophysis in Fishes:

1. Growth Hormone (GH):

- **Stimulates Growth:** GH plays a crucial role in regulating growth and development in fishes by promoting cell division, protein synthesis, and tissue growth.
- **Metabolic Effects:** It influences metabolism by enhancing nutrient uptake and utilization, regulating energy expenditure, and mobilizing energy reserves.

2. Prolactin (PRL):

- **Osmoregulation:** PRL is involved in osmoregulation, particularly in freshwater fishes, by regulating ion uptake and water balance. It helps fishes maintain proper hydration levels in varying environmental conditions.
- **Reproductive Behaviors:** PRL may also play a role in reproductive behaviors, such as courtship, spawning, and parental care.

3. Thyroid-Stimulating Hormone (TSH):

- **Thyroid Function:** TSH stimulates the thyroid gland to produce thyroid hormones (thyroxine and triiodothyronine), which regulate metabolism, growth, and development in fishes.

4. Gonadotropins:

- **Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH):** These gonadotropins control reproductive processes such as gametogenesis (sperm and egg production), gonadal development, and the release of sex steroids (e.g., estrogen, testosterone) from the gonads.
- **Reproductive Cycles:** The release of FSH and LH is often regulated by hypothalamic gonadotropin-releasing hormone (GnRH), which coordinates reproductive cycles in response to environmental cues such as photoperiod, temperature, and food availability.

Regulation of Adenohypophyseal Hormone Secretion:

- **Hypothalamic Control:** Adenohypophyseal hormone secretion is under the control of the hypothalamus, which releases releasing and inhibitory hormones that regulate pituitary hormone release. These hormones travel to the adenohypophysis via the hypophyseal portal system.
- **Feedback Mechanisms:** Adenohypophyseal hormone secretion is often regulated by negative feedback mechanisms, where rising hormone levels inhibit further hormone release. This helps maintain hormonal balance and homeostasis in the body.

Gonadotropin

Gonadotropin (GTH) cells are richly found in the proximal pars distalis (PPD), where they may form a solid ventral rim of cells. Such situation is found in Cyprinoide. In salmonids and eel they are spread throughout rostral pars distalis (RPD) and PPD. Gonadotrops are basophilic cell types and are PAS and AB positive. These cells have irregular and more or less dilated cisternae of granulated endoplasmic reticulum (GER) containing granules with varying electron density. The gonadotroph (GTH) is under the control of gonadotropin releasing hormone. In many teleosts, unlike mammals, neurosecretory stimuli may pass along the nerve fibres piercing the laminae, that separates the neuro from adenohypophysis, and penetrating into the endocrine parenchyma of pars distalis (Ball, 1981). There are two types of nerve fibres designated as A and B types. The fibres of A type remain in contact with hormone producing cells, including gonadotrops and even terminate with synapse on these cells. B type fibres form synaptic contact with a large granular vesicle of 60-100 nm diameter, while the A synapse have granules of 100- 200 nm diameter. The gonadotropin (GTH) releasing hormone (GnRH) of teleost is similar to luteinizing hormone releasing hormone (LH-RH) is localized in ventral lateral nucleus preopticus periventricularis (NPP) and posterior lateral nucleus lateral tuberis (NLT) as well as other areas. In hypothalamus, localization of immunoreactive fibre tracts from cells in the NPP and NLP to the pituitary gland suggests that these areas are the origin of endogenous releasing hormone.

In fishes there is only one functional gonadotropin is found, which is often regarded as piscian pituitary gonadotropin (PPG). This single gonadotropin has similar properties of two hormones. LH and FSH of mammals. Mammalian luteinizing hormone (LH) promotes release of gametes from nearly mature gonads in fishes and stimulates appearance of secondary sexual characters. This indicates that there must be a similar hormone in fishes also. Salmon pituitary secretes gonadotropins which resembles LH. Furthermore, the gonadotropins from human chorion and urine of gravid mares, have LH like properties which hasten the release of eggs in female fishes. The presence of follicle stimulating hormone in fishes (FSH), which is the second gonadotropin hormone found in mammalian pituitary gland, is still not confirmed. Recently, prostaglandin, which is hormone-like substance has been isolated from testis and semen of blue fin tuna (Thynnus thynnus) and flounder (Paralichthys olivaceus).

The duality of gonadotropins (GTHs), follicle-stimulating hormone (FSH) and luteinizing hormone (LH), has been confirmed in most teleost species, but very little is known about their biological functions. To elucidate the physiological roles of FSH and LH in fish reproduction, the expression profiles of GTH subunit genes during gonadal development were analyzed in both male and female red seabream. Furthermore, *in vitro* studies were carried out to examine the effects of GTHs on steroid hormone production and cytochrome P450 aromatase (P450arom) expression in red seabream gonads. In both sexes, LHβ mRNA was maintained at high levels from the early gametogenesis until spawning season, and declined with gonadal regression. Interestingly, FSHβ mRNA levels in males increased in parallel with testicular development, whereas those in female were remained low throughout oocyte development. From *in vitro* studies using purified red seabream FSH and LH, both GTHs had a similar potency in stimulating 11-ketotestosterone production by testicular slices, while the biological activity of FSH was much lower than that of LH in stimulating production of estradiol-17β by vitellogenic follicles. Moreover, expression of P450arom mRNA was induced by LH, but not FSH, in ovarian follicles *in vitro*. FSH was also ineffective in inducing maturational competence and final oocyte maturation. These results suggest that, unlike salmonids, FSH may play an important role during gametogenesis in male, but not female, red seabream, whereas LH may be involved in regulation of both early and late gametogenesis in both sexes.

Thyrotrophs

Thyrotropin (TSH), a pituitary glycoprotein hormone that stimulates the thyroid gland, has been cloned and sequenced from over a dozen teleost fish species. Although TSH is established as a primary driver of systemic thyroid status in mammals, its importance in the regulation of fish thyroid function is still uncertain. We review recent studies indicating that TSH structure is highly conserved across species representing six teleost families. These studies have found TSH messenger RNA consistently expressed in teleost pituitary tissue, although ectopic expression, particularly in gonads, has also been observed. They have also provided evidence for negative feedback inhibition of TSH expression by thyroid hormones, as well as stimulation by hypothalamic peptides. Descriptive studies have found increased TSHbeta expression associated with life history events thought to be promoted by thyroid hormones. These results, coupled with the discovery of a G-protein coupled TSH receptor in several teleost species, supports an active and conserved role for TSH in the regulation of teleost thyroid function. The relative importance of central pathways in regulating thyroid hormone provision to targets and the identity of a proposed thyrotropin-inhibiting factor in teleost fish are still unanswered questions whose resolution will be facilitated by development of methods to measure circulating TSH and its secretion from the pituitary gland.

* THYROID GLAND IN FISHES*

The thyroid gland in fishes, as in other vertebrates, plays a crucial role in regulating metabolism, growth, and development. Though fish thyroid anatomy can vary among species, the fundamental functions and regulatory mechanisms are similar. Here's an overview of the thyroid gland in fishes and its functions:

Anatomy and Location:

- **Location:** In most fishes, the thyroid gland is located in the ventral region of the pharynx, close to the gills. However, its precise location and structure can vary among species.
- **Histological Structure:** The thyroid gland consists of follicular cells that produce thyroid hormones, mainly thyroxine (T4) and triiodothyronine (T3), which are stored in follicles within the gland.

Functions of the Thyroid Gland in Fishes:

1. Metabolism Regulation:

- **Thyroid Hormones:** T4 and T3 play a central role in regulating metabolic rate and energy expenditure in fishes. They stimulate cellular respiration, oxygen consumption, and ATP production, influencing overall metabolic activity.
- **Temperature Regulation:** Thyroid hormones help fishes maintain optimal body temperature by modulating metabolic processes in response to environmental temperature changes.

2. Growth and Development:

- **Somatic Growth:** Thyroid hormones are essential for promoting somatic growth, tissue differentiation, and skeletal development in fishes. They stimulate protein synthesis and cell proliferation, contributing to overall body size and musculoskeletal structure.
- **Metamorphosis:** In species with complex life cycles, such as amphibious fishes or fish larvae undergoing metamorphosis, thyroid hormones regulate developmental transitions, including changes in morphology, behavior, and habitat use.

3. Osmoregulation:

- **Ion Regulation:** Thyroid hormones can influence ion transport mechanisms in the gills and other epithelial tissues, affecting ion balance and osmoregulation in freshwater and marine fishes.
- **Water Balance:** Thyroid hormones may indirectly influence water balance by regulating metabolic processes that affect water uptake, retention, and excretion.

4. Reproduction:

- **Reproductive Physiology:** Thyroid hormones play a role in regulating reproductive physiology and behaviors in fishes, including gonadal development, gametogenesis, and spawning activities.
- **Seasonal Breeding:** Changes in thyroid hormone levels may be associated with seasonal variations in reproductive activity, particularly in species with specific breeding seasons.

Regulation of Thyroid Hormone Secretion:

- **Pituitary-Thyroid Axis:** Thyroid hormone secretion in fishes is regulated by the hypothalamic-pituitary-thyroid (HPT) axis, similar to other vertebrates.
- **Thyroid-Stimulating Hormone (TSH):** TSH, produced by the anterior pituitary gland, stimulates the thyroid gland to release thyroid hormones in response to hypothalamic signals.
- **Feedback Regulation:** Thyroid hormone levels are regulated by negative feedback mechanisms, where rising hormone levels inhibit further hormone release. Environmental factors, such as photoperiod, temperature, and food availability, can also influence thyroid hormone secretion in fishes.

* MOULTING IN PRAWNS*

Moulting, also known as ecdysis, is a vital process in the life cycle of prawns and other crustaceans. It involves the shedding of the old exoskeleton (outer shell) and the growth of a new, larger exoskeleton to accommodate the animal's increasing size. Moulting is essential for prawns' growth, development, and reproduction. Here's an overview of the moulting process in prawns:

1. Pre-moult Stage:

- **Indicators:** Before moulting, prawns exhibit certain physiological and behavioral changes. These may include reduced feeding, increased locomotion, and changes in coloration or opacity of the exoskeleton.
- **Stages:** The pre-moult stage can be divided into several substages, including intermoult, pre-moult, and post-moult.

2. Moulting Process:

- **Separation of Exoskeleton:** Prawns initiate the moulting process by secreting enzymes that weaken the connection between the old exoskeleton and the underlying epidermis.
- **Softening of Exoskeleton:** As the connection weakens, the old exoskeleton becomes soft and pliable, allowing the prawn to extract itself from the shell.
- **Extraction:** Prawns typically extract themselves from the old exoskeleton by arching their bodies and using appendages to push and pull themselves out of the shell.
- **New Exoskeleton Formation:** After shedding the old exoskeleton, the prawn's body is soft and vulnerable. It secretes a fluid containing chitin and other materials to form a new exoskeleton.
- **Hardening:** The new exoskeleton gradually hardens and becomes sclerotized through a process called tanning or sclerotization. This process may take several hours to days, during which the prawn is highly vulnerable to predation.

3. Post-moult Recovery:

- **Feeding:** After moulting, prawns may exhibit increased feeding activity to replenish energy reserves and support the growth of the new exoskeleton.
- **Behavior:** Prawns often seek shelter and avoid predators during the post-moult period until their new exoskeletons fully harden and provide adequate protection.
- **Growth:** Moulting allows prawns to grow and accommodate their increasing body size. The frequency of moulting decreases as prawns reach maturity.

4. Factors Affecting Moulting:

- **Environmental Conditions:** Factors such as temperature, photoperiod, water quality, and availability of food can influence the moulting frequency and success in prawns.
- **Nutritional Status:** Adequate nutrition, including sufficient protein, vitamins, and minerals, is essential for supporting moulting and the growth of the new exoskeleton.
- **Hormonal Regulation:** Moulting in prawns is regulated by various hormones, including ecdysteroids and crustacean hyperglycemic hormone (CHH), which respond to internal and external cues.

Importance of Moulting:

- **Growth and Development:** Moulting allows prawns to grow, develop, and adapt to changing environmental conditions.
- **Reproduction:** Moulting is essential for reproductive success in prawns, as it facilitates gonadal development, maturation, and spawning.
- **Health Maintenance:** Regular moulting helps prawns maintain the integrity of their exoskeletons, repair damage, and remove parasites or pathogens.