LECTURE NOTE ON FIS 301

FIS 301: FISH BIOLOGY (2 UNITS)

This Course is taught by three (3) lecturers – Dr. I.T Omoniyi, Dr. F.I. Adeosun and Dr. A.A. Akinyemi.

The Course Synopsis is further outlined on lecture basis as follows:

Lectures 1 – 3: Gross external anatomy of typical bony and cartilaginous fishes.

Lectures 4 – 5: Gross internal anatomy of typical bony and cartilaginous fishes.

Lectures 6 – 7: Anatomy of systems and basic functions

Lectures 8 – 9: Reproductive biology treated under fecundity

Lectures 10 – 12: Embryology/life history of fish.

GROSS EXTERNAL ANATOMY

By way of introduction, basic diagnostic features of fish need to be identified.

1. Fishes are cold blooded/poikilothermic animals i.e their body temperature varying passively in accordance with the ambient temperature (surrounding water temperature). Although, fishes as a group can tolerate wide range of temperature from just below O^0C to 45^0C, individual species generally have a preferred or optimum as well as a more restricted temperature range. For example, salmonids inhabit water with temperature range from $0\text{-}20^0C$. Any change within the optimum range can significant influence the biology as related to the anatomy.

2. The adoption of aquatic habit has other implications for the structure and physiology of fish. For instance, it makes the streamlining and shaping of the body an important pre-requisite

for success in aquatic life. The shapes range from ovoid to torpedo-like or fusiform shape. This is due to the higher density of water than air.

3. Respiration assumes a greater important through the gills when compared to terrestrial animals because water contains $1/20^{th}$ of 0_2 available in air. This proportion of 0_2 is still further reduced by an increase in temperature and/or ionic concentration. Fishes are exposed to much greater ionic and osmoregulatory challenges than land animals because their bodies are permanently immersed in water (a medium) which is not only the universal solvent but also the fluid in which gases must diffuse during respiration exchange. Microbial infection and multiplication are more likely to occur from the water medium.

Therefore, there is the need to consider the structural implication of fish to an aquatic existence. The gross external anatomy allows an individual especially the fisheries scientist to identify most species with a fair degree of accuracy. When doubt exists, other anatomical details may have to be examined. The body shape of fish is totally adapted to a free-swimming life in water and it is adapted to give maximum efficiency to its propulsion through the water.

Make a drawing each of body and cartilaginous fish. e.g tilapia as bony and *Scoliodon* (shark) as cartilaginous fish. Label each fully during class lecture.

There are basically two shapes of fish-round and flat fishes. Flat fish such as Skate, Rays, Plaice and Soles are adapted to life on the bottom of the water body. Round fish in general have evolved an efficient hydrodynamic shape to allow them to move through the water body with the minimum expenditure of energy. Body shapes of fishes can also be described based on the cross-sections of the body. These shapes include:

i Fusiform shape- Cross section fish is round e.g in tuna, mackerel. Draw.

ii Compressiform shape-Shows lateral compression e.g Tilapias, *Ilisha* etc. (Draw)

iii Anguilliform shape-compressed body form but are laterally long e.g *Gymnarchus*.(Draw)

iv Filliform shape- Round cross-section but with long body e.g eel, *Calamiochthys calabaricus*.(Draw)

v Teaniform shape- cross-section shows oval outlook e.g *Clarias, Heterobranchus*.(Draw)

vi Sagittiform- eound but with upper part flat e.g *Hepsetus odoe* (the African pike). (Draw)

vii Depressiform shape-cross section is dorso-ventrally compressed. e.g Soles,Skates and Rays. (Draw)

viii Globiform shape- Round cross-section and looks like a ball when viewed from the side. e.g globefish, sunfish (Draw)

The Skin: The external surface of the body of fish is the skin which is composed of two layers – an outer epidermis and the inner dermis. It is from the underlying dermal layer that the characteristic scale covering of fish is produced. The epidermis is a thin, fragile layer which is constantly sloughed off and renewed. It contains mucous cells which secrete the sliming outer covering of fish. The slime on the epidermis is called mucus which makes the fish slippery to handle. The mucus protects the epidermal layer against abrasion and by lubrication makes the fish more streamlined and also difficult to hold. It also renders the skin less permeable and prevents entry of pollutant materials and microorganisms which would otherwise infect the fish. This is why fish are handled with care to avoid damage or injury to the skin or its protective coating. The lipoprotein properties of the slime also trap or bind heavy metals and bacteria which are then lost as the mucus is washed off the surface of the fish. Draw the TS of Skin. The scale

which are composed of bone and connective tissue growth in size in accord with other tissue in the body. Each scale overlaps the one behind producing a relatively impermeable but living cover. Growth rings or annuli are seen on the scale. Variations in thickness of these rings are produced by seasonal changes in diets or temperature or by spawning. The annuli can be used to determine age of fish. Note that these rings are more difficult to interprete with tropical fishes than the temperate fishes. The reason being that growth in tropical fishes is usually more rapid than it is in temperate water. Also, growth rings are not clearly seen in cultured fish because they are maintained under relatively stable conditions and feed at constant rates.

Types of scales: (i) Placoid scales – sometimes called dermal denticles. It has an ectodermal cusp made up of an enamel-like substance. Commonly found in shark (Elasmobranchii/cartilaginous fish).

(ii) Cosmoid scale – is another type of scale in this category. It resembles placoid but thinner and with harder water layer. It is made up of material known as virtrodentine. Found in the living and extinct lobefin fishes.

(iii) Ganoid is another type of scale in this category. It differs in having inorganic salt substance called ganoine. It has a diamond-shape flat, smooth enamel-like surface. Sometimes called rhombic scale because of its shape. Found in *Polypterus*, *Calamoichthys calabaricus.*

The other two types of scales commonly called bony ridge scales are found in many living fish species especially the Osteichthyes. These are:

(a) Cycloid scale which is characterized by its exposed surface being smoothly rounded. That is, its thin smooth disc-like surface edge has a more or less circular outline. Fishes having this type of scales are therefore smooth to touch e.g. tilapias, *Heterotis, niloticus* (Draw)

(b) Ctenoid scale has its posterior surface or margin toothed i.e. comb-like.

Therefore, fish is rough to touch e.g. *Ctenopoma kingsleyae*. It should be noted that there are fishes without scales. These are called Scaleless or 'naked' fishes. These fishes are usually covered with thick slime/mucus which make them more slippery to touch or handle e.g. *Malapterurus electricus, Clarius sp.*

Mouth positioning can be used to describe fish. Make diagrams of such which include:

(i) Terminal mouth e.g. in tilapias

(ii) Sub-terminal mouth e.g. in *Clarias*

(iii) Inferior mouth e.g. in Shark

(iv) Superior mouth e.g. in *Hemichromis*

(v) Retracted mouth e.g. in African barrel fish (*Hyperoglyphe*)

(vi) Protrusible/Protracted mouth e.g. Star gazer (*Uranoscopus*)

The mouth of fish is equipped with teeth are used in connection with feeding. Teeth are one of the structural adaptations to feeding habit. Based on location in the mouth, teeth could be described as:

(i) Premaxillary – teeth located on the front margin of the upper jaw.

(ii) Maxillary – teeth located on the sides of the upper jaw on separate bones

(iii) Mandibular teeth – these are located on the margin of the lower jaw

(iv) Vomerine – these are located on the front part of the roof of the buccal cavity.

(v) Pharyngeal teeth – these are located on the throat.

Based on the types cusps, there are 3 types:

Unicuspid teeth – Have one cusp each

Bicuspid teeth – Each tooth has two cusps

Tricuspid teeth – Each tooth has three cusps

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Based on the form, there are

(i) Villiform teeth – these are numerous, short, fine and pointed teeth e.g. found in *Channa*, stargazer.

(ii) Incisor-like teeth – these are with sharp edges used for cutting. Highly characteristic of the carnivorous e.g. *Gymnarchus*

(iii) Canine-like teeth – these are relatively big pointed teeth used for piercing and holding prey. Found in piscivorous fish e.g. Barracuda, *Hepsetus odoe, Hydocynus*, Shark etc.

(iv) Molar-like teeth – these are flattened broad teeth used for cutting and crushing e.g. in benthic fishes feeding on shellfish and detritus e.g. Rays, Skates.

Note that in some fishes, teeth may remain vestigial e.g. the planktophagous feeding fishes – *Ilisha africana* and in Carps which are omnivorous.

FISH APPENDAGES – FINS

The fish external appendages are essentially the fins which constitute the most vital external features for identifying fish using the ray counts especially of the dorsal and anal fins. The sizes and shapes of fins, their location on the body and positions in relation to each other are important in classification. Each fin is made up of a number of rays which are usually bony and flexible and they may be either simple or branched. In many fishes, some of the rays especially of the dorsal fin are replaced by strong and sharp spines which are counted as a tool in systematic e.g. Tilapias. An appendage may be median in that their rays are in line with the axis of the fish. They are found at the back of the fish e.g. dorsal fin or at the tail region referred to as the caudal fin and the lower edge behind the vent called the anal fin. In some fishes, there are two dorsal fins e.g. lamprey, shark, *Mugil, Pentanemus.*

However, there are some species which second smaller posterior dorsal fin is soft, fleshy tissue that is not rayed. This is termed adipose fin e.g. in *Heterobranchus, Bagrus, Chrysichthys* etc. The function of the adipose fin remains unclear but it is useful to fishery scientists and farmers to mark or identify individual fish. It is incapable of regeneration once cuts.

Some mackerel groups have small series of dorsal fins which are soft rayed, referred to as finlets, may also occur ventrally. (Illustrate all these in class).

The second categories of fins are called the paired fins. These are the pectoral and pelvic fins. Fins are generally used by fishes to achieve all forms of locomotion, stabilization, balancing, change of direction and brake in the aquatic environment.

It should be noted that the internal skeleton is noted to form the frame to which are attached the muscles used for swimming and breathing. The fish propels itself through the water by sinusoidal movements of the body amplified by the flat tail.

There are modifications in some fishes to the general functions of some fins e.g.

Pectoral fins are modified for crawling in Australian lungfish; used as tactile organ for feeling in *Trichurus tricurus*; as gliding organ in some flying fish e.g. *Exocoetus sp*; as taste organ in primitive species e.g. Hag fishes or as a protective organ because of the associated powerful spines e.g. *Synodontis, Clarias, Heterobranchus*.

Pelvic fin is also modified as tactile organ in *Protopterus;* as suckers in gobies or even as intromittent organ known as Clasper e.g. in shark and skates. It aids in reproductive activity.

Anal fin is modified as intromittent organ in the family Poecillidae.

The caudal fin in most fishes is lobed i.e. it is forked given rise to upper and lower lobes attenuated to points. But in some fishes, it is rounded, pointed, truncate etc. Candal fin is used for identification.

Illustrate in class the different types of caudal fins in fishes.

The Lateral line: Constitutes a visible feature of the extraordinary sensory system in fishes. It consists of a series of marks or pits usually one on each scale, running along. The midline of each side of the body and also at times on the head e.g. *Heterotis.*

Some fishes have a discontinuous lateral line, the anterior part often being higher on the body and more conspicuous e.g. Tilapias. A few fishes have no lateral lines e.g. Clariids. These pits are connected through special sensory organs to the nerves running to the brain. By means of these sense organ, fishes are able to detect movement and vibrations which are far beyond their range of vision.

REPRODUCTIVE BIOLOGY IN FISHES

Briefly, reproduction is a process or means whereby a fish can maintain its continual existence mainly by sexual method. This method allows for genetic variation, leads to hybrids and evolution of new species. Three types of reproduction are recognized in fishes.

(a) Bisexual reproduction – involves two individuals male and female. This method is mostly common in fishes.

(b) Hermaphroditic reproduction – occurs in very few fishes e.g. some salmonids and perches and Black bass (*Micropterus* being introduced in Nigeria). In this case, both male and female reproductive organs are present in each individual. In some fishes, there is sex reversal i.e. at any point in time there is either testis or ovary. But it can change when it is necessary, ovary changing to testis and vice versa. The two sex organs do not occur at the same time.

(c) Parthenogenetic reproduction – in fishes, it is appropriately known as Gynogenetic reproduction where sperm penetrates the egg but will not fuse with the nucleus of the egg. It only stimulates the egg.

Reproductive systems include ovaries in female and testis in female. The system also include reproductive ducts. In primitive fishes e.g. jawless fishes (Agnatha), there are no productive ducts, but have gonads only. He gonads are internal, longitudinal and originate as paired in most fishes. In few fishes, the two may become partly fished or fused totally together. In some, one may become degenerate, one functions (Illustrate all these during lecture hours). Gonads are enclosed and suspended in mesenteries called mesorchia and attached to the air bladder. In very rare or abnormal cases, some fishes may have two pairs of gonads. The size, weight and colour of gonads vary depending on the stage of sexual maturity. The weight of gonad is usually expressed as percentage of the body weight of fish. This is known as Gonado-somatic index

(GSI). The GSI in male fish is about 12% or less while in female it is between 30-40%. In terms of colours, the virgin or immature gonads are almost colourless and translucent. But the developing and mature testis, it is usually creamy white and flocculent while the developing and maturing ovaries, colour ranges from yellow through golden yellow to green. The ovaries are usually granular in texture, testis and smooth. The size of granular in texture, testes are smooth. The size of granules depends on the stage of gonads. In outline, the ovary is usually longer than the testis and when they ripen, the ovaries occupy most of the body cavity leaving vary little space for other viscerals. In some fishes especially the catfish Clarias, Synodontis the testis looks wavy or folded in outline. Illustrate the TS of testis.

The structure of sperms varies from species to species. Illustrate with examples of eel, trouts, perch, guppy. Most eggs in fishes are spherical, some are oval in outline e.g. Cichlid, may look like tear-drops e.g. in guppy. Some eggs may have appendages used for anchorage e.g. Shark (Draw). The maximum size of eggs varies from species to species. This is attributed to parental care exhibited by the fish. Fishes which show some care for their egg and young one tend to have large sized eggs and young have tiny or small eggs. Fish with large sized eggs produce fewer numbers of eggs while those produce small sized eggs spawn large number of eggs. The smallness of the eggs is associated with the fecundity or number of eggs produced by the fish. The small sized tends to have higher density of yolk and hatch faster than big sized eggs. The sperm cells are produced in large number in a juicy fluid secreted by the sperm duct. The sperm cells (Spermatozoa) and the sperm duct secretion make up the white fluid called MILT. A drop of milt may contain thousands of sperm cells

Fecundity

Simply, fecundity is the number of eggs produced by a fish. This term has been variously defined by authors e.g. (i) defined as the number of eggs produced by fish at each spawning (number of eggs/spawn) (ii) Number of eggs produced in a season (number of eggs/season) (iii) Number of eggs produced in a year (number of eggs/life time). The first three definitions for fishes which spawn in a year are essentially the same. But, in case of fishes e.g. Tilapias, which spawn between 4 and 14 times in a year, these definitions are not useful. The 4th definition above is more difficult because it is not easy to know the life span of a fish. Therefore, the more convenient definition of fecundity is taken as the number of eggs in the ripe ovary of a fish. As fishery biologist, look for ripe ovary and count number of eggs. This is called total or individual or absolute fecundity of a fish. Relative fecundity is taken as number of eggs in the ripe ovary of a fish per unit weight or length of a fish. Relative fecundity is a more reliable expression of fecundity of a fish for comparative purpose.

Importance of Fecundity (i) used as part of systematic in racial studies (ii) useful in studies of population dynamics and productivity (iii) Preserves species and relative stability both in space and time.

In order to assess fecundity, the stage of gonad development need to be determined e.g. Using Kesteven (1960) key.

Stage I – Gonad appears as a strand lying within the visceral.

Usually, it is impossible to determine sex except by microscopical examination.

Stage II – Enlargement of gonads. Stages I and II are immature.

Stage III – Further increase in size of gonads. The ovary takes on a pale greenish colour whereas testis assumes a cream colour e.g. in Sarotherodon. The stage is maturing.

Stage IV – Gonads tend to move in the mid-line thus increase in size. No further numbers of eggs can be added. Counting of eggs can start at this stage.

Stage V – Ripe stage. With small taping, few eggs are released.

Stage VI – With taping, the eggs are running. The stage is referred to as running stage of spawning.

Stage VII – Gonads empty

Stage VIII – Recovery stage

Stages IV and V can be used in estimation of fecundity.

How to determine the fecundity of a fish

- Measure length and weight of the fish, preferably when still fresh.
- Take out the ovaries, weigh and then take a sub-sample of 1g or 5g or 10g. Count the eggs. A lens or a binocular microscope can be used in the counting. It may be necessary to take sub-samples from different parts of the ovary and calculate the average number of eggs per unit weight or length of fish.

Multiply the number of eggs in sub-samples by the weight of the ovary to get the total number of eggs in the ovary. This method is known as Gravimetric method. For example –

W – Weight of two ovaries

w – Weight of subsample of ovary

n – Number of eggs in sub-sample

$N = \frac{n}{W} \times W$ (N = total number of eggs i.e. fecundity)

The second method is volumetric which utilizes volume of eggs instead of weight of the eggs.

Direct enumeration is another method. This is a direct count, very accurate and useful when the ovary is small and number of eggs is very low. During counting, eggs may damage, it is

therefore necessary to harden the eggs before counting. Different technique for hardening eggs, the most convenient method is by using the Gilson's fluid. Put ovaries in the fluid and shake intermittently for 1-2 weeks after which the count could be made. Before preserving the ovary, remove the ovarian walls for the fluid to penetrate into the eggs. Other method is by boiling the ovary, many eggs are gummed together hence break at counting. 70% alcohol or 10% formalin may be used but still stick together and break during counting.

Factors affecting fecundity will be discussed during lecture hours. Endeavour to attend.