

Fisheries and Aquaculture (Biol.3092) Handout Two

2 REPRODUCTIVE SYSTEMS AND GROWTH IN FISHES

2.1 INTRODUCTION

Determination of sex does not normally present any serious difficulties. In some species, e.g., salmon, characins and some cichlids, this can be done from external characteristics without opening the fish to expose the gonads. Normally the body cavity has to be split open. Even after exposure of the gonads differentiation between sexes by gross examination may be difficult or impossible in small virgin individuals. In specimens which are beyond the immature virgin stage, the distinction can normally be made easily by eye examination; Ovaries are usually tubular, pink, and granular while the testes are flat, white and their ventral edges frequently have a wave like outline. The testes also have a more flattened knife-edged shape than the ovaries

Fish reproduce from eggs. In herring, mackerel, and many other species, spawning (the act of reproduction) is a mass enterprise. Gathered in huge schools, the females expel eggs and the males discharge milt (sperm) into the water. In some species the eggs float; in others they sink. In all species thus spawned, vast numbers of eggs and young are eaten by fish and birds or are otherwise destroyed. However, each female produces thousands, even millions, of eggs at a spawning. Many fish lay their eggs in nests. The nests may be depressions in the beds of streams and lakes, such as those made by salmon and bass. The stickleback's nest is made of plant material. Fighting fish use floating bubbles as nests.

The eggs and young of nesting fish are commonly guarded by one of the parents, usually the male. The males of certain ocean catfishes carry the eggs, and later the young, in their mouths for as long as six weeks, fasting until the young is large enough to defend for themselves. Male sea horses and pipefish carry the eggs in abdominal pouches similar to those of kangaroos. In Nile tilapia, mouth brooder, the females hatch their eggs in their mouth and take care of the fries by hiding them in the mouth till they are capable of protecting themselves from enemies. In some species, especially shark species, the females give birth to living young from eggs that are fertilized and hatched within their bodies

2.2 REPRODUCTIVE SYSTEM OF FISH

Reproduction is the process by which animals increase their population to continue their races in nature. There are four types of reproduction: - homosexuals, bisexual, Hermaphrodites and parthenogenetic. Reproductive system mainly consists of reproductive organs known as gonads, (testes and ovary), the gametes (sperms, ova). Fishes reproduce by several methods and are generally bisexual. Some species are hermaphrodite and even parthenogenetic reproduction occurs in a few cases. Some fishes are highly specialized for breeding and show interesting development of parental care comparable with higher

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animals. The sperms and the eggs develop in separate gonads except in some species of Sparidae and Serranidae, which are true hermaphrodites and the eggs and sperms, develop in the same gonad and self fertilization takes place. However, hermaphrodite gonads sometimes occur in other species also. Parthenogenetic development takes place in *Poeciliaformosa*, in which the sperms simply induce the egg to develop, but take no part in fertilization.

2.3 Sexual dimorphism

The characteristics of sexual difference or sexual dimorphism that enables identification of the sexes are classed as primary and secondary. Primary sexual characters are concerned with reproductive organs, the testes in males and ovaries in females. The primary sexual characters often require dissection for their discernment, which makes the secondary sexual characters often more useful, although sometimes not so positive. Some species show well marked sexual dimorphism, which may be of two kinds:

(i) Some species possess structural peculiarities directly related with fertilization of ova. These are in the form of copulatory organ in the male for introducing the milt into the body of the female, as the claspers in sharks.

(ii) Some species possess structural peculiarities that are not connected with sexual union or fertilization, but are related with courtship, or fight among rival males. In most fishes excepting the elasmobranches and a few teleosts, fertilization is external in water. In Chondrichthyes, the eggs are fertilized within the body of the female, and the males are provided with claspers or myxopterygia for transferring the sperms into the body of the female.

In several species of fishes, sexual differences are not related with copulation between male and female, and are generally well marked during spawning season. In most of the teleosts, females are larger in size with enlarged rounded belly during the breeding season. A common secondary sexual character is the brighter color of the body and fins in the male, as in the Cyprinodontidae, Cichlidae, Labyrinthidae and Labridae. In a number of cyprinids, the male becomes much brighter in colour during the breeding season.

In fish biology, knowledge of fish reproductive biology is very important for the rational utilization of fish stocks and their sustainable production. Understanding the reproductive aspects of fish is also very important for providing sound scientific advice in fishery management. This is because availability of fish reproductive data is very important for a better understanding of the observed fluctuations in a population. Mainly, studies on breeding season, fecundity and their associated factors are very important to protect the new recruits and predict recruitment variability. Life history parameters, such as size or age at sexual maturity, sex ratio and spawning time considerably vary between fish species. This variation involves balancing of energy allocation between fish growth, reproduction and interactions with mortality. Observation of changes in seasonal gonad development is the most

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suitable method for determining the reproductive biology of fishes. Study of seasonal gonad development is through an observation of morphological changes that gonad undergo to attain full growth and ripeness

2.4 Maturity stage in fishes

Fishes have five maturity stage scales in Males and females, Immature(i) Developing virgin /recovering spent(ii) maturing/ripening(iii)Ripe and running(iv) and spent (V) as described in table below. Stage 4 (Ripe and running) in both female and male fishes (Figures 1 and 2) is important in fishery management, since fishes are in spawning at stage 4 and, it is used to close the spawning seasons/ breeding seasons.

Description of gonads

Maturity stage	Male	Female
1	Immature, virgin - A pair of small thread-like, colourless organs (with slightly serrated edges, in <i>C. gariepinus</i>). Difficult to distinguish between the sexes (except in <i>C. gariepinus</i>).	Immature virgin - A pair of small, thread-like colourless organ. Difficult to distinguish between the sexes in <i>B. tsanensis</i> and <i>O. niloticus</i> . In <i>C. gariepinus</i> (size >18 cm) the ovary is discernible as tiny, bulb-like and pinkish in colour.
2	Developing virgin or recovering spent - Long thin, up to 1/2 length of body cavity but distinct opaque white in <i>B. tsanensis</i> and <i>O. niloticus</i> and translucent white in <i>C. gariepinus</i> , with distinct serrated edges and shorter.	Developing virgin or recovering spent - Long thin, up to 1/2 length of body cavity thicker than the testis and translucent yellowish-white in <i>B. tsanensis</i> and <i>O. niloticus</i> and pink in <i>C. gariepinus</i> . Recovering spent has larger gonad size and thicker wall.
3	Maturing or ripening - Long and thicker, 2/3 body cavity (or 1/2 in <i>C. gariepinus</i>), firm and more solid. Colour white in <i>B. tsanensis</i> , cream or beige in <i>O. niloticus</i> and greyish-white in <i>C. gariepinus</i> .	Maturing or ripening - Long and thicker, 2/3 body cavity Colour yellowish in all. Ova discernible in all.
4	Ripe and running - Large thick and slimy. Milky white in <i>B. tsanensis</i> , creamy in <i>O. niloticus</i> and white in <i>C. gariepinus</i> . Sperm easily flows when pressed or cut. <i>C. gariepinus</i> testis has smoother edge.	Ripe and running - Ovary large, yellow, almost filling the peritoneal cavity in all. Ova well developed and large may flow out when pressed.
5	Spent - testis shrunk and flaccid. Numerous folds appear in <i>O. niloticus</i> , and serrated edges revert to original sharpness and colour changes grey in <i>C. gariepinus</i>	Spent - ovary shrunk and flaccid. Some remnants of disintegrating, opaque and ripe eggs appear in ovary of <i>O. niloticus</i> and sometimes in <i>B. tsanensis</i> ; rarely in <i>C. gariepinus</i> . Colour changes translucent in <i>O. niloticus</i> and <i>B. tsanensis</i> but in <i>C. gariepinus</i> the ovary changes colour to greyish-red.

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Figure 1: Matured Female (F IV)) with eggs



Figure 2: Matured male (MIV) with milt

3. GROWTH IN FISH

Fish grow as long as they live and eat, though they grow more slowly as they age. The rate of growth varies greatly, being most rapid where food is most abundant. Growth is commonly quicker in warm regions than in cold. Fish have a wider range of size than any other group of vertebrates. The smallest fish known, the pygmy goby of the Philippines averages less than one-half of an inch (13 mm) at maturity. The largest is the whale shark, which is estimated to reach a length of 60 feet (18 m) or more. (The largest of all sea-dwelling animals, the blue whale, is not a fish but a mammal). The normal life span of fish varies greatly. Some die after one year. Certain large fish such as sturgeon, lake trout, and Atlantic halibut may live for decades.

3.1 Factors affecting growth rate

The growth rate in fishes is highly variable and depends upon a number of environmental factors such as Temperature, amount of dissolved oxygen, ammonia, salinity, photoperiod, degree of competition, quality of food taken, age and the state of maturity of the fish. Temperature is one of the most important environmental factors, and along with other factors, influences growth rate. Thus, optimum food consumption for maximum growth is temperature dependent. For example, in the young salmon maximum growth rate is achieved at 15°C. Dissolved oxygen level depends on temperature, and by itself is also an important factor affecting growth rate of fishes. Possibly, the fish is deprived of 'extra' aerobic energy required for growth and reproduction, if dissolved oxygen falls below a certain level. Ammonia, if present in high concentration will slow down the growth rate. Growth rate depends on the population density also. Higher densities slow down the growth and lower densities tend to increase it. This may also be due to competition for available food. Competition may, be interspecific as well as intraspecific. Food availability which depends upon temperature affects growth rate on a seasonal basis. Growth may be rapid during warmer months, when plenty of food is available and slow during winter. Similarly photoperiod may also affect seasonal growth. Age and maturity are also important factors.

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Fish typically grow very fast in length in the first few months or years of life until maturation, later, large amount of energy is diverted for the growth of gonads, hence body growth slows down. Growth rate of mature fish are therefore, much less than those of immature fish. Growth in fishes has curvilinear relation with weight and is indicated with the following formula

$$TW = a TL^b$$

Where TW –total weight (gm)

TL- total length (cm)

a- intercept of regression line

b- Slope of regression line

Mature fish are typically heavier per unit of length than the immature fish, partly due to the large sized gonads. This is shown by their higher Condition factor (K), Condition factor represents the condition of the fish during a certain period, and is the ratio of the length to the weight of the fish, as calculated by the following formula:

Fulton condition factor is calculated as:

$$FCF = \frac{TW}{TL^3} * 100$$

Where, TW- total weight in gram and TL- total length in cm

3.2 Methods of determining age- and growth

Growth rates in fishes can be determined by measuring the changes in size in relation to time. One of the following methods can be used:

1. Rearing the fish in a controlled environment

This is one of the direct methods for determining the growth of fish. A fish or egg or larvae of known age are placed in a tank or in a cage in water bodies. Its length and body weight is measured at intervals of time for calculating growth rate. This method is especially useful for determining growth of cultured fishes, as feeding rate, temperature and other environmental factors can be kept under control.



Glass Aquarium



Plastic tank

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2. Tagging

Fishes are marked or tagged, and released after recording initial measurements of length and weight; the fish are recaptured after an interval of a few months and measured again. The growth rate is calculated from the change in size over the time period fish spent in its natural habitat. Marking should be done in such a way that it does not affect the behavior or feeding rate of the fish, and can be done by clipping the fin rays, coloring the epidermis by spray painting or providing fluorescent rings on scales or bones. Various dyes such as chromium dioxide, Fast Blue, Lead acetate may be injected, so that the fish can be recognized when caught again. Tagging is however, more popular. Various types of tag bearing particulars about the fish and date of tagging etc. are attached to the body, so that they remain in position and are not lost. A tag may be a disc made of plastic, aluminum, silver, nickel etc. Tag may be attached to the body by means of a thin wire without actually piercing it. The wire may be tied by encircling the jaw or caudal peduncle. In some cases a thin wire is used to actually pierce the tissue of the body. The wire carries the disc or plate, and the two ends of the wire are twisted after piercing through the tissue, to keep it in place. The marked or tagged fishes provide more realistic data regarding growth and movements of the fish, but are more difficult to recapture, hence a very large number of fish must be used in this method.

3. Rings or annuli on hard substances

In many species, the rate of growth in the diameter of the bones, spines and scales is proportional to the growth of the fish. Some of the hard parts that can be studied for age determination are, otoliths, scales and dorsal and pectoral spines, of these the most commonly used are the scales and otoliths. Generally, scales are used for age determination of fish. This is the simplest and most accurate method, and with some experience, annuli on the scales can be easily counted. About 10 scales are taken from the fish, usually from below the origin of the dorsal fin just above the lateral line. These are called 'key scales'. The scales are cleared in water by scrubbing them. Wet or dry mounts are then prepared. Permanent preparations are made either by cellulose or plastic impression or as a whole mount in glycerin, glycerine-gelatin mixture. The scale is examined under a binocular microscope, or the image may be enlarged by using a micro projector for easy and accurate counting of growth rings. The focus of the scale is the first part to develop and is usually located in the centre. An annulus is usually marked by a clear, narrow streak, encircling the focus. One annulus represents one year, and addition of successive annuli indicates the number of years the fish has attained. The age of fish is determined by scales on the basis that successive rings are formed as the fish grows in age. During summer and autumn, plenty of food is available and the fish grows at a faster rate so that the rings formed in this period are widely spaced. During winter, the food supply is limited and growth is restricted so that the rings are tightly picked,

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giving an appearance of alternate rot and dark bands. These two bands are together considered to have been formed in one year and are called the annuli. The number of annuli on the scale gives the age of the fish. Circuli are the actual sites of heavy deposition of bone material, and annuli represent the period of slow growth in a year. Sometimes false annuli also appear in some fishes due to slowing or fluctuation in temperature, and must be distinguished from real annuli.

Generally a true annulus runs all along the surface of the scale, and is formed at the same time each year but a false annulus does not run all along the scale and can be formed at any time due to various factors. It was formerly thought that availability of food was responsible for the formation of rings, and so this method is valid for fish living in temperate zones, where the amount of food varies with the season, while in tropics where the food is available throughout the year, this method is not reliable.

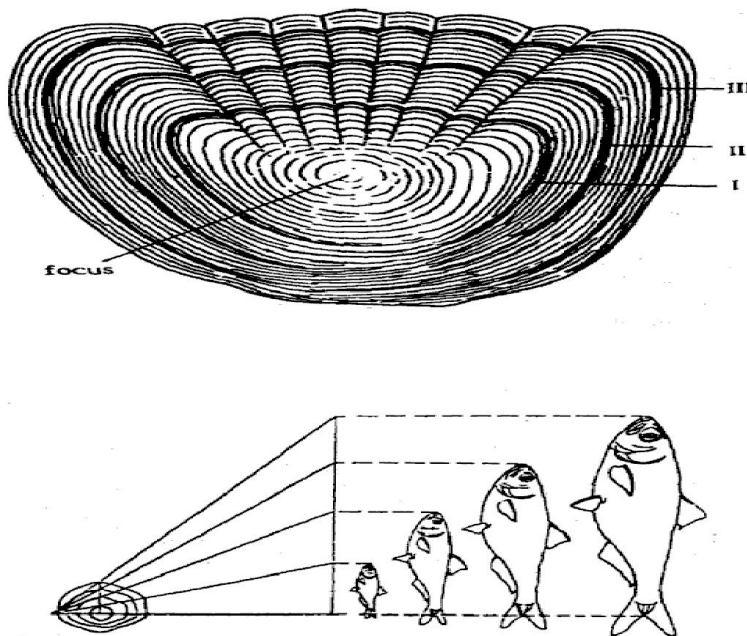


Figure 3: Relation between age and number of annuli in fish

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Assignment (20 points)

Write a minimum of 5 pages review on :-

1. Fish parasites
2. Temperature effect on growth of fishes in ponds
3. Fish diseases treatment methods
4. Fecundity of fishes
5. Gonado-somatic Index
6. Types of Reproduction in fishes
7. Diversity of Temperate and Tropical fish species
8. Commercially important fish species of temperature
9. Finfish and shell fish
10. Current fishery production (capture and Aquaculture) in the world

Format

1. Cover page
 - Name of students with ID
 - Section
2. Introduction
3. Review literature
4. Summary
5. References

Note: Date of Submission: May, 12/2011