**FISH CULTURE**

SPECIFIC OBJECTIVES:

* Define fish culture
* State at least six (6) factors affecting fish culture
* Differentiate between Aquaculture, Mariculture and Aquaculture

FISH CULTURE: this is the art and science of breeding, cultivating, rearing or nurturing of fish in a confined water area.

Fish culture system is defined as the various ways, methods, techniques or approaches adopted by fish farmers in the cultivation or growing of fish and other aquatic organisms.

FACTORS AFFECTING FISH CULTURE SYSTEM

* Land availability
* Economic parameters (capital, money, finance)
* Availability of fingerlings
* Fish farmers culture, tradition or beliefs
* Demand for fish
* Water availability
* Security
* Feed and feed material availability

AQUACULTURE: it is also known as aqua-farming. It is the cultivation or farming of fish, crustaceans, molluscs, aquatic plants, algae and other marine organisms. Aquaculture involves cultivating fresh water and salt water flora and fauna population under controlled conditions. It also involves some form of intervention in the rearing process to enhance production; such as regular stocking, feeding, protection from predators etc.

MARICULTURE: it refers to the cultivation of organisms in sea/salt water. Mariculture may consists of raising the organisms on or in artificial enclosure such as in floating netted enclosures for salmon and on rack for oysters.

AQUARICULTURE: this refers to the cultivation of aquatic organisms in an aquarium. It involves the management of an aquarium, which include feeding, stocking and other management activities.

**DIFFERENCES BETWEEN AQUACULTURE AND MARICULTURE**

|  |  |  |
| --- | --- | --- |
|  | AQUACULTURE | MARICULTURE |
| a | it is related to fresh water and sea water | It is associated with sea water |
| b | It encompasses the whole spectrum of fish production | It is only a branch of aquaculture |
| c | It is associated with organisms in fresh water and marine water | It is associated with organisms in sea water/brackish water only. |

**SYSTEMS OF FISH CULTURE**

SPECIFIC OBJECTIVES:

* Mention and explain six (6) fish culture systems
* State four merits and three demerits of fish monoculture
* State three merits and four demerits of Polyculture
* Explain the term hybrid fish
* State two merits and demerits of hybrid fish

FISH CULTURE SYSTEM

Aquaculture worldwide is practice in three types of environment: fresh water, marine water and brackish water for a great variety of culture organisms. Fresh water aquaculture is carried out either in fish ponds, pens, fish cages or in a limited scale in rice paddies. Brackish water aquaculture is done mainly in fish ponds located in coastal areas. Marine culture employs either fish cages for molluscs and seaweeds such as stakes, ropes and rafts.

The following are fish culture systems:

MONOCULTURE: this is the rearing of only one species of fish in a pond environment over time.

POLYCULTURE: it is also known as mixed culture. It is the rearing or breeding of two or more species of fish in the same pond environment. In Polyculture system, a carnivore species is used to control the population and keep it from exceeding the carrying capacity of the pond. E.g. Clarias spp and Tilapia spp.

MONOSEX CULTURE: this is the rearing of a single sex of a particular fish species in a pond; i.e. either male or female fish species.

MIXED SEX CULTURE: this involves the rearing of both male and female fish species in the same pond.

FINFISH CULTURE: this is the rearing of finfish such as Tilapia, Clarias spp etc. only in a pond.

SHELLFISH CULTURE: this is the rearing of crustaceans (shrimps, prawns, crabs) and molluscs (oysters, clams) only in a fish culture facility.

**MERITS OF MONOCULTURE**

* It is easy to monitor individual fish breed performance
* It is less expensive in terms of production cost
* It gives rise to specialization
* It does not require high skills for managing fish, since they are all the same.

**DEMERITS OF MONOCULTURE**

* Cannibalism among fish may set in if they are not well fed
* Overstocking the pond with the same species may led to disease outbreak
* In case of uncertainty and risk, the farmer does not have something to fall back on.

**MERITS OF POLYCULTURE**

* New and better hybrid of fish are produced
* Polyculture fishes are bigger and attract better market value
* In case of loss in one species, the farmer can rely on other species of fish

**DEMERITS OF POLYCULTURE**

* One species can easily prey on the other
* It requires a high culture skill to manage the fish
* It is laborious and tasking
* It is expensive in terms of operational cost.

**HYBRID FISH**

Hybrid fish are new species of fish produced by cross-fertilization of two different breeds of the same species. E.g. *Clarias gariepinus* and *Clarias macrocephalus* has produced a new hybrid of *Clarias* with fast maturity and more resistance to disease. Also, *Clarias gariepinus* and *Heterobranchus bidorsalis* has produced *Heteroclarias*, with fast maturity but delayed sexual maturity.

**MERITS OF HYBRID FISH**

* Disease resistance breed
* Fast growth rate
* Quick maturity

**DEMERITS OF HYBRID FISH**

* Single sex population may be produced
* Delayed sexual maturity

**INTEGRATED FISH FARMING**

SPECIFIC OBJECTIVES:

* Define integrated fish farming
* Highlight four (4) examples of integrated fish farming
* Explain three (3) management systems in aquaculture
* State at least three (3) merits and demerits of the management systems

INTEGRATED FISH FARMING: is a system of producing fish in combination with other agricultural operations centered around the fish pond. The farming sub-systems e.g. fish, crop and livestock are linked to each other in such a way that the by-products or wastes from one sub-system becomes the valuable inputs to another system. This ensures total utilization of land and water resources of the farm, resulting in maximum and diversified farm output with minimal financial and labour cost. In a proper fish, crop and livestock integrated farming system, the possible inter sub-system interaction are excreta and waste feeds. By-products or wastes from livestock and crop can serve as manure for fish pond and crop land and can also be used as feed for fish and livestock. Also, nutrient rich bottom silt and water from pond can be a good source of fertilizer for the crop land. Example of integrated fish farming include:

* Rice cum fish: swamp rice is grown on flooded land into which fish is later introduced.
* Fish cum chicken: battery cages are placed on a support of iron/wooden grill over one end of a fish pond to allow bird droppings to fall into the water for pond fertilization (which aid plankton and algal growth) and fish feed. Some fish culturists would bag wet poultry droppings and generate maggots after sieving the manure. The maggots are later thrown into the pond as feed
* Fish cum pig
* Fish cum duck

**MANAGEMENT OF SYSTEMS IN AGRICULTURE**

There are three (3) basic management systems employed in aquaculture, namely:

* **EXTENSIVE CULTURE SYSTEM:**  this system involves culturing fish and other aquatic organisms with no supplementary or artificial feed administered. The fish stocked in the pond feed on natural feed such as plankton, invertebrate organisms, smaller fishes, algae etc. The culturist relies entirely on nature; hence fish development and growth is slower and harvesting period is prolonged by delayed maturity. The stocking rates are usually low and the rearing media is earthen ponds, fenced-in streams, rivers, lakes or sea.

**MERITS OF EXTENSIVE CULTURE SYSTEM**

* low cost of operation and production
* less labour is required for pond management
* disease emergence is greatly reduced due to low stocking density

**DEMERITS OF EXTENSIVE CULTURE SYSTEM**

* low output, yield or productivity
* prolonged period of culturing fish
* low farmers’ income
* **SEMI-INTENSIVE CULTURE SYSTEM:** in this system, a balance is created between the extensive culture and intensive culture system, whereby fish feed on natural and artificial feeds. The fish farmer has a level of control over the farm operations in terms of feeding, regulation of water levels, pond management and maintenance. The stocking rate may be low or high.

**MERITS OF SEMI-INTENSIVE CULTURE SYSTEM**

* Growth rate is faster than in the extensive system
* It is less expensive compared to intensive culture system
* Water quality can be maintained when supplementary feed is less.

**DEMERITS OF SEMI-INTENSIVE CULTURE SYSTEM**

* It requires more labour than in the extensive system
* It is expensive when compared with the extensive system
* There is occurrence of disease when quality of water is not maintained, due to the use of artificial feed.
* **INTENSIVE CULTURE SYSTEM:** in this system, the whole farm operations are completely in the control of the fish farmer. It depends totally on artificial feeds and the stocking rate is high.

**MERITS OF INTENSIVE CULTURE SYSTEM**

* Great harvest which encourages high profit
* It leads to specialization
* High rapid growth rate of cultured species
* Early cropping period 3-4 months

**DEMERITS OF INTENSIVE CULTURE SYSTEM**

* It is capital intensive
* It requires more labour
* Pollution occurs due to high usage of artificial feeds
* Fish mortality may be high due to pollution.

**FISH CULTURE FACILITIES**

SPECIFIC OBJECTIVES:

* Define fish culture facility
* Explain the term pond and state six (6) of its components
* Discuss on the two (2) types of pond
* Highlight and explain four (4) types of earthen pond and three (3) types of concrete pond

**FISH CULTURE FACILITIES**

These are structures put in place to rear fish and other aquatic organisms either for consumption or sale. These structures include: ponds, tanks, raceway etc.

**FISH POND**

This is a confined water body, which is supplied with or drained of its water in order to culture fish and other aquatic organisms. It is advisable that the depth of the pond should not exceed 1.2m, in order to maintain dissolved oxygen (DO) availability.

**COMPONENTS OF A FISH POND**

* WATER INLET: this component is constructed or fixed at the highest part of the pond to ensure easy impoundment (filling of water) and aeration.
* WATER OUTLET: this is a drainage device used for evacuating water from the fish pond. It is situated at the deepest end of the pond in order to ensure efficient and reliable drainage.
* DYKES: these are the walls or embankment of a pond. It is also known as a levee.
* SPILLWAY: this is a channel constructed along an embankment aimed at taking excess water away from the pond.
* CORE TRENCH: this is the evacuated portion of the pond. More or less the base of the pond.
* MONK: this device has a vertical low and horizontal pipes or culverts constructed with concrete to regulate water level automatically in the pond. Monk just like sluice gate can act a dual role as water inlet and outlet.
* SCREEN: this structure helps to prevent the entry of undesirable organisms into the pond.

**TYPES OF POND**

* EARTHEN PONDS: these ponds are constructed by excavating the soil to create a deep trench, which is then filled with water. The dykes and core trench are usually clayey to prevent seepage of water. Earthen ponds popular due to the ease of construction, low maintenance, low water usage and availability of natural feed that promotes fish health. However, earthen ponds are difficult and technical to manage in terms of maintaining adequate oxygen level, ensuring water quality all year round, sorting of fish and avoiding contamination from fertilizers and other chemical substances. Also, pumping of water and harvesting is very cumbersome. Examples of earthen ponds are:

1. Dug-out pond: this is a typical earthen pond that is fed by surface run-off, rainfall or ground water. It has a 4-sided walls.
2. Barrage pond: this pond is made by building a wall or barricade across a small stream.
3. Paddy pond: this is made in places where the ground is flat such as in swamps, food plains or dambos, rice farm.
4. Contour pond: here, the pond is constructed on sloping ground, having a 3-sided walls

* CONCRETE POND: this pond have a concrete core trench and dykes. They may be raised above the ground or sunken i.e. excavated (below the ground). Concrete ponds are more expensive to construct and fishes in this culture facility rely mostly on artificial feed. Concrete ponds make use of a lot of water in the growing season as the water quality is easily deteriorated. However, management practices are easy to carry out. Examples of concrete ponds are

1. Stagnant concrete pond: this pond does not have water flow out channel; however, when the water is polluted, a pumping machine is employed. It is cheaper to construct but has low stocking capacity.
2. Free-flow concrete pond: it has water flow-out channel; thus, water when polluted is easily regulated or exchanged. It is expensive to construct and have a high stocking capacity compared to stagnant concrete pond.
3. Water recirculatory concrete pond: this pond have a complete water filtration system. Waste water from the pond pass via a biofilter and its used again in the pond. This pond is advanced in terms of water efficiency, stocking capacity, water quality and DO percentage in the pond water. It is expensive to construct and maintain.

* TANK: fish tank is a container used to raise fingerlings before transferring them to the main pond. These tanks vary in shape, size, colour and material. Poly-tanks, Fibre-glass tanks and Fibre-reinforced polyester (FRP) tanks are examples of fish tanks.
* RACEWAYS: a raceway usually consist of a rectangular basins or canals, constructed of concrete with an inlet and outlet at either end to create a flow-through system. Raceway is also known as flow-through system. A continuous water flow-through is maintained to provide the required level of water quality for the fish.
* CAGES: a fish cage is usually made of alloy (copper). It is an enclosure with bottom and sides made with pipe slats and netting to allow passage of water. They can be floating cages or fixed cages i.e. driven into the bed of the water body. They are widely used in Mariculture.
* PENS: fish pen is an enclosure in the water body. It is constructed with metal and is hitched to the bed of the se, close to the shore. It serves to keep desired cultured fish in and unwanted species out; yet, allow the passage of water to create the impression of fish being in the wild.
* LAKES: these are large earthen ponds; the difference being that, there are wild fishes in it. To maintain continuity of the fish species, fish seeds are placed in the lake. Lakes are not usually owned by a single individual but the whole community. E.g. Lake Yamama in Kebbi State (Argungu fish festival), Ebean Lake in Abia State.
* RESERVOIR AND DAM: a reservoir is a body of water stored by diverting a large body of water into an area sunken to accommodate it; to be used as a fish culture facility. Dams are similar, only that it is on a course of a natural body of water and the volume of water is usually higher than reservoir.
* RAFT: rafts are made up of bamboos with strong ropes used to connect barrels which serves as floaters. Raft culture is one of the economically important method of intensive aquaculture used widely in Japan. It is made for the culture of invertebrates such as oysters, mussels etc.

**FISH DISEASE**

SPECIFIC OBJECTIVES:

* Define fish disease
* Highlight seven (7) factors that can predispose fish to disease condition
* Enumerate four (4) demerits of fish disease
* State seven (7) general symptoms of fish disease
* Explain cultural and prophylactic method of fish disease prevention
* Discuss nutritional deficiency disease
* Discuss extensively on the parasitic and pathogenic disease of fish

Fish disease is the deviation of fish from its normal state of health to an abnormal state caused by pathogens, parasites and environmental conditions. It is simply the abnormality in the general health condition of a fish.

**FACTORS THAT PREDISPOSES FISH TO DISEASE CONDITION**

* Overstocking/overcrowding
* Stress
* Contaminated feeds
* Water pollution
* Injuries
* Malnutrition
* Poor water quality especially low DO level

**DEMERITS OF FISH DISEASE**

* Death of fish
* Reduced economic/market value
* Reduces fish productivity
* Loss of fish culturist interest
* Increase in cost of production in terms of treatment and maintenance

**GENERAL SYMPTOMS OF FISH DISEASE**

* Sluggish swimming
* Skin discolouration
* Heamorrhage
* Emaciation
* Oedema (collection of fluid under the skin)
* Fin and tail rot
* Deformed parts of the body (gills, fins, scales, eyes etc.)

**FISH DISEASE PREVENTION**

CULTURAL METHODS:

* Maintain suitable stocking density. Ideally, 2-3 fingerlings/cm
* Proper feeding
* Quarantine and vaccination
* Avoidance of predators in pond
* Remove the carcass of fish and other waste
* Maintain optimal water conditions (Ph, DO, NH3 contents) at all times

PROPHYLACTIC METHODS:

Prophylaxis is the administration of drugs not for curative reasons, but for preventive purposes. Examples are

* The use of oxygenated chemicals (vinegar+baking soda in the ratio of 2:1, Oxymax, Oxyplus) to increase DO
* Salt water dip
* The addition of antibiotics to fish feed
* The use of anti-foaming chemicals (Defoam FG-10, Aqui-5)

**NUTRITIONAL DEFICIENCY DISEASE**

Nutritional deficiency disease is caused by the absence of one or more micro and macro basics nutrients in the fish body. Malnutrition and anorexia (severe loss of appetite) are responsible in most cases for deficiency diseases.

* CARBOHYDRATE DEFICIENCY: this leads to sluggishness, dullness, reduced metabolic activities and weight loss.
* PROTEIN DEFICIENCY: the ability of a fish to resist and tolerate the harmful effects of high stocking, pollution, oxygen competition and disease will be due to the fish feeding on diets containing necessary quantity and quality of protein. The most common signs of protein/amino acids deficiency in fish are retarded growth, anaemia, mortality etc.
* LIPID DEFICIENCY: the common signs are reduced growth of the fish, skin discolouration, fin erosion, rapid swimming, followed by immobility and loss of reflex. Also, fishes may float or sink to the bottom of the pond and may either recover or die.
* VITAMIN DEFICIENCY: the symptoms of vitamin deficiency include: reduced blood clotting, breathing disorder, anorexia, anaemia, blindness, pigmentation abnormalities, fin erosion etc. NB: lack of vitamin C causes broken back disease while lack of vitamin E causes steatitis (White fat disease). Other diseases resulting from vitamin deficiency are: cataracts, nutritional gill disease, ceroidosis or lipoid liver degeneration (LLD) etc.
* STARVATION: starvation occurs due to a number of reasons other than underfeeding. One reason is incorrect assessment of fish receiving the feed, and the physical characteristics of the feed particles. Signs of starvation are: loss of weight and failure or inability to reproduce. This may lead to an increase in cannibalism ranging from fin nipping to attempts to swallow whole fish, particularly young ones.

**PARASITIC AND PATHOGENIC DISESES OF FISH**

These are diseases caused by parasite and pathogens. They include protozoa, bacteria, fungi and virus

**BACTERIAL DISEASES**

1. DROPSY/AFRICAN BLOAT: it is caused by internal bacterial infection of the kidney (which causes fluid accumulation or renal failure), malnutrition and unhealthy pond condition. Dropsy is contagious among weakened fish and causes high mortality.

* SIGNS/SYMPTOMS: raised scales, bloated body and skin discolouration
* PREVENTION/TREATMENT: once diagnosed, remove the fish and quarantine. The water of the quarantine pond should be changed daily and medication should be administered.

1. FIN AND TAIL ROT DISEASE: this bacterial infection is caused by poor water condition, stress and increased toxic compounds in the pond. It is contagious and can be transmitted via injuries caused during fish fight, fin nipping and cannibalism.

* SIGNS/SYMPTOMS: fin and tail rot, skin discolouration, weakness, anorexia, white or grey line on the margin of the fin.
* PREVENTION/TREATMENT: maintain ideal water quality, destroy badly infected fishes and add antibiotics to feed (Oxytetracycline at 75mg/kg to fish/day). Dip treatment for 1 minute in 1:2,000 copper sulphate solution for 3-4 days

1. ULCER DISEASE (COLUMNARIS DISEASE): it is caused by Flexibactor columnaris. Most fish species are susceptible to Columnaris and it is often referred to as cotton wool disease, fish fungus or saddle-back disease. Stress can also cause this illness. This disease is extremely contagious and fatal.

* SIGN/SYMPTOMS: cotton-like growth on the gills, skin or fins, gill damage, open ulcer, rapid breathing and death.
* PREVENTION/TREATMENT: maintain water quality, lower pond temperature to 25o c since the infection is more dangerous at higher temperature, use medicated feed, administer antibiotics such as Furan-2, kanamycin, jungle labs binox crystal etc. Also, dip bath infected fish in methylene blue or potassium permanganate (KMNO4).

1. POP-EYES DISEASE: this disease causes one or both eyes of the fish to protrude or pop-out. It is not contagious. Mortality rate is on the average, as the disease is more likely to cause blindness than death.

* PREVENTION/TREATMENT: change pond water regularly, increase the quality of feed and supplement with vitamin enriched feeds. Also, use antibiotics such as tetracycline, penicillin or amoxicillin.

1. ENTERIC REDMOUTH DISEASE: ERM is caused by a bacteria pathogen called Yersinia ruckeri common in trout and salmon.

* PREVENTION/TREATMENT: treat with amoxicillin, florfenicol, oxolonic acid

**FUNGAL DISEASE**

1. SAPROLEGNIASIS: it is caused by a fungus called Saprolegnia parasitica. It affects fertilized eggs and manifest as white or brown coloured tufts on the skin. It usually occur as a secondary infection caused by handling, parasites or bacteria attack and appears like cotton balls.

* SYMPTOMS: appearance of grey-white threads like cotton balls on fish and fish eggs, brown or green skin colouration.
* PREVENTION/TREATMENT: maintain good water quality, avoid over stocking, and ensure good nutrition. Bath in 1-5g/litre of common salt. Also, treat using potassium permanganate, formalin, povidone iodine solution.

1. BRANCHIOMYCOSIS (GILL ROT): it is caused by fungus called Branchiomyces sanguinis and Branchiomyces demigrans. The infection is predominant among fish suffering environmental stress – low pH, low DO, high algae population and temperature <25o c or >35 o c

* SIGNS/SYMPTOMS: gill covered by excess mucus, gill tissue falls off, gulping of air at the surface of water
* PREVENTION/TREATMENT: lime pond occasionally, dip in 2.5% salt solution.

**VIRAL DISEASE**

1. FISH POX (CYPRINID HERPESVIRUS): it is common in European countries. The causative agents is herpesvirus. They invade the epidermal cells of fish and causes tumours called papilloma.

* SIGNS/SYMPTOMS: smooth shiny raised plaques on the skin, lesion, ulcers, poor growth and death in severe cases.
* PREVENTION: avoid high stocking density, use vaccine, avoid skin damage, create a quarantine pond and monitor new stock for at least a month.

1. INFECTIOUS HEMITOPOIETIC NECROSIS: this infection is caused by novirhabdovirus in the family Rhabdoviridae (rod-shaped virus) affecting Salmon population in the Pacific and Atlantic oceans.

* SIGNS/SYMPTOMS: lethargy (extreme fatigue and tiredness), exophthalmia (bulging of eyeballs), pale gills, distended abdomen, kidney, pancreas and spleen necrosis (death of cells or tissues).

**NOTA BENE:** no treatment for viral diseases; however, prevention and control is obtainable. Other viral diseases are Gill curl, Spring viremia (swim bladder inflammation) etc.

**PROTOZOAN DISEASES**

1. ICHTHYOPTHIRIASIS (ICH): this infection affects fish through the activities of a protozoan ciliate called Ichthypothiriasis multifilis. It causes hyperplasia (abnormal increase in number of cells) of the epidermal cells, creating postules i.e. lumps or inflamed portions on the skin filled with pus.

* SIGNS/SYMPTOMS: whitish cysts on the skin, gills and fins
* PREVENTION/TREATMENT: good pond management, dip infected fish in Nacl solution

1. COSTIASIS: this infection is caused by a protozoan called Costia necatrix.

* SIGNS/SYMPTOMS: bluish coating on the skin, presence of large amount of mucus, impaired respiration and irritation.
* PREVENTION/TREATMENT: ensure good pond management, give a 10 minutes bath in Nacl solution, administer antibiotics such as Terramycin, Oxytetracycline etc. Other protozoan diseases include: Trichodiniasis, Epistylis (Red sore disease) etc.

**BREEDING**

SPECIFIC OBJECTIVE

* Define breeding
* Highlight the two (2) types of breeding
* Explain fish culturing and state at least ten (10) qualities of cultural fish species
* Enumerate nine (9) steps involved in artificial breeding of fish
* State five (5) importance of artificial breeding of fish

**BREEDING:** fish breeding is also known as fish seed production. It is the process of producing fish seed from parent brood fish or brood stock. This inevitably causes a continuity of fish species through the availability of fingerlings for stocking grow out ponds, pens, tanks and cages. Breeding is governed by internal factors and external or environmental factors. The internal factors are influenced by hormones (via the endocrine system) and the physiological condition of the fish. The external factors influencing breeding include: temperature, pH, good water quality, nutrition, photoperiod (length of day).

**TYPES OF BREEDING**

1. NATURAL BREEDING: this is the process whereby brood stock produce new offspring in their natural habitat without the interference of man.
2. ARTIFICIAL BREEDING: this is the science and technology of manipulating sexually matured male and female fish to reproduce. This can be done by:

* Controlling the environment: this method is referred to as Nest Stimulus Technique. Here, favourable environment is ensured or conditioned to stimulate breeding.
* Using hormones: here, brood stock are incited by injecting irritant into their bodies to aid breeding. The hormones used to artificially induce fishes include: pituitary extract, ovaprim, deoxycorticosterone acetate (DOCA), human chorionic gonadotropin (HCG), ovatide etc.

**FISH CULTURING**

This is the artificial propagation and breeding of fish. It involves regular stocking, fertilization, feeding, protection from predators and diseases, and taking care of the environment. Examples of culturable fish species are: Clarias spp, Heterobranchus spp, carp, tilapia, heterotic niloticus, Nile perch etc.

**QUALITIES OF CULTURABLE FISH SPECIES**

* Fast growth and high survival rate
* Accepts supplementary feeds
* Resistance to disease
* Tolerate poor water quality
* Must be popular and marketable
* Low cost of production
* Easy to breed in captivity
* Compatibility, i.e. must be able to co-exist with other fishes
* Hardness, i.e. must be able to withstand handling condition
* Hardy larvae, the fry should be strong enough to withstand the unfavourable condition of artificial and natural aquatic environment.

**STEPS INVOLVED IN ARTIFICIAL BREEDING OF FISH**

* Brood stock selection: desirable hereditary quality, hardy, active, matured (3kg) should be selected
* Conditioning of the brood stock: here, brood stock are kept in suitable environment and placed on balanced diet
* Inducement of the brood stock stimulate ripening of eggs
* Stripping of the female brood stock
* Extraction of the milt
* Fertilization of the eggs
* Management of fish hatchlings in the hatchery
* Nursing of the fries
* Feeding of fries after yolk absorption

**MATERIALS USED IN ARTIFICIAL BREEDING**

* Weighing scale
* Calibrated jug
* Pincers/forceps
* Dissecting kits/knives
* Basin
* Salt solution (9gm/1lire of water)
* Syringe/needles
* Hormones
* Substrate/kakaban/nets
* Eggs/testes

**IMPORTANCE OF ARTIFICIAL BREEDING OF FISH**

* It produces high quality fish species
* It produces hybrid fish
* It aid in obtaining large quantity of fish seed
* It makes fingerlings to be readily available
* It provides healthy and fast growing fish seed

**BREEDING CONCEPTS**

SPECIFIC OBJECTIVES:

* Differentiate between spawn and spawning
* Explain gamete
* Explain fertilization and state its two (2) types
* Explain Hypophysation, latency time, hatchery and incubation time.

**SPAWN:** spawn are eggs and sperm of fish; while spawning is the process or act of releasing eggs and sperm by fish inside the water. Spawn consists of the reproductive cells (gametes) of aquatic animals, some of which will become fertilized and produce offspring.

**GAMETE:** the word gamete was introduced by an Austrian biologist called Gregor Mendel. Gamete is a reproductive cell or sex cell that has only half the usual number of chromosomes. Gamete carry half of the genetic information of a species and are created via meiosis. A gamete is a haploid cell that fuses with another haploid cell during fertilization in organisms that sexually reproduce. The process of formation of female gamete (ova/ovum) is called **OOGENESIS**, while the formation of the male gamete (sperm) is called **SPERMTOGENESIS**

**FERTILIZATION:** this is the fusion of gamete to initiate the development of a new offspring. It can be divided into two (2):

* INTERNAL FERTILIZATION: it is the occurrence of internal insemination as the mode of fusing or uniting sperm and egg. It occurs mostly in mammals and cartilaginous fishes.
* EXTERNAL FERTILIZATION: here, the sperm fertilizes the eggs outside the female’s body. External fertilization occurs in water or in a moist area because it gives the sperm external mobility to get to the eggs. When female fish spawn, they release a batch of eggs into the water and the males in close proximity releases sperm to aid fertilization – OVULIPAROUS REPRODUCTION

**BROOD STOCK:** these are sexually matured male and female fish, which can produce sperm and eggs for breeding.

**DIFFERENCES BETWEEN MALE AND FEMALE BROOD STOCK**

* Males have a long conical papilla
* Females have rounded papilla and central opening (ovipositor)
* Males papilla tip is reddish in colour
* Females have a swollen and round abdomen, which discharges eggs when pressed

**MILT:** this is the sperm or semen of a male brood stock

**STRIPPING:** this is the process of manually releasing the eggs from the female fish. This is done by using the thumb to gently palpate or press the belly of the fish just below the lateral line.

**HYPOPHYSATION:** this is also known as induced breeding. It is a technique of breeding fish by administering pituitary gland extract injection. The pituitary gland secrete several hormones such as: Somatotrophic or Growth hormone (GH), Adrenocorticotropic hormones (ACTH), Thyrotrophic or Thyroid stimulating hormones (TSH), Gonadotropic hormones [Follicle stimulating hormones (FSH), Luteinizing hormones (LH), and Interstitial cell stimulating hormones (ICSH)], Prolactin (Lactogenic) hormones etc. However, gonadotropin is the most important hormone for breeding. Other hormones aid to stimulate growth, development, maturity, ovulation and other metabolic activities.

**COLLECTION OF PITUITARY GLAND:** the pituitary gland is situated on the ventral side of the brain just below the hypothalamus. While taking out the gland, the dorsal side of the head is first chopped with a knife; the brain is exposed to carefully lift or detach it from the nerves. The glands are usually collected from freshly killed brood stock to aid Hypophysation.

**LATENCY TIME:** this is the period between Hypophysation and stripping. The length of the latency period is affected by the temperature of the water.

25oc = 11 hours before stripping

28oc = 8 hours before stripping

30oc = 7 hours before stripping

The best time for Hypophysation is in the evening or night, so that stripping can occur the following morning.

**HATCHERY:** this is where the fertilized eggs are incubated until the eggs are hatched into fries. This interval is known as INCUBATION TIME.

**NB**

ACTH – Cortisol: stress hormone

FSH: aid sperm and ovary production

LH: ovulation and testosterone stimulation

TSH: regulate metabolism, energy and nervous system

ADH: Anti-diuretic hormone or vasopressin: regulate water and Nacl levels

Adrenaline: fight or flight hormone

Hypophysis – PG

**FISH REPRODUCTION**

SPECIFIC OBJECTIVES:

* Define fish reproduction
* Explain four (4) types of fish reproduction
* Expatiate on the three (3) classes of fish migration

**FISH REPRODUCTION:** this is a biological process by which new organisms are produced from their parents. It is the fundamental feature of all life and each individual organisms exists as a result of either sexual or asexual reproduction.

**TYPES OF FISH REPRODUCTION**

1. OVULIPARITY: this is a fish reproduction method whereby female brood stock lays unfertilized oocytes or eggs in water and it is then fertilized externally by the male brood fish. E.g. Salmon, Goldfish, Catfish, Cichlids, Eel, Tuna etc.
2. OVIPARITY: here, brood stock copulate and internal fertilization occurs. Thereafter, the female fish lays the fertilized eggs. **NB:** Approximately 96% of fishes are egg layers. The basic classes of fish eggs are Pelagic eggs (floating eggs) and Demersal eggs (egg that sinks). Pelagic eggs are associated with marine fishes while Demersal eggs are spawned by fresh water fishes. Among fish which reproduce by egg laying are:
3. Egg scatterers e.g. Tetras, Danios, Barbs, Rasboras
4. Egg depositors e.g. Catfish, Rainbow fish, Angel fish, Guyana
5. Nest builders e.g. some species of catfish, trout, stickleback
6. Mouth breeders e.g. Tilapia, African lake cichlids, Cardinal fish
7. Egg buriers e.g. Killi fish
8. VIVIPARITY: this is a method of fish reproduction whereby internal fertilization occurs and the female brood stock gives birth to live young fish. When embryos develop in the female fish oviduct and obtain nutrients by consuming tissues such as zygotes or ova, it is called Histotrophic Viviparity (tissue eaters). However, when embryos receive direct nourishment from the mother fish via a structure similar to a placenta, it is referred to as Haemotrophic Viviparity (blood eaters/drinkers). This type of nutrition exhibited by viviparous fish is known as MATROTROPHY. **NB:** young viviparous fish are at advantage of greater survival from the risk of predators; however, the mother fish is vulnerable to predators during labour. E.g. Grey nurse shark, Surf perch etc.
9. OVOVIVIPARITY: here, eggs are fertilized in the body of the female fish and remain within the mother fish while they develop. However, there is no direct nourishment from the mother as the developing eggs are separated by the egg membrane. The embryos rely mostly on nutrients in the yolk. This form of nutrition is known as LECITHOTROPHY. **NB:** Ovoviviparous species give birth to their young one live. The disadvantage is that, fewer offspring are born and it requires more energy for females to carry eggs inside their bodies. E.g. Angel shark, Rays, Guppies etc

**FISH MIGRATION**

This is the movement or drifting of part or all of a fish population (school) from one aquatic habitat to another. This directed movement could be seasonal or specifically for foraging/feeding on a daily basis, breeding or spawning or by physical or physiological challenges created by osmoregulation issues between fresh water and salt water.

**CLASSIFICATION OF FISH MIGRATION**

1. POTAMADROMOUS MIGRATION: this type of movement occurs entirely within fresh water - lakes, streams, rivers etc. E.g. Flathead catfish, Lake Sturgeon etc.
2. OCEANADROMOUS MIGRATION: this type of fish movement occurs entirely within salt water (ocean, sea). E.g. Bluefin tuna (Thunnus thynnus)
3. DIADROMOUS MIGRATION: this is a type of fish migration, whereby fishes cross salt water and fresh water boundaries. Diadromous species are described as euryhaline; that is they are able to tolerate a wide range of salinity. The three (3) sub-groups of Diadromous fish species are:
4. ANADROMY: these fish spawn in fresh water. Hatching and juvenile period also takes place in fresh water. However, most feeding and growth processes occur in salt water. The brood stock returns to fresh water to spawn. E.g. Pacific salmon, Smelt, American shad, Steelhead trout etc.
5. CATADROMY: these species of fish are spawned and hatched in salt water but migrate to fresh water habitat where they spend majority of their lives growing and maturing. As adults, they return to the salt water to spawn. E.g. Long fin eel, Short fin eel, Inanga, European/American eel etc.
6. AMPHIDROMY: this involves the fish migrating briefly from fresh water to salt water during their juvenile stage. Most feeding, growth and reproduction activities take place in fresh water. This is common among fishes living in islands in the tropics and sub-tropics. E.g. Torrent fish, Bigmouth sleeper, Mountain mullet etc.

**FISH FEEDING**

SPECIFIC OBJECTIVES:

* Differentiate between feeding and fish feed
* State six (6) characteristics of a good fish feed
* Highlight five (5) factors affecting feeding response of fish
* Explain fish feeding habits and enumerates it types

Feeding is the act or process of eating or being fed. Fish feed are edible materials that contains essential nutrients for the rapid growth and development of fish. Fish feed materials are indispensable to assuring palatability of fish feed. Feed materials include:

* Carbohydrate (maize, wheat bran, rice bran, millet etc.)
* Protein (soya beans, groundnut cake, chicken offals, blood meal, cotton seed cake, fish meal, maggot etc.)
* Lipid (soy oil, palm oil, fish oil, groundnut oil etc.)
* Vitamins and Minerals- ash (air-dry vegetables, egg shells, oyster shell, lysine, methionine, salt etc.)
* Binders (cassava starch, corn starch etc.)

**CHARACTERISTICS OF A GOOD FISH FEED**

* It should contain the entire feed components in the right proportion, so as to stimulate the growth and health of the fish
* It should be stable in water for at least ten (10) minutes
* It should be attractive and acceptable to the fish
* It should not pollute the water medium in any way
* It should promote and ensure fish growth
* It should be affordable and cost effective to the fish farmer

**FACTORES AFFECTING FEEDING RESPONSE OR BEHAVIOR OF FISH**

* Fish size (Average weight): the body weight percent is used to determine the amount of feed the fish is fed per day. This implies that the feed conversion ratio of a large fish is lesser than that of a smaller fish; since they can live on less feed. Also, smaller fish tend not to consume large feed pellets
* Age of fish: the older the fish, the more voracious their appetite for feed; hence feed expenses increases with age, especially if the culturist decides to feed *ad libitum* (as desired as often)
* Temperature: an excessive drop in temperature makes some fish anorexic and remain immobile at the benthic zone (bottom of the pond). Temperature below 20o C affects feeding and reproductive processes in fish
* Water quality
* Fish health status

**FEEDING HABITS** this refers to the modes of feeding. There are specifically seven (7) feeding habits exhibited by fishes in natural or artificial water bodies**:**

* **CARNIVOROUS FEEDING HABIT:** this mode of feeding involves consumption of animal materials by fish. Carnivores need at least 45% of protein in their feed without which they become severely malnourished. They feed on live feed like worms, mosquito larvae, fruit flies, oysters, shrimps and other small fishes. E.g. Clarias spp, Heterobranchus spp
* **HERBIVOROUS FEEDING HABIT:** this mode of feeding occurs when fishes feed mostly on plant materials. They feed on algae, phytoplankton, water lettuce, water lily, water cress, cucumber etc. E.g. Grass carp, Heterotis niloticus (African bony tongue/arowana)
* **OMNIVOROUS FEEDING HABIT:** this feeding occurs when fishes obtain their nutrition from animal and plant materials. E.g. Cichlid (Tilapia zilli, T. guineensis, Mozambique etc.)
* **LIMNIVOROUS FEEDING HABIT:** this mode of feeding occurs when fishes feed on mud full of decomposed flora and fauna. Limnivores are known as mud-eaters. E.g. Goby
* **DETRITIVOROUS FEEDING HABIT:** this feeding mode occurs when fishes feed on dead or decayed materials. They are mostly referred to as saprophytes. E.g. crabs, lobsters etc.
* **FILTER FEEDING HABIT:** e.g. clams, shark, jelly fish, baleen whale
* **GRAZING FEEDING HABIT:** e.g. butterfly fish, parrot fish etc.

**FISH FEED AND FEEDING METHODS**

SPECIFIC OBJECTIVES:

* Differentiate between natural and artificial fish feed
* State four (4) merits of natural fish feed
* Enumerate three (3) merits of artificial fish feed
* Explain the six (6) types of fish feeding methods

**NATURAL FISH FEED:** these are feed produced from pond fertilization and inoculation of fish pond mechanism, i.e. introduction of micro-organisms inside the pond. Examples are:

* Phytoplankton (algae, water lettuce, water lily, water cress)
* Zooplankton (daphnia, copecoda, diaptomus, insect larva)
* Crustaceans (prawn, crayfish)
* Protozoans, insects, worms, maggots etc.

**MERITS OF NATURAL FISH FEED**

* They are cheap source of nutrition for fish
* It requires less technical know-how to adopt
* Natural feeds sustains pond ecosystem
* It helps to maintain high water quality in the fish pond

**ARTIFICIAL OR COMPOUNDED FISH FEED:** these are fish feed formulated from relevant fish feed constituents following a professional standardized formula. The range in size and ingredients of compounded fish feed vary according to the ages and sizes of fish. Examples are:

* Pulverized fish feed: it is compounded for feeding fries and fingerlings only
* Granulated fish feed: compounded for feeding juveniles
* Pelleted fish feed is formulated for grown-out and brood stock

**MERITS OF ARTIFICIAL FISH FEED**

* It promotes faster fish growth because of its compounded balance diet
* It enables high stocking density, especially in Polyculture system
* Low feed conversion ratio (FCR) is ensured if the feed is from a good manufacturer.

**LIVE FEED:**  these fish feed are reared or bred in large quantity and serve live to the fish. E.g. maggots, tadpoles, earthworms, small fishes etc.

**ANIMAL OFFALS:** these fish feed are derived from the carcass and internal organs or slaughtered animals. They are derivable from animals such as poultry, cattle, sheep, goat, pig etc.

**AGRICULTURAL WASTES:** agricultural by-product or waste (residues) gotten during harvest and processing are sometimes used for feeding fish under culture. These include: poultry waste, grasses/leaves, pig dungs, cattle dungs, brewery waste (spent grains) and human waste in biodegradable and treated forms.

**TYPES OF FISH FEEDING METHODS**

1. **BROADCASTING METHOD:** this is a manual feeding method, which involves spreading or throwing of fish feeds into the pond over a wide area.
2. **SPOT FEEDING METHOD:** this method emphasizes feeding by concentrating on a particular spot, usually from the highest part of the pond (dyke or levee).
3. **MULTIPLE SPOT FEEDING METHOD:** this method involves two or more people feeding the fish at different spot of the pond at the same time, using the same feed.
4. **DUMPED METHOD:** here, poultry viscera, kitchen refuse, bread or agro-products can be dumped or put in the pond.
5. **DEMAND FEEDING METHOD:** this is an automated method of feeding fish. It operates through a simple funnel-shaped device with a metal trigger hanging into the water. The fish hit or give a nudge in order to dispense the artificial feeds. The fishes by activating the trigger actually demand for the feed.
6. **AUTOMATIC FEEDING METHOD:** this method uses an equipment that works with a timing device. It discharges a measured amount of feed into the pond at programmed intervals during the day.