FISH ADAPTATION AND PHYSIOLOGY (3 UNITS)

FIS 314

LECTURE GUIDE

BY

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The bony fishes are an incredibly diverse group, and it is impossible to present all the morphological variations found in these fishes. There are certain external features typical of bony fishes, and structures found on them such as cirri, spines and snouts. The bony fishes are often represented by species like the yellow perch, *Perca flavescens*, which is quite abundant and is available for study.

The main external features such as dorsal and caudal median fins, the pectoral and pelvic paired fins, the bony gill cover (operculum), the mouth with its bony jaws structures and flexibility, and the lateral line, are all relatively common to bony fishes.

Not all fishes have bodies shaped like the hypothetical fish which is referred to as elongated, bass-like or fusiform.

Other common body shapes like eel-like or elongated and ovate or truncated. When describing the shape of a fish body, the perch would be considered compressed, thin or narrow. Other possible shapes are depressed or flattened and sub-circular or hemisphere. Others presented a lateral view combined with the cross-sectional views, results in such terms as compression, depressiform, anguilliform, filiform (an extreme elongation such as in the snipe eel) taeniform (an eel-like body that is laterally compressed as in gunnels) and globiform.

The placement of the pelvic fins also varies considerably among bony fishes and provides information about its phylogenetic position and maneuverablility of the body. The perch has its pelvic fins in a thoracic position, direct under the pectoral fins and connected internally to the pectoral girdle. In more primitive bony fishes, such as herrings, the pelvic is located abdominally, while in more advanced bony fishes, it is thoracic or jugular, well an advance of the pectoral girdle. An extreme case is one in which the pelvic fin is actually under the chin or eye, and this condition is termed mental.

Caudal fin shape and structure have many variations among the bony fishes, ranging from naked, without rays on the tip, to forked, indented, and rounded. The shape and structure of the caudal fin is related to its function. Fishes, for example, with narrow caudal peduncles have forked caudal fins often are continous fast-swimming types, while those with differentiated

caudals are less active with their swimming activities and some occupy small crences in near shore rocky environments.

Two other structures associated with caudal fins should be mentioned. In some primitive fishes an adipose fin, a median dorsal fin no bony elements lies near the caudal fin. In fast swimming fishes, such as tunes, there often is a series of little median fins (called finlets) dorsally and ventrally immediately in front of the narrow caudal peduncle. Theses fins supposedly reduce drag created by water flowing over the fish's body during swimming movements. Often a lateral protuberance called a keel occurs on the caudal peduncle of such fishes and probably serves as a stabilizing factor in theses fast fishes.

Additional structures associated with the tails of bony fishes are:

(a) The tail of a tuna, family scombridge

(b) The tail of a salmon, shaving the adipose fin

(c) Caudal rays extending over the hypural bones.

Bony fishes occupy many kinds of habitats and consume a wide variety of feeds, so they have evolved a vast array of mouth and snout forms. The perch has a typical mouth shape that is usually referred to as terminal, located directly at the front of the body. Other shapes include overhanging or inferior mouths such as in anchovies projecting lower jaws or superior mouths as in barracudas; tubular snouts with the fishes and prolonged upper jaws, as in swordfishes. The words terminal, inferior, superior and extended can also be applied to the position of the lips.

Terminologies of the various mouths and snout forms

a. The lower jaw projecting beyond the upper jaw as in the sphyraenidae.

b. A tubular snout with jaws at the top, as found in the Macrorhamphosidae.

c. A snout that is over-hanging or projecting beyond the mouth so that the moth is termed inferior as in the Engraulidae.

d. a prolonged upper jaw that form a sword-like beak, as found in the Istrophoridae.

e. Jaws (and lips) that are terminal (i.e. at the end of the body) as in the cottidae.

f. An extended upper jaw with the lower lip inferior or included, as found in the Blennidae.

Teeth occur mostly in the mouth; usually on the lower jaw bone (mandible) and free margin (gape) of the upper jaw per-maxilla and sometimes maxilla. In more primitive fishes, both the pre-maxilla and maxilla bear teeth, although more advanced bony fishes have the maxilla excluded from the gape and therefore it id toothless. Several kinds of teeth occur in fishes. These can be categorized as canniform, incisoriform, or molariform. The kinds differ in general morphology with canniform teeth having an elongated, narrow appearance, ibncosors having a sharp cutting edge, and molariform being blunt and snout for grinding and crushing. Other head bones that may bear teeth include the vomer palatine, basibranchials and gill arches, even the tongue of some fish carry teeth.

FISH REPRODUCTION

The sex of a fish can be accurately determined by examination of the gonads. In adults males, the paired testes are smooth usually whitish in colour, and with no granular appearance. In adult females, the paired ovaries may be smooth, usually coloured (orange, dark green, cream, black), but always granular in appearance, due to the presence of mature oocytes (eggs). In immature specimens, the sex is determined accurately by examination o the gonad through a dissecting microscope under which the developing oocytes are readily observed as numerous roundish structures in contrast to the uniform features observed in the testis.

A simple and accurate method for sexing mature fish around spawning time is to apply gentle pressure on the belly around the genital papillae. In ripe males, milt will run while in females eggs will be discharged.

MATURITY STAGEG OF THE GONADS

A simple classification of the stages in gonad development is to refer to them as immature ripening, ripe and spent. These maturity stages can be readily observed in cichlids, catfish, and cyprinids.

The Physiology of Reproduction

As with all other vertebrates' hormones play vital roles in the physiology of reproduction of fishes. In all classes of fishes, the pituitary gonadotropins and gonad steroid are the hormones directly involved in the regulation of reproductive physiology. It is the recognition of these facts that result in the practical use of hypophysation technique to induce spawning in fishes under laboratory pond of hatchery conditions.

Reproductive Behaviour

Reproduction includes gonads development, maturation, ovulation and spawning. The male and female gametes fuse to form a zygote which develops into a larva, and ultimately a young adult. Each of the various steps involves a complex series of behavioural events which vary considerably among fish species.

REPRODUCTION IN FISH WITHOUT PARENTAL CARE

Many fish species have members which aggregate during the breeding season. The egg (ova) are shed into the open water and fertilized externally in the body; thus it is likely that many eggs will remain unfertilized and therefore perish. The fertilized eggs develop in the open water and many will be carried off to unsuitable habitats and perish. A very large percentage will serve as food for other aquatic organism. Again a large proportion will die. It has been estimated that 1% larval survival will ensure the maintenance of this category of fish species. The tremendous wastage is compensated for by production of a large number of eggs. For example a herring can produce lates niloticus, can be produce up to 300,000 eggs in a single spawning.

REPRODUCTION IN FISHES WITH PARENTAL CARE

Many groups of fish exhibit parental care. It may be restricted to providing nets for the laying of eggs (e.g. Heterotis niloticus) or it may involve protection of the egg, larvae and juiveniles from predators. The protection may be offered in the form of guarding the rest, as in species of eggs and larvae in the buceal cavity, as in Sarotherodon, Oreochromes, Chrysichtys and Arius species.

REPRODUCTION/BREEDING IN TILAPIA (*Hemichromis fasciatus)*

The basis pattern of breeding behavior in *Hemichromis fasciatus* is one in which the male and female exhibit a four-phased breeding cycle, namely;

(a) Pair-bonding
(b) Nest building
(c) Spawning
(d) Parental care over eggs and young fish

For breeding to be initiated in this species, the physio-chemical properties of the aquatic habitats have to be at optimum level in addition to availability of some solid objects like stones, logs or plant roots, which can serve as spawning sites for the attachment of the adhesive egg from the female. The area must also be large enough so that the young fry can find sufficient food within the shortest range for at least the first few days of free-swimming live.

Most of these conditions are usually perceived through visual signals, and as soon as this happen the first phase of the breeding cycle sets in.

First Phase in Pair-Bonding

Establishment of the area thus identifies by the right male as its territory marks the beginning of this phase. This area is simply a part of the aquatic habitat including some suitable spawning sites; with this done, the male fish deeply and brightly coloured, defend the territory with increasing vigor, by attacking any intruder. One or more lightly coloured ripened females persist in entering the territory, whereupon the two sexes engage in courtship activities, swimming around for few hours or days until the male come to accept one of the females as a partner, and subsequently drive away the other females. Once accepted by the male, the female become aggressive and helped in chasing away intruder from the territory.

This phase thus establishes individual recognition between the partners so that in defending their eggs and young ones there would be no risk of attacking each other. Territorial and courtship behavior continue until the pair enters the next phase.

2nd Phase: - Nest Building

The two sexes now set out to make their nest although the greatest part of the work is usually done by the male. The male *Hemichromis* swim around the chosen site, fanning off all sand and other materials lying on or around the chosen rock. The fanning and cleaning is usually done with the pectoral fin, pelvic and caudal fins and occasionally the mouth is used in picking out unwanted material like small stones. Larger stones and material are pushed off the sites by means of the head and cheeks. The female fish occasionally swims in to add some helping hands. This cleaning exercise continues, until the female is ready to lay her eggs hence the beginning of the swimming phase.

3rd Phase: - Spawning

The female *Hemichromis* with its distended abdomen swim very close to the rock nest in a survey manner. The male also follows, but occasionally swims to and float over the nest, allowing the female to start releasing her eggs. The female eventually start laying her eggs, swimming very gently in the process. This may be a way of ensuring that no egg is laid on top of another, and that the eggs are laid in rows. When the female might have laid the first batch of her eggs, the male usually interchange position with the female. The female fish now float over the nest, allowing the male to move in and fertilize the already laid eggs. The male *Hemichromis*

swims gradually over the rows of eggs with its pelvic or ventral fins hanging down and rushing though the laid eggs on the spawning site. This is probably to ensure that the eggs are still there and in rows. Having ascertained this, the release of the milt over the eggs then follows immediately. This interchange of eggs lying and milt releasing by the female and male respectively, continues until the female stop spawning. This set for the last phase in the breeding cycle of *Hemichromis fasciatus).*

4th Phase: - Parental Care Over Eggs & Fry

Bi-parental care is usually exhibited by both male and female fish in guarantying their fertilized eggs with the male and female taking turn to guard the eggs. One parent usually swims just above the eggs ventilating them by fanning water over them, while the other parent usually the male set about building a new nest chosen to the first one. The second nest serves as a second home to which newly hatch larvae's are transferred. The effectiveness of parental care over the eggs could be seen by observing what happens when the male *Hemichromis* usually attack such intruder by picking it up with its mouth and swims off to deposit it elsewhere. The male and female *Hemichromis fasciatus* are also involved in the removal of the unfertilized eggs which appear as whitish bits on the spawning site.

As soon as the larvae start hatching out with both parents transfer them with their mouth to the second nest, which usually look more secure than the first in term of protecting young larvae from predators. Great care is usually exhibited in keeping these larvae together and any larva that stays away is often brought back to the population. This continues until the larvae yolk sac is almost totally absorbed and the young fish can fan for themselves. This parental care over the eggs and young fish largely contributed to the success of these fish species, which is known to lay not too may eggs.

FEEDING HABITS

Food is the source of energy for all vital activities of all living organisms which enables the cultivated fishes to live successfully in their habitats.

The choice of food covers a wide spectrum. During photosynthesis, the radiant energy of the sun is used by plant to convert carbon dioxide and food water into carbohydrates which is utilizes as the food source for these organisms. As a consequence they are known as autotrophs , or primary producers. These organisms are, in turn eaten by herbivores which are subsequently eaten by carnivores. This mechanism creates the concept of the food chain in a particular ecosystem. Therefore a sound knowledge of the food and feeding habits of cultures fishes will ensure that fishes are to be stacked with a pond or reservoir are capable of utilizing the resources to a maximum.

A broad classification of feeding pattern among cultured fishes is as follows:

Herbivores Species

These are fishes that derive nutritional requirement almost exclusively from plant materials. The grass carp *Ctenopharyngodon idella* is a typical example. *Tilapia zilli* is also a well known herbivore. It feeds on phytoplankton, fragments of aquatic insects, cladocerans, and copepods. Strictly, no single fish species is known to be an obligate herbivore (exclusively plant-eating) as in terrestrial ruminants.

Omnivorous Species

This group of fishes includes both plant and animal materials in their diet. A vast majority of cultural species e.g. *Oreochromis nileticus, Sarotherodon galilaetus* and *Sarotherodon melanotheron* are plankton feeders fall into this category. This cichlids feed on a combination of phytoplankton e.g. diatoms & desmids and zooplankton (copepods, rotifers).

Another group of omnivores are those that combine plant materials with invertebrates other than plankton. This group may also include detritus in their diet. Examples of cultural fishes in this group are *Heterotis niloticus* and *Cyprinus carpio.*

Predatory Species

Several fish species feed specifically on animal foods with the exclusion of plant materials and detritus. This group of fishes is referred to as predators. Their choice of food

ranges from an assortment of invertebrates to predation on other fishes. They can be divided into two groups:

(a) Non-Piscivorous Predators

The diet of fish species like *Synodontis schall* commonly comprises insect larvae and pupae. In *Chrysichthys nigrodigitatus,* copepods, pawns, gastropods and aquatic insects are the main components of the diet.

(b) Piscivorous Predators

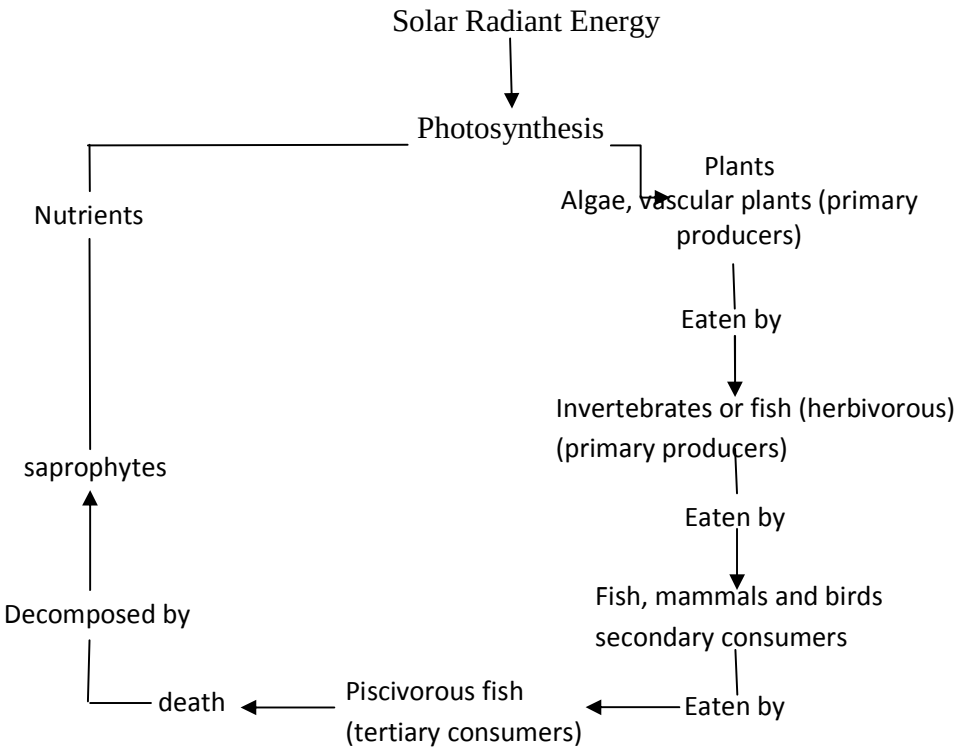
Many fish species feed exclusively on other fishes when adult but usually consume invertebrate foods as sub-adults. Only a few species are useful in fish culture. *Lates nilotraus* is a well known piscivore in the inland waters of tropical Africa. It grows to a length of more than one meter and can weigh as much as 100kg. They feed exclusively on other fishes and serves as a useful species to control stunting in tilapias. Some other piscivores which may be encountered in fish pond include *Hemichromis fasciatus* which feeds on the eggs of tilapia, but rarely reach 200g in weight. *Clarias gariepinus* and *heterobranchus bidorsalis* prefer to feed on other fishes but can utilize invertebrate without harm to their growth. They will also accept artificially formulated diets.

Detritivirous Species

Detritus means (decomposing plant and animal material). Many freshwater fish species utilize detrital materials as a source of food. These include many tilapia species e.g. *S. galilaeus, O. niloticus* and *T. zilli* in estuaries and lagoons, cichlids such as *S. melanotheron* and *Tilapia guineensis* utilize bottom detritus as do the mullets (*Mugil cephalus, Mugil bananensis).*

The quantity of food found in the full stomach of fish species varies considerably. It highest in the piscivorous species where food consumed in single meal serves as a meal for several days. At the lower end of the scale are herbivores, detritus and omnivorous whose single meals are on average about 1.5% of their body weight or less.

The food in the full stomach of *Tilapia cichlids* was about 1% of body weight or less. This suggests that supplementary feeding need not exceed this value. There are no precise data on the quantity of supplementary feed that a fish requires to achieve the best growth rate, but this will undoubtedly be influenced by the quality of food.


Solar Radiant Energy
Photosynthesis
Plants
Algae, vascular plants (primary producers)
Eaten by
Invertebrates or fish (herbivorous) (primary producers)
Eaten by
Fish, mammals and birds secondary consumers
Eaten by
Piscivorous fish (tertiary consumers)
death
Decomposed by
saprophytes
Nutrients