Extension manual on production of quality catfish seed

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WorldFish

TAAT
Technologies for African Agricultural Transformation

Extension manual on production of quality catfish seed

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Overview

Guide for users

The material in this guide has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to catfish breeders for profitable ventures. The content uses plain language for easy understanding.

In the modules, learning objectives, activities, materials and facilitation methods have all been highlighted, along with other key components, including instruments for pre- and post-course evaluations. Output evaluations, outcome evaluations and feedback mechanisms have been provided for periodic improvement of the manual. To achieve the learning objectives, activities must be properly scheduled and executed. The learning materials have been packaged for hatchery and nursery operators to acquaint themselves with the knowledge and skills necessary to run a successful hatchery operation.

This manual is for instruction only. Trainers should adjust the modules as needed depending on the knowledge and experience of the trainees. The training methodologies and techniques for each module have been described in detail and carefully planned. Sticking to the methodologies will ensure that trainees actively participate and will help trainers achieve the expected outcomes. The modules have been arranged in order with a set time in which to discuss the information. If necessary, trainers, in light of their own experience, can change or modify the modules while maintaining the topic. However, starting and ending the session on time is important for both trainers and trainees. Assessing the success of the program is necessary for everyone involved, so trainees need to be evaluated during and after the modules to assess how much they have learned. Instruments for evaluation assist trainers in assessing how well the set targets have been met, while feedback from trainees enables assessment of the progress toward achieving the overall objectives.

Targeted audience

The manual is aimed at mainly catfish breeders—both women (30%) and men (70%) as well as youths (25%)—according to their level of involvement along the aquaculture value chain. Any catfish breeder from 15 to 60 years of age is considered a prospective learner.

FISH CRP

The CGIAR Research Program on Fish Agri-Food Systems (FISH) led by WorldFish is developing guidelines for better management practices (BMPs) at the global level and contextualized BMP resources at the country level to support sustainable catfish farming in WorldFish focal and scaling countries. This BMP manual, produced as part of this approach, aims to enhance the capacity of catfish breeders, grow-out fish farmers and extension service providers in Africa to support scaling of catfish production.

Background

Technologies for African Agricultural Transformation (TAAT) is a framework developed by the African Development Bank as part of its efforts for agriculture development on the continent. The program aims to enhance the use of proven agricultural technologies among stakeholders to foster the changes needed through farm-level productivity and value chain development. Aquaculture is one of the nine commodity compacts with proven technologies that have the potential to increase yields and benefits for upscaling in 12 African countries: Benin, Burundi, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia. Led by WorldFish, the TAAT Aquaculture Compact has been training aquaculture subject matter specialists and youth agripreneurs as facilitators under capacity development and technology outreach.

There are three specific objectives of the Aquaculture Compact:

1. To create an enabling environment for aquaculture technology adoption by value chain actors.
2. To effectively deliver technologies to fish farmers and other actors along the aquaculture value chain.
3. To increase aquaculture production and productivity by identifying and disseminating quality tilapia and catfish seed, producing low-cost fish feed and through value addition.

The African catfish (*Clarias gariepinus*), also known as the mud catfish, is a good candidate species for culture to boost fish production for both domestic and global markets, which will improve human nutrition and food security in Africa. However, the scarcity of good quality fingerlings in hatcheries remains a major obstacle to realizing the full potential of catfish farming. Fish farmers are often forced to resort to collecting fish seed from the wild or purchasing poor quality seed from hatcheries. The purpose of this manual is to distribute methods that will expose extension workers to better practices in the production of catfish fingerlings and facilitation techniques. This will enable them to spread these skills to catfish hatchery operators in their respective areas for increased production of quality fingerlings, which will further the development of overall catfish farming production.

The African catfish is widespread in Africa and has the potential to provide cheap fish protein throughout the continent. Other catfish species that are good culture candidates are the red mud catfish (*Heterobranchus bidorsalis*) and the African catfish/red mud catfish hybrid (*Hetero-Clarias*). The hardy nature of catfish in terms of its high tolerance to water stress and high use of supplementary feeds make it a suitable candidate for culture promotion in Africa. Catfish also has a high market acceptance and allows value addition for a variety of products.

Rationale

The TAAT Aquaculture compact has noted that fish farmers in Africa are confronted with many challenges in producing catfish. These include a lack of poor quality fish seed, low skills of fish breeders in BMPs, high fry and fingerling mortality and the lack of knowledge on fish health management among hatcheries. This manual has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to catfish breeders to produce fast-growing and healthy fingerlings for profitable ventures.

Development objectives

i. To enhance the productivity of catfish.
ii. To increase fish farmers' income.
iii. To improve food (fish) security and nutrition.

Learning objectives

i. To enhance knowledge on broodstock selection, management and artificial breeding methods.
ii. To acquire experience of BMPs in a hatchery for increased productivity.
iii. To build entrepreneurial skills in business plan development for sustainable hatchery ventures.
iv. To learn skills on how to share knowledge with other hatchery operators and fish farmers in their respective areas for increased catfish production.

Module instructions

Trainers should refer to the following instructions for how to begin and end modules 1 through 5. (Please note that these instructions do not apply to module 6.)

How to start each module

Before beginning each module, trainers must prepare prompting questions for the participants. The purpose of the questions is to encourage participants to share their knowledge about the intended contents of the module. Next, trainers must then conduct a pre-evaluation by soliciting feedback from the participants. The purpose of the pre-evaluation is to assess the knowledge, skills and attitude of the participants before they start learning. After the pre-evaluation is complete, trainers can begin the module.

Each module begins with a set of questions about the content. This helps the trainers assess how much the participants know before the module begins.

How to end each module

Before ending each module, trainers must carry out a learning activity that leads to discussion, memory retention and action. Methods that trainers can use include lecturing with audio-visuals, brainstorming on issues raised, role playing on key issues, and group discussion and feedback. For learning materials, trainers can either write narrations or draw further illustrations about the content of the module and indicate or attach further reading material related to the content.

Each module also ends with a set of questions about the content. This helps trainers assess how much the participants learned during the module.

Selecting catfish broodstock at the Great Aquaculture Farm in Iwo, Osun State, Nigeria.

Module 1: Introduction

Pre-evaluation questions

1. Which of the following is not a fish seed?
   a) broodstock
   b) fingerlings
   c) fry
   d) juveniles

2. At what age is a catfish considered mature enough to use as a broodfish?
   a) 4 months
   b) 7 months
   c) 9 months
   d) 12 months

3. What is the optimal temperature for broodstock?
   a) 1°C
   b) 80°C
   c) 11°C
   d) 25°C

4. What is the proper range of water pH for rearing broodstock?
   a) 1–2
   b) 6.5–8.5
   c) 3.5–4.1
   d) 10.5–13.5

5. Which of the following is needed in high amounts?
   a) ammonia
   b) nitrite
   c) dissolved oxygen
   d) mercury

6. Which of the following reduces dissolved oxygen in water?
   a) overcrowding due to high stocking density
   b) crash of algal population
   c) reduction in the rate of photosynthesis because of cloudy weather
   d) heavy plankton bloom due to excess nutrients

7. Broodstock should be fed 1% of their weight per day. True or false?

8. What are the general sources of fish seed?

9. What will too many nutrients in pond water likely cause?

10. What will be the likely response of fish in water with a low dissolved oxygen level?

1.1. Sources of fish seed

Availability of quality catfish fingerlings is a major challenge for fish farmers. This is partly due to non-adherence to BMPs for quality fingerling production. Fish farming starts with stocking fish seed that are then grown to the desired size or weight. Every farmer wants a breed that grows fast, reaches sexual maturity early and converts feed to flesh more efficiently.

Fish seed consists of the following:

- eggs and spermatozoa (fertilized eggs)
- hatchlings (freshly hatched fish less than 5 days old)
- fry (hatched fish less than 6 weeks old)
- fingerlings (hatched fish less than 8 weeks old)
- juveniles (hatched fish less than 12 weeks old)
- post-juveniles (hatched fish less than 15 weeks old).

There are two major sources of fingerlings: hatcheries and wild/natural water bodies.

Getting fingerlings from hatcheries has the following advantages:

- African catfish do not reproduce well in captivity, so artificial reproduction in a hatchery might be the only option.
- Broodstock from hatcheries are already adapted to controlled breeding.
- They are genetically improved.
- Genetically improved fish obtained from a hatchery have a selection of desired traits from their parent stock, so they grow faster than those in the wild.
- The scientific study of hybridization is enhanced through hatchery operations.

Conversely, getting fingerlings from the wild/natural water bodies has the following disadvantages:

- Stunted growth is common with stocks from the wild.
- They are not adapted to farming conditions.
- They could introduce pests and pathogens into farms.

1.2. Sourcing fish seed

The following are the BMPs for sourcing fish seed:

- Collect fish seed from reputable farms in catfish breeding. Since it is difficult to verify seed sourced from the wild, the age of fingerlings is often uncertain and their genetic integrity and vigor is doubtful.
- Source more mature seed, such as fingerlings or juveniles, because they have higher survival rate. Although they might be relatively more expensive than less mature seed, the reduction in mortality will more than compensate for the increased cost.
- Ascertain the health of seed to prevent losses from the spread of diseases and to ensure there are no deformities or lesions and no abnormalities in movement or activities.

1.3. Identifying male and female broodstock

It is easy to distinguish male and female African catfish. Male broodstock have a well-pronounced genital (sexual) papilla, which tapers to the tip. It is an elongated, nipple-like projection located just behind the anus and is usually red at the tip in a sexually matured male (Plate 1). They have to be dissected to access the milt sac.

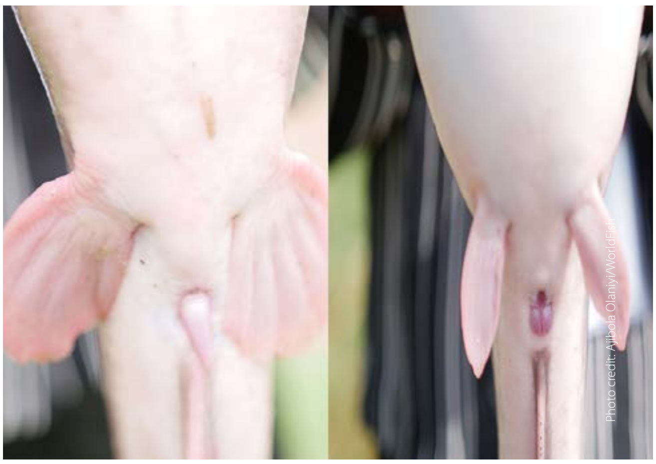

Plate 1. Male (L) and female broodstock (R).

Females have a urogenital septum that separates the urinary and genital opening that is rounded, giving the opening a more slit-like appearance. A sexually matured female has a swollen abdomen, with a reddish genital opening (Plate 1). A gentle press on the swollen belly, toward the genital opening, will release the matured eggs of a female African catfish, indicating the readiness and viability of the female.

1.4. Broodstock selection

The following are the BMPs for the broodstock selection process:

- Do not breed offspring from the same parents or close relatives. This leads to inbreeding and reduces genetic diversity, which decreases the suitability of the stock. Inbreeding makes it easier for an entire stock to be wiped out when challenged by environmental or biological factors.
- Collect broodstock from either fishponds or natural waterbodies. Take precautions for wild stock. Selecting broodstock from hatcheries is preferred because they have desired traits and better growth performance.
- Rear fast-growing fingerlings, also known as "shooters" or "jumpers," to broodstock size in fishponds. At harvest, select these as breeders and transfer them to the holding unit or a special brood fishpond.
- If possible, select female broodfish that weigh 1–4 kg and are at least 1 year old. Older fish tend to have more mature eggs, which increases hatchability.
- The size and number of the male broodstock depend on the number of females required for artificial propagation and on the number of artificial reproductions per year. Male broodstock should also weigh 1–4 kg and be at least 1 year old.
- In some places, wild brooders are captured and used for breeding during the breeding season. They aggregate in or near shallow spawning grounds during the dry season when they are relatively concentrated in their reduced natural habitats, especially small pools and streams. However, it is not advisable to source broodstock from the wild. This should only be done if there are no certified hatcheries to buy from in the country.
- Regularly check the development of sexual organs before selecting broodstock. Males will have genital papilla with a red tip, while

females will have a swollen abdomen that will release ripe eggs when slightly pressed near the genital opening.
- When selecting broodstock, check to make sure there are no wounds, parasites or deformities.

1.5. Broodstock management

The following are the BMPs for broodstock management:

- Broodstock should be conditioned in a 2 m^3 earthen pond at a stocking density of 3–4 kg of fish per m^3. Concrete or plastic tanks can also be used, though these can cause female brooders to absorb their eggs.
- After spawning, begin feeding broodfish brooder feed that is 6–8 mm in size, depending on the size of the fish, and continue this for 8–10 weeks. This will maintain the health of the broodfish so that they can be used again for spawning.
- Separate male and female catfish into different holding facilities to avoid fighting.
- Make sure to maintain the following parameters for optimal water quality (Table 1).
- Dissolved oxygen should not be less than 5 mg/L.
- The optimal temperature for qualitative and quantitative gonadal development is 25°C.
- The pH should fall between 6.5 and 8.5 (around a neutral pH value).
- The need to feed broodstock adequately cannot be overemphasized because nutrition impacts gonadal development. Yolk sacs form in broodfish during embryo development, and developing embryos and hatchlings depend on their yolk sac until they begin feeding on live prey or are fed artificial feed. This is because the yolk sac is the only source of food during the first days of the larvae. Therefore, its quality and quantity are key indicators of successful broodstock feeding. Feed broodstock a balanced compounded diet that meets the amino acid, mineral and vitamin requirements as well as all the other essential nutrients required by the fish in this stage of life.
- Feed broodstock once daily at a total of 1% of their weight (Table 2). Make sure to use feed containing 40%–42% crude protein. To prevent overfeeding, stop feeding when the fish show no interest in the food. Determine the amount of feed according to the number of fish, not the weight, because the weight changes as the fish grow.
- Replace 20% of the water daily to wash out non-ingested food and fecal deposits. Scrub the walls of the troughs once every 6–8 weeks to remove algae growth.
- Hygiene is one of the most important factors determining the health of the broodstock and healthy sexual gametes, which can affect the health of the offspring.
- Disinfect the hatchery floor weekly and then disinfect your hands with a 1%–2% iodine solution before and after cleaning.

Post-evaluation questions

1. Which of the following is not a fish seed?
   a) papaya seed
   b) fingerlings
   c) fry
   d) juveniles

2. Why are broodstock considered mature only after 1 year of age?

3. What is the optimal temperature for good performance of catfish broodstock?

4. What type of water pH is best for broodstock rearing?
   a) highly acidic
   b) around neutral
   c) acidic
   d) highly alkaline

5. Which of the following is not essential for good water quality?
   a) phosphorus
   b) honey
   c) dissolved oxygen
   d) pH

6. Which of the following reduces dissolved oxygen in water?
   a) overcrowding due to high stocking density
   b) low algae levels
   c) reduced photosynthesis because of cloudy weather
   d) heavy plankton bloom due to excess nutrients
   e) all of the above

7. Why should broodstock be fed at 1% of their weight every day?

8. What are some advantages of sourcing fish from reputable farms instead of the wild?

9. What problem is an excessively high nutrient level in the water likely to cause?

10. What are the effects on fish from too much ammonia in the water?

Parameters	Recommended values	Possible associated cause	Possible effects	Control
Dissolved oxygen	4 mg/L (minimum)	• overcrowding due to high stocking density • crash of algal population • reduction in photosynthesis, because of cloudy weather • heavy plankton bloom due to excess nutrients	• increased susceptibility to diseases • refusal to accept feed • gasping for air at the pond surface • crowding near water inflow source	• Suspend feeding. • Flush out water. • Replace with fresh water. • Aerate with aerators connected to the air supply.
Ammonia (NH_3)	0.05 mg/L	• pollution from sewage • overfertilization • accumulation of waste at the pond bottom	• poor acceptance of feed • daily mortalities • gasping for air	• Avoid excessive stocking densities.
Nitrite (NO_2)	0.30 mg/L		• brown patches on the gills, known as brown blood disease • mortalities from a lack of oxygen	• Add chloride ions, such as sodium chloride. • Flush the system. • Use an adequate stocking density.
Turbidity or suspended clay particles	5 mg/L for fry, 20 mg/L for growing fish, 40 cm using a Secchi disk	• excessive mucus on fish body • gill damage • limited algae growth • solids coating eggs • reduced oxygen transfer • reduced hatchability in hatchery	• poor growth • mortalities	• Correct the stocking density. • Filter the water. • Use wood ash (100–1500 kg/ha for old ponds or 2500–5000 kg/ha for new ponds). • Use settling tanks.

Table 1. Water quality parameters and management.

Feed type	Feed size (mm)	Fish weight (g)	Feed quantity (kg) per 1000 fish
Powder	0.1–0.3	≤0.3	0.15
Micro particles	0.5	0.3–1	0.42
Crumble	0.7	1-3	1.2
Crumble	1	3–10	4.2
Mini pellets	1.8	10–15	4
Floating pellets	2	15–40	22.5
Floating pellets	3	40–150	91
Floating or sinking pellets	4	150–900	750
Floating or sinking pellets	5 or 6	900–1500	660

Table 2. Appropriate feed sizes for quantities for various weights of catfish.

Module 2: Hatchery operation

Pre-evaluation questions

1. Which of the following processes is correct in terms of order of activity?
   a) Inject with pituitary gland extract, strip, and lay eggs in incubating troughs, mix the eggs
   b) Inject with pituitary gland extract, strip, mix the eggs and the milt (fertilization), lay eggs in incubating trough
   c) Mix the eggs and the milt (fertilization), inject with pituitary gland extract, strip, lay eggs in incubating trough
   d) Lay eggs in incubating troughs, strip, and then mix the eggs and the milt (fertilization), inject

2. Which of the following is not needed during catfish breeding?
   a) incubating trough
   b) cast net
   c) saline water
   d) pituitary gland extract

3. What color are healthy eggs collected from a mature female catfish?
   a) red
   b) black
   c) golden brown
   d) white

4. How do you recognize the testes of a male catfish after cutting it open?
   a) round shape
   b) blood-red color
   c) comb-like shape
   d) black color

5. Which of the following is fungi more likely to grow on?
   a) broodstock
   b) dead eggs
   c) smoked fish

6. Depending on the water temperature, how long should it take for incubated eggs to hatch?
   a) 20–36 hours
   b) 2–3 hours
   c) 2–3 days
   d) 40–71 hours

7. Depending on the temperature, how long does it take between the time of injection and stripping?

8. How do you recognize a gravid female catfish?

9. Why should a female fish be weighed before hypophysation?

10. What is a fish hatchery?

2.1. Definitions and infrastructure requirements

2.1.1. Hypophysation

Hypophysation is artificial or induced breeding, a technique that uses pituitary gland extract injection for breeding fish.

2.1.2. Hatchery

A hatchery is an indoor or outdoor structure that is built for fish reproduction. It is a sanctuary for fish seed production and rearing before transferring seed to nursery ponds or selling them. Broodstock meant for hatching are also often kept and maintained in hatcheries.

The hatchery environment must be healthy to prevent and reduce infections, diseases and fish mortalities. Temperature and illumination are controlled or regulated in hatcheries, and operations demand a lot of care for success, especially within the first 2 weeks of eggs hatching. Depending on the technical and managerial skills of the operator(s), a hatchery can be a high-profit or a high-risk venture.

The following are the major requirements and infrastructure needs for hatchery operations:

- good and reliable water supply
- specified hatchery equipment and chemicals/drugs
- good broodstocks (fertile and healthy)
- knowledgeable and skillful operators
- a standard hatchery building with indoor units and outdoor structures
- efficient waste management for environmental health
- understanding and compliance with biosecurity issues
- water storage tanks
- hatching/incubating troughs
- water filtration to remove all mineral solids and debris from the water
- buckets to transport larvae
- water testing kit
- rectangular or circular fry tanks
- fingerling ponds
- pumping machine, aerators, syringes
- hormone to induce matured female broodstock

2.2. Injecting female broodstock

Inject the fish with the appropriate dose of hormone to induce final maturation and then ovulation. The success of artificial propagation depends on the size of the female gonad and gonadal maturity.

The steps for injecting female broodstock are as follows:

1. When more than 10 females are to be injected, separate them into two groups of equal numbers and inject them 30–60 minutes apart. This gives the fish breeder enough time to strip each fish after the female has been isolated for 10–12 hours for inducement of final maturation and ovulation.

2. When selecting gravid broodfish, weigh the female and place her on a firm surface or the work table (Plate 2).

3. Extract the pituitary gland from either male or female fish (regardless of the species) and then store it in ethanol before using it to induce egg maturity in the selected female broodstock (Plate 3).

The steps for preparing the pituitary hormone are as follows:

i. Cut the head and separate the upper jaw from the lower jaw.
ii. Clean the palate with soft tissue paper or a towel.
iii. Open the palate with a surgical blade.
iv. Open the ridge of bone gently.
v. The pituitary gland is a whitish tiny round tissue.
vi. Use tweezers to remove the pituitary and then store it in alcohol until use.
vii. Dry the pituitary gland in methylated spirit prior to use.

4. Different hormones can be used to induce ovulation in gravid broodstock. These include natural hormones, such as African catfish pituitary gland, and synthetic hormones, like Ovaprim or Overtide. Select hormones for induced egg maturation in the female broodstock. The manufacturer usually gives the prescription and dosage in accordance to the weight of the female fish.

5. For freshly removed pituitary glands, the recommended ratio for recipient to donor is 1 kg to 1 kg. If dried, the recipient to donor ratio for preserved pituitary glands is 1 kg to 1.5 kg.

Plate 2. A gravid female on a weighing scale.

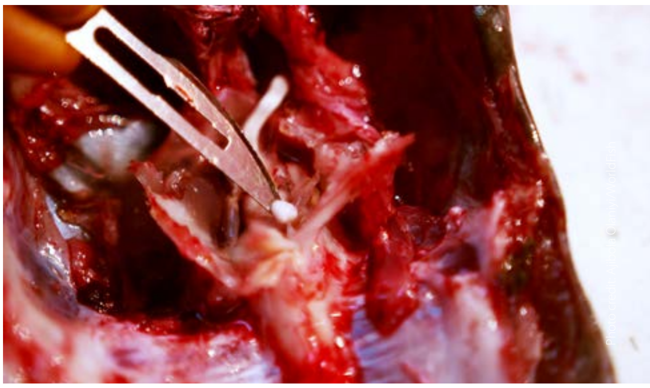

Plate 3. Pituitary gland being extracted.

6. For synthetic hormones, inject 0.5 ml of the hormone for a 1 kg female fish (Plate 4).

7. Cover the fish's head with a moist towel to reduce agitation and hold the fish against the worktable to help it remain calm during the entire process of injection.

8. Do not inject the fish on the lateral line. Inject it just below the anterior part of the dorsal fin and above the lateral line by pointing the syringe toward the tail. Inject the fish into the muscle above the lateral line with the needle at a 30- to 45-degree angle to the body of the fish (Plate 5).

9. Carefully and gently withdraw the syringe. Massage the injected spot with your finger to evenly distribute the hormone into the muscles.

10. Put the injected female broodstock in an isolated tank or bowl of water with enough water to cover half of the body. Leave the fish for about 10 to 12 hours before stripping.

2.3. Collection and incubation of milt

Since the natural procedure of spawning will not be carried out, the collection of milt often comes with impurities. These impurities are separated from the milt during incubation and milt are kept active and ready to fertilize. This sperm incubation is essential to commercial fish breeders, as it will prevent the use of multiple males.

A drop of a milt contains a million of active sperm cells or spermatozoa; this drop can fertilize the egg of a female if mixed properly.

The materials to be use are: Surgical blade or a pair of scissors, container and clean cloth material. These materials should be sterilized and the container for milt collection rinsed properly with saline water before use. Use normal saline water (0.9% saline solution) for the procedure.

The incubation is usually done two hours before the expiration of the latency period of the female catfish. The procedure for the incubation of milt is as follows:

Plate 4. Ovatide: A synthetic hormone that can also be used.

Plate 5. Injecting a female broodstock above lateral line.

Plate 6. Dissecting a male broodstock to extract the milt sac for fertilization.

Plate 7. Carefully removing the milt sac.

1. Cut the male open from the ventral side.
2. Detach the milt sac from the other organs of the body.
3. Use saline water to rinse sac to prevent impurity.
4. Cut the milt sac with blade or scissors into the incubating container.
5. Rinse sac with saline water.
6. Neatly wrap the container inside a bowl with cloth for a minimum of 1 hour and a maximum of 3 hours.
7. Store under room temperature for effective incubation before mixing with the egg for fertilization.

In a situation when the milt cannot be used immediately, the milt in the saline water can be stored in a refrigerator for 24 hours before use.

2.4. Stripping female broodstock

The following procedure outlines the steps required for stripping female broodstock:

1. Carefully bring the female fish out after 10–12 hours, depending on the temperature. Check for eggs at the base of the tank. If your fingers crush some eggs, this means that eggs are coming out already, which means the eggs can be said to be running. The fish is ready for stripping.

2. Wipe the body of the broodfish with a dry soft towel. Two people might be required to handle the fish at both the tail and the head. One person holds the head with a towel while the other holds the tail (Plate 8).

Plate 8. Stripping female broodstock for collection of matured egg.

3. Remove ripe eggs from the abdomen by gently pressing several times from the anterior end until a high percentage of the eggs is collected into a dry bowl. Immediately stop pressing when blood is on the eggs.
4. Carefully collect the eggs in a clean dry plastic or metallic bowl. Ripe eggs are usually uniform in size with a dark spot in the center, which is the nucleus.
5. Weigh the stripped eggs to estimate the expected number fry. African catfish contains approximately 600 eggs per gram, so weighing the eggs helps estimate the expected number of fry for egg hatchability. Alternatively, the quantity of eggs can be estimated as 15%–20% of the fish's weight.

Plate 9. Extracted milt in a tube.

Plate 10. Milt sac.

Plate 11. Mixing saline water with milt.

2.5. Egg fertilization and incubation

The following procedure outlines the steps required for egg fertilization and incubation:

1. Spread the collected milt on the eggs in a plastic bowl (Plates 9–11).
2. Immediately add the saline solution (0.9%) to the mixture. This will enhance the motility of the milt cells in fertilizing the eggs (Plate 18). The saline water also makes the milt last longer before it fertilizes the eggs.
3. Saline water extends the lifespan of the sperm cells. This makes it possible for all the eggs to receive active milt.
4. Adding fresh water reactivates and makes the sperm cells motile and initiates the external fertilization process.
5. Continue mixing to prevent the eggs from sticking or clogging together. This should be done within 60 seconds. Then mix the eggs properly for 1 minute to increase the chances of all the eggs to be fertilized.
6. After fertilization, incubate the eggs in an incubating unit.
7. Spread the eggs evenly on a spawning mat with a mesh size of 1.2 x 1.2 mm inside an incubating trough (80–100 L) prefilled with water. A constant waterflow rate of about 1 to 3 L per minute is allowed to flow through in the incubating unit (Plate 12).
8. Depending on the water temperature, which should be higher than 25°C, the eggs will hatch between 20 and 36 hours and the fry will emerge.
9. Remove the hatching tray after a maximum of 36 hours to prevent fungi from attacking the fry, as unhatched eggs will attract the growth of fungi.

Plate 12. Adding and mixing a saline solution (0.9%) to the eggs.

10. Monitor incubation at regular intervals to prevent water overflow and subsequent loss of hatchlings.
11. Attach a mesh screen to the outlet of the incubation system to prevent the fry from escaping or being washed away.

Post-evaluation questions

1. Approximately how many eggs would there be in 0.8 kg of eggs?
   a) 480,000
   b) 1,000,000
   c) 48,000,000
   d) 100,000
2. Approximately how many eggs would there be in a female fish weighing 6 kg?
   a) 540,000–720,000
   b) 1,000,000–1,200,000
   c) 48,000,000–50,000,000
   d) 50,000–100,000
3. Which of the following is needed during catfish breeding?
   a) incubating trough
   b) cast net
   c) glucose
   d) cutlass
4. A well-matured egg has a color ranging from greenish to golden brown with a visible germinal disk-like a dot. True or false?
5. Depending on the water temperature of the incubated eggs, how long will it take for them to hatch?
6. Which of the following is incorrect regarding fungi during breeding?
   a) Fungi help hatchlings grow faster.
   b) Fungi have no effect on fry and eggs.
   c) Fungi kill eggs and fry.
   d) Fungi serve as feed for hatchlings.
7. How do you differentiate between male and female catfish?
8. How do you recognize a gravid female catfish?
9. What is fish hypophysation?
10. Why should female fish be weighed before hypophysation?

Module 3: Better management practices for hatcheries

Pre-evaluation questions

1. Which of the following is not a benefit of biosecurity?
   a) minimizes the risk of project failure
   b) reduces viability and leads to eventual loss
   c) lowers the chance of disease outbreak
   d) decreases the chance of economic losses from fish loss

2. Which of the following is not a potential facilitator of a disease outbreak?
   a) exposure of fry and fingerlings to stress
   b) hygiene
   c) hatchery equipment
   d) visitors

3. Which of the following is not a better management practice for waste disposal in a hatchery?
   a) proper treatment and discharge
   b) chlorinating and dechlorinating wastewater from sedimentation tanks before discharge
   c) discharging water close to the intake point or water source
   d) burying or burning dead fish

4. Which of the following is not a quality of good fingerlings?
   a) uniform sizes, which prevents cannibalism
   b) vigorous activity and a healthy appearance
   c) absence of deformities or wounds
   d) number or quantity

5. Which of the following is not a disinfectant?
   a) oxytetracycline
   b) formalin
   c) chlorinated water
   d) potassium permanganate

6. Transporting fingerlings is best when the weather is hot. True or false?

7. Why are hatchlings not fed for the first 3 days after they hatch?

8. Stress heightens the chance for opportunistic bacteria on fry. True or false?

9. How many times per day should fry be fed?

10. What do hatchlings feed on for their first 3 days?

3.1. Managing larvae, fry and fingerlings

The following procedure outlines the steps required for managing hatchlings/larvae and fingerlings:

1. Siphon the hatched larvae into transportation buckets and then transfer them into a different trough. Since dead eggs are lighter than larvae, stir the water to make the dead eggs can come up and then siphon the larvae. Ensure that the water is saturated with oxygen. Siphoning can be done manually (mouth-siphoning) or mechanically (pressure tube operation).

2. Transport the larvae into the fry tanks (Plate 13). During this period, water can be recycled or flow-through at the rate of 1 L per minute in a 1000 L fry tank with gentle aeration. This is because high flow rate or high aeration could stress the fry leading to mortality. Do not feed the hatchlings/larvae for 3 days because they are feeding on their yolk sac.

3. By this time, the fry have consumed their yolk sac. Feed them for 5–8 days with live food (cultured zooplankton) or other compounded feed for fry.

4. Stock 50%-65% fry per liter.

Plate 13. Flow-through nursery tank.

5. Feed fry until satiation six times a day from 06:00 to 20:00. During feeding, shut off the water supply. Resume the water supply once the fry are satiated and feeding has been stopped.

6. Observe the behavior of the fry to determine how much feed to give them. Hungry fry will swim vigorously close to the surface, while satiated fry will gather in clusters on the bottom of the tank.

3.2. Caring for larvae, fry and fingerlings

Catfish larvae are small and needle-like with a light-green globe-shaped yolk sac. At this stage, feeding is not required until about 3 days after they absorb their yolk.

The following procedure outlines the steps required for caring for larvae, fry and fingerlings:

1. Remove shells and unhatched eggs through careful siphoning to prevent the water from being contaminated with ammonia, which could lead to bacterial or fungal infections among the hatchlings.

2. Aeration is necessary because fry are very active and require a lot of oxygen. If mechanical aeration is not affordable, ensure constant water flow. This will aerate the water and remove feces and uneaten food, which can easily contaminate the water.

3. Active feeding begins soon after the fry absorb their yolk sac. Give artemia or other fry feed to the fry for about 2–3 weeks.

4. Next, give fry formulated branded feed with a crude protein content of 50%-65%. Continue until they reach the fingerling stage of 6–8 weeks old.

5. Make sure to feed fingerlings properly.

6. Catfish can be carnivorous, so it is important for weekly or fortnight sorting to various sizes.

7. Avoid overstocking. It leads to high mortality due to more waste and consequently an elevated rate of water pollution and lower water quality (Plate 21).

8. Avoid overfeeding. This is one of the main causes of disease outbreak at this stage of development.

9. Minimize stress on fingerlings. Opportunistic bacteria infect with ease when fish immunity is low due to stress from transfer.

10. Follow proper health management of fingerlings. Avoid prolonged exposure of excessive concentrations of toxic substances, like carbon dioxide and ammonia. Employ preventive as well as curative methods promptly to manage the health of fingerlings.

3.3. Biosecurity

Biosecurity is the establishment and implementation of a system of procedures in a hatchery to prevent the introduction of pathogens into fish from outside the farm or from another section within the farm. Biosecurity involves putting into place all activities (sometimes simple and zero cost measures) to prevent diseases from occurring or spreading. This costs less than treating or trying to control diseases.

Several factors can cause disease outbreaks: stress upon fry and fingerlings, poor quality feed, broodstock, infected eggs, contaminated water source and contaminated hatchery equipment. In addition, visitors can accidentally bring in pathogens and contaminate the system.

Biosecurity is important because it minimizes the risk of the project failing. It prevents high fish mortality, reduces the chance of disease outbreak and lowers the chance of economic losses from fish loss. Customers/clients will no longer trust the quality of fry, fingerlings or juveniles without biosecurity measures.

3.3.1. Necessary biosecurity measures

The following procedure outlines the steps required to implement biosecurity measures in a hatchery:

1. Restrict indiscriminate entrance into the facility, which increases the chances of contamination and transfer of pathogens.
    - Control or restrict the entrance of vehicles, visitors, staff and other disease vectors to prevent the transfer of infection.

- Install a handwash and a footbath at the entrance of the hatchery.
- Disinfect the wheels of vehicles as they enter.
- Change the disinfectant regularly.

2. Water quality is the most important factor for managing fish health.
   - Hatchery operators must ensure optimal physical and chemical conditions of the water. Use reliable instruments to take measurements so that fish are not unduly stressed and predisposed to opportunistic bacterial infection.
   - Use chlorine, ozone, UV, ultrafiltration or other methods to kill pathogens in water used for production.

3. Clean and disinfect all hatchery equipment properly after use and before beginning another production cycle.
   - Maintain a clean work environment and do not take any hatchery equipment outside the facility or use it in other places within the facility.
   - Disinfect all hatchery equipment regularly and dry it thoroughly.
   - Flush sand filters and remove the sand to dry under the sun.
   - Keep nets and other equipment off the floor.

4. Quarantine incoming broodstock, juveniles or fingerlings from other farms, as they can introduce diseases into the facility. Prophylactic treatment is given to rid the fish of parasites and bacteria before introducing them into a hatchery.
   - Prophylactic treatments include medicated baths in oxytetracycline and potassium permanganate.
   - Repeat prophylactic treatments three to four times a week.
   - Allow water to flow through when treatment is not ongoing.
   - Feed fish when they are not undergoing treatment.
   - Smooth inner surfaces in tanks allow easy and complete cleaning.
   - During quarantine, monitor fish closely.
   - Apart from quarantine treatment, give broodstock regular prophylactic treatment with or without oxytetracycline at least once a month.

5. Feeding is one of the most important daily routines that determines fish health, rate of growth and resistance to stress and diseases, so it is necessary to obtain quality pathogen-free feed from a reliable source.
   - Keep feed in a cool dry place, away from rats and other animals, which can contaminate the feed.
   - Commercial pelletized feeds are usually safe and low risk.

6. Minimize the amount of fish handling, which can stress fish and make them susceptible to pathogens.
   - Do not transfer fish more often than necessary, and use anesthesia whenever needed.
   - Except when necessary, avoid removing fish from the water or handling them roughly to minimize mucus loss.
   - Avoid overstocking, which puts more stress on available resources and consequently on the fish.

7. Improper waste disposal can affect a hatchery. Waste like dead animals and processing waste can transmit diseases into a hatchery.
   - Ensure proper treatment and discharge to minimize the risk of disease within the hatchery or others in the vicinity.
   - Release wastewater into sedimentation tanks. Chlorinate and dechlorinate wastewater from sedimentation tanks before discharge.
   - Do not discharge water close to the intake point to avoid contaminating the water source.
   - Bury or burn dead fish to prevent diseases from spreading.

Qualities of good fingerlings

The viability of seed depends highly on the nutrition of the broodstock. Nutritional components in the diet, feed intake rate or the feeding period can each affect spawning as well as egg and larval quality. Good quality can be determined by simply observing the fry or through more technical assessments. The holding facility for fingerlings in the hatchery must be clean and not contain any foul smells.

The following are qualities of good fingerlings:

- Uniform sizes prevent early cannibalism.
- Healthy fingerlings display vigorous activity and appear healthy.
- They are free from deformities and wounds.
- They are brightly colored.
- They eat at least 2 mm extruded and compounded pellet feed.
- There are no mortalities at the collection point.
- There are no visible stomach protrusions or wounds, such as hemorrhages, spots, cysts or discolored patches on the body, gills or fins. These are signs of diseased fingerlings and must be avoided.
- Good growth and an efficient feed conversion ratio (FCR) can take a week or more to determine. The FCR is a measure of the amount of flesh gained from a quantity of feed consumed. For fish of the same age, a higher FCR means low efficiency of feed conversion.

3.4. Uses of probiotics

There are various commercial probiotics available in the market that can be used for soil treatment and in the hatchery.

BactoSafe application in pond soil treatment
BactoSafe S pond soil treatment is a specially formulated biological and biochemical system designed to accelerate the biological decomposition of highly befouled aquaculture pond soil. It is a natural microbial ecosystem designed to inoculate soil waste and start the bioremediation process. It also is fortified with unique accelerants to speed up microbial action.

Step 1: Ensure the pond is already emptied.

Step 2: Determine the quantity of BactoSafe S according to the size of the pond.

Suggested dose: 500 g for a 40 m x 60 m pond (average-sized).

Step 3: Get a carbon source like molasses for activation (bacteria becomes active and multiplies).

Recommended dose is double the amount of BactoSafe S.

e.g. 500 g of BactoSafe S will require 1 kg of molasses.

e.g. 1 kg BactoSafe H will require 2 kg of molasses.

Step 4: Activate 1 kg BactoSafe S bacteria by hydrating with 2 kg molasses in 100 liters of warm fresh water or clean pond water for 30 minutes with an oxygen tank or air pump running (aeration). Broadcast hydration mixture evenly over 1-hectare of pond surface. Allow mixture to stand without covering for a maximum of 4 hours and then broadcast the mixture evenly across the pond surface. Use a shovel to tilt and stir up the pond bottom for efficient colonization. A pply mixture before 10:00 in the morning to prevent the sun from denaturing the bacteria.

Step 5: To allow activated positive bacteria to colonize the pond soil effectively, leave the pond alone for 24 hours before filling it with water.

Step 6: For better results, repeat the entire process 30 days after filling the pond with water and stocking it with fish.

Applying probiotics in hatcheries

Many fish farmers depend on Smart Choice Probiotics marketed as Defence. It is customised Direct Fed Microbial Privately (DFM). It is privately cultured in USA Laboratory. It is heat stable product. Contains a source of live (viable) naturally occurring microorganisms.

Guaranteed analysis: Minimum 1.0 x 1011 (100 billion) CFU kilogram. Per Kilogram.

- Lactobacillus acidophilus.
- Lactobacillus casel.
- Bifidobacterium casel.
- Enterococcus faecium.

Direction for use:

- For non-high-pressure feed 0.5 kg/t
- For extruded feed with high temperature 1 kg/t
- For fry: 5–10 g/kg feed
- External use in water: 3–5 g/m^3 of water. It can be fed directly at the same rate.

Other commonly used probiotics in Africa are:

- Shandong Baolai Leelai – China.
- Sanzyme Biologics (p) Ltd. India.

Benefits of probiotics:

1. Balance the intestinal micro flora.
2. Increase feed conversion rate.
3. Promote growth, especially when they are used with good enzymes like 10 strength enzymes

produced by Smart Choice Eggriculture in the US. In a trial using the above combination, a batch of tilapia will attain 1.8 g in weight at 5 weeks old and escapees will reach an average weight of 3.7 g, which are higher than most breeders' expectations.
4. Improve immunity.
5. No side effects, no residues and no drug resistant bacteria.
6. Not harmful to health and are ecologically friendly.

BactoSafe application in hatchery

BactoSafe H is a concentrated complex of live bacteria selected specifically to enhance the health of fish and shrimp in hatcheries. It is a natural microbial ecosystem with added stabilizers and growth stimulants for detoxifying aquaculture hatchery water. It eliminates water-fouling waste products such as ammonia, nitrites and hydrogen sulfide, thereby lowering stress and providing a healthier environment for aquatic animal growth. It also improves animal health and disease resistance by creating a probiotic environment.

BactoSafe H application

Step 1: Determine the stage of fish in need of BactoSafe H. They must be held in a hatchery.

Step 2: Determine the quantity of BactoSafe H based on the volume of water in the fish tank or overhead GeePee tank. It should be noted that the recommended quantity varies with the stage of fish (yolk sac fry, fingerlings, juveniles).

Suggested dosages to 1000 L of water per day are;

- Yolk sac (before feeding starts i.e., after 3 days of hatching) – 4 mg/1000 L
- Fingerlings – 6 mg/1000 L
- Juveniles – 8 mg/1000 L
- For extreme ammonia situations in any of the stages – 10mg/1000L

The following are the suggested daily doses for 1000 L of water: 4 mg for yolk sac fry, 6 mg for fingerlings, 8 mg for juveniles, and 10 mg for extreme ammonia situations at any stage. Each of these doses can be administered either once or 2–3 times per day.

Step 3: Next, mix BactoSafe H in 5 L of fresh, non-chlorinated water in a clean bucket. Measure any of the suggested doses depending on the situation, pour and stir (to prevent coagulation) in the non-chlorinated water. Cover (anaerobic) the stirred solution for maximum of 4 hours and then introduce it into either the fish tank, with a suitable recirculatory aquaculture system, or an overhead GeePee tank for a flow-through system.

Step 4: Leave solution to digest the available ammonia in the system. For a recirculatory aquaculture system, leave solution for as long as 24 hours to digest all of the ammonia in the system before flushing out the water. For flow-through systems, leave for 3 hours before flushing and then allow fresh activated water flow in the overhead GeePee tank. In extreme ammonia situations, local adaptions must be made to suit the condition.

3.5. Fingerling production

The following procedure outlines the steps required for fingerling production:

1. Water quality is important for good hatching and larvae survival. If using borehole water, filter water to remove all heavy metals during hatching.

2. Prepare ponds the day before stocking with fry to avoid predators in the pond. The fry will be able to compete with incoming predators and eat up their eggs and small insects. Use hydrated lime at 2000 kg/ha for highly acidic soil or ponds, 1200 kg/ha for moderately acidic soil or ponds, or 1000 kg/ha for slightly acidic soil or ponds. For neutral soil or ponds, use 400 kg/ha. Probiotics or chlorine can also be used.

3. Earthen ponds with concrete walls reduce the presence of predators by 50%. Use aerators in these ponds if overstocked.

4. If using water from a river, treat the water with potassium permanganate before stocking with fry to control diseases. If necessary, mix the water with water from a pre-fertilized pond. No flow-through is needed.

5. Syphon larvae into a clean environment after hatching and do not disturb them for 3 days. No flow-through during this time, but aerate the water entering the fry tank.

6. Grow larvae inside a controlled environment for at least 5 days before putting them into earthen ponds. They will be big enough to eat up the eggs of predators in the water.

7. Grade fingerlings after 2 weeks in the pond.

8. Hybrid fingerlings (*Hetero-Clarias*) have the best performance in terms of growth. The male is *Heterobranchus bidorsalis* and the female is *Clarias gariepinus* for hybrids with a smaller head and longer body.

9. Transport fingerlings in airy vessels/vehicles. Drain the transportation water on arrival and fill the container with recipient pond water.

3.6. Fish seed transportation

Transportation can be very stressful for fish. This can lead to losses from mortality or increased cost of production, or mortality due to diseases. Fingerlings usually come from hatcheries that are often located far away from the farm destination. Therefore, fish seed needs to be transported as economically as possible in a healthy condition with minimal mortalities.

If fingerlings are to be transferred from a hatchery to another farm, then fish breeders must adhere to the following precautionary measures:

1. Prepare ponds before buying fingerlings.

2. Precondition fish seed in hapas to reduce handling stress at the point of transportation.

3. Do not feed fish seed on the day before transportation to allow them to empty their stomach. This will reduce water pollution and keep the oxygen demand at a minimum.

4. The conditioning period depends on the size of the seed, prevailing temperature and duration of transportation.

5. Condition fry for a minimum of 3 hours: early fingerlings (35–50 mm) for 6 hours, advanced fingerlings (80–100 mm) for 9 hours and juveniles (150 mm) for 12 hours.

6. Do not use tap water unless kept for 2–4 hours and well agitated to drive off the chlorine. Avoid using water that is rich in iron and poor in oxygen.

7. Before the seed are put in the bags, first grade them through a sieve to sort out the fry for fingerlings of uniform size.

8. Check the plastic bags for any leaks, and keep them in a clean container with a lid to close it. Put cloth or used newspaper between the bags and the wall of the container and at the bottom to provide insulation from heat.

9. Before packing the fingerlings, give them a bath in a solution of potassium permanganate (2–3 ppm) or common salt (0.3%).

10. Fill the bags with water from the same source as the seed. However, if the water is rich in plankton or is turbid, avoid it and use clean agitated well-water instead.

11. Add a saline solution (5 g/L) to the transportation container for 5–10 minutes as an anti-stress measure.

12. Pack the seed either in the morning or evening to avoid an increase in metabolic rate due to high temperatures.

13. Pack fish in plastic bags filled with one-third water and two-thirds oxygen. Keep the plastic bags in containers to prevent puncturing.

14. Using a perforated cup at the base, take at least three random samples of seed. Count them separately and take the average of the three samples. This is the number of seed the cup can carry. This method saves time and reduces the stress fingerlings are exposed to during counting.

15. Put the required number of seed into the bag. Twist the upper part of the bag to expel all the air above the water level.

16. Insert the tube from the oxygen cylinder into the bag. Oxygen is released by turning the key on the cylinder. Allow the bag to inflated.

17. When the bag is fully inflated, turn off the oxygen supply and remove the tube. Twist the top of the bag two or three times to prevent oxygen from leaking. Tie it tightly with a fine cotton, jute or nylon rope.

18. Follow this process as fast as possible, and put the containers in the vehicle for transportation to the destination.

19. Handle the containers with care, and keep them in the shade during the day.

20. Transport seed in either morning or evening. However, if the distance requires 4–6 hours or more of driving, then it is better to transport them at night.

21. Do not allow the vessel to come into contact with petrol or chemicals during transportation.

22. Avoid bad roads to prevent stress.

23. Transport at a cool time of day to prevent the water from heating up.

24. Refresh the water for long-distance transportation of 5–6 hours.

25. Remember to check the fish during transportation and keep them cool.

26. Gently lower the container and allow the fish to swim to the pond (acclimatization). Make sure the temperature in the bag has time to become the same as that in the pond, then release the fish gently into the pond.

27. Do not feed fingerlings until 3 hours after transfer into a new pond.

28. Fingerlings are tender, so be sure to handle them with care.

Post-evaluation questions

1. Which of the following is toxic or problematic for fingerlings as a result of prolonged exposure or excessive concentrations?
   a) carbon dioxide
   b) oxygen
   c) suspended solids
   d) all of the above

2. Which of the following does not cause disease outbreaks?
   a) water source contamination
   b) infected eggs
   c) disinfection
   d) broodstock

3. Which of the following is not a quality of good fingerlings?
   a) vigorous activity and a healthy appearance
   b) absence of deformities
   c) lethargy
   d) number or quantity

4. Why is biosecurity important?
   a) reduces the chance of disease outbreak
   b) lowers fish immunity to pathogens
   c) decreases feed efficiency
   d) exposes fingerlings to toxins

5. Should equipment be shared between tanks? If equipment is shared, what should the farmer do to prevent breaking biosecurity measures?

6. Does a good feed efficiency translate to a good FCR?

7. Why is giving fish fresh feed discouraged?

8. What is the minimum crude protein content of feed that fry should be given?

9. What are the reasons why fish should not be fed the day before the transportation?

10. How long should fish be without feeding prior to transportation?

Catfish feeding, Fishking Tatt Farms and Research Ltd, Akuse, Ghana.

Module 4: Fish health and disease management

Pre-evaluation questions

1. Which of the following is needed in fish seed pond water where phytoplankton grow?
   a) carbon dioxide
   b) oxygen
   c) none of the above
   d) all of the above

2. Which of the following is not a potential source of disease outbreak?
   a) water source/contamination
   b) infected eggs
   c) disinfection
   d) broodstock

3. Which of the following is not a quality of good fingerlings?
   a) vigorous activity and a healthy appearance
   b) absence of deformities
   c) lethargy
   d) quantity

4. Why is biosecurity important?
   a) reduces the chance of disease outbreak
   b) decreases fish immunity to pathogens
   c) lowers feed efficiency
   d) exposes fingerlings to toxins

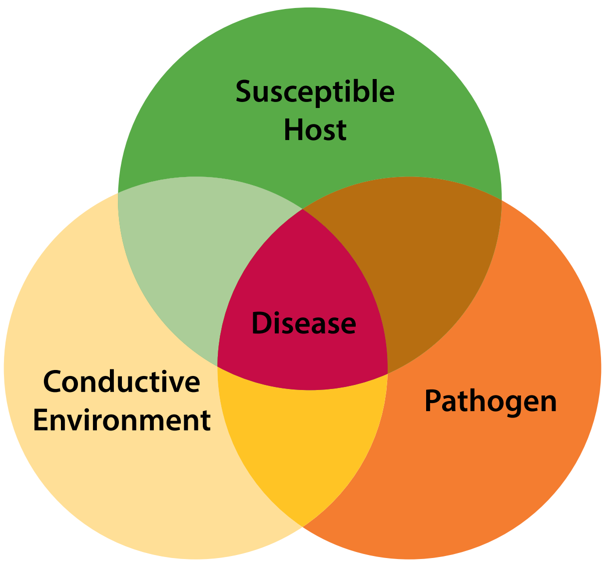

Figure 1. Classes of factors that affect fish health.

5. Should equipment be shared between tanks? If so, what should farmers do to not break biosecurity?

6. What are the two broad types of parasites?

7. Why is giving fresh feed to fish discouraged?

8. What is a secondary infection?

9. What are some reasons why should fish not be fed the day before transportation?

10. How long should fish be starved before transportation?

4.1. Factors affecting fish health

Fish health management is a term used in aquaculture to describe management practices that are designed to prevent fish infections and diseases, and to control diseases when they occur. Once fish get sick, it can be challenging to rescue them (Figure 1). Successful fish health management begins with preventing diseases rather than treatment. Preventing fish disease is accomplished through good water quality management, nutrition and sanitation.

Observing fish behavior and feeding activity daily helps detect health problems early so that a diagnosis can be made before the majority of the population becomes sick. Treatments are successful if they are implemented early following the occurrence of a disease while the fishstock is not seriously infected.

Fish disease is significant in aquaculture because it leads to substantial economic loss and reduction in the market value of fish. Disease outbreaks increase production costs because of the loss of fish (mortality), cost of treatment and decreased growth during recovery. In nature, fish diseases are not obvious because sick animals are quickly removed from the population by predators. In addition, fish are less crowded in natural systems than in captivity or culture systems.

4.2. Types of fish diseases

There are two major categories of diseases: infectious and non-infectious.

4.2.1. Infectious diseases

Infectious diseases are caused by pathogenic organisms in the environment or carried by other fish species. They are contagious, and treatment might be necessary to control the outbreak. Infectious diseases are broadly categorized as parasitic, bacterial, viral or fungal (Figure 2).

4.2.1.1. Parasitic diseases

Parasitic fish diseases are frequently caused by small microscopic organisms called protozoa, which live in the aquatic environment. There are several classes of protozoans. They target the gills, gut and skin, causing irritation, weight loss and even death. Potassium permanganate can be used to control most protozoan infections. There are broadly two types of parasites: ectoparasites and endoparasites.

4.2.1.1.1. Ectoparasites

Ectoparasites are organisms that live on the skin of another organism, called a host. They use the host for food and protection at the detriment of the host, sometimes even costing it its life. Examples of ectoparasites among African catfish include the Ich or fish louse (*Ichthyophthirius multifiliis*), the salmon fluke (*Gyrodactylus*) and Trichodina species. Trichodina is a protozoan parasite that has severely affected production at many facilities. It can result in extremely high mortality rates, particularly in young fish.

These parasites heavily infest the gill and body surfaces of infected fish. Infected fish display flashing (swimming against the floors of tanks to scrape off the parasites off), rapid breathing, weakness and uncoordinated swimming. These parasites attacks the gills, rendering fish less efficient at absorbing oxygen, releasing carbon dioxide, excreting ammonia and maintaining chemical balance between their body and the environment.

Copper sulfate and salt can temporarily control Trichodina. However, treated fish remain carriers even after treatment, and much like Streptococcus, it is nearly impossible to eliminate Trichodina from a system once it has been introduced. Carefully examine any fish from outdoor ponds or other farms for Trichodina before letting them onto the premises.

4.2.1.1.2. Endoparasites

Endoparasites are organisms that live on the inside of a host, from which they derive their food. They exist in two forms: intercellular parasites and intracellular parasites. Intercellular parasites, such as nematodes, tapeworms and other helminthes (which live in the gut of the host), inhabit spaces of the host body. Intracellular parasites, such as protozoan, live within the cell of the host.

4.2.1.2. Bacterial diseases

Bacterial diseases are often internal infections, but they can also be external, resulting in erosion of the skin and ulcerations. Columnaris is an example of an external bacterial infection and can be caused by rough handling. Opportunistic bacterial pathogens are microorganisms that cause diseases in hosts that are predisposed to environmental stressors or have reduced immune function. Stress factors like hypoxia, high concentrations of ammonia, abnormal pH and high population density make it possible for opportunistic pathogens to thrive. Typically, fish infected with a bacterial disease will have hemorrhagic spots or ulcers along the body wall, around the eyes and mouth. They might also have an enlarged, fluid-filled abdomen and protruding eyes. Most bacterial infections occur when fish immunity has been compromised or when a parasitic infection has opened the way. Bacteria in these cases are considered secondary infections.

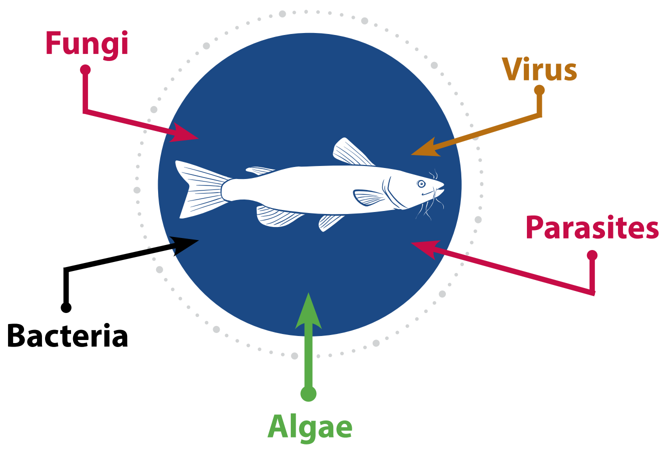

Figure 2. Biotic factors that affect fish health.

4.2.1.3. Viral diseases

Viral diseases are difficult to distinguish from bacterial diseases without special laboratory tests. They are difficult to diagnose, and there are no specific medications available to cure viral fish infections. Consultation with an aquaculture or fish health specialist is recommended if you suspect a bacterial or viral disease is killing your fish.

4.2.1.4. Fungal diseases

Fungal spores exist freely in the aquatic environment, but only affect unhealthy fish. Healthy fish tend to be immune. When fish are infected with an external parasite, bacterial infection or are injured by handling, the fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cotton-like growth or brown matted areas when the fish are removed from the water. Potassium permanganate is an effective treatment for most fungal infections. Since fungi are usually a secondary problem, it is important to diagnose the original problem and correct it as well.

4.2.2. Non-infectious diseases

Non-infectious diseases are caused by environmental problems, nutritional deficiencies or genetic anomalies. They are not contagious and usually cannot be cured by medications. Environmental diseases are the most significant in commercial aquaculture. They include low dissolved oxygen, high ammonia, high nitrite, natural or human-made toxins in the aquatic environment. Proper techniques for managing water quality will enable producers to prevent most environmental diseases.

4.3. Signs of sick fish

These signs can be observed in fish seed as they grow from fingerlings to juveniles. The most obvious sign that something is wrong within the culture system is the presence of dead or dying fish. This is because a careful observer would notice a change in the behavior before mortalities begin (Table 3).

The following are easily detectable signs of sickness in fish:

- Fish stop feeding. Healthy fish eat actively if fed at regularly scheduled times.
- The entire stock or a few fish appear lethargic or sluggish.
- Fish hang lazily in shallow water, gasp at the surface or rub against objects. These behavioral abnormalities indicate that the fish are not feeling well or that something is irritating them.
- The presence of sores, such as ulcers or hemorrhages.
- Ragged fins.
- Abnormal body shape, such as a distended abdomen or "dropsy" and exophthalmia or "pop eye".

When any of these abnormalities occur, evaluate the fish for parasitic or bacterial infections.

4.4. Fish disease management

If you suspect that your fish are getting sick, the first thing to do is check the water quality. Low oxygen is a frequent cause of fish mortality in ponds, especially in the summer. High levels of ammonia are also commonly associated with disease outbreaks when fish are crowded in vats or tanks.

Condition	Healthy fish	Sick fish
Escape reflex (determined in water)	Reactions to any external stimuli, like sounds or vibrations	Lose ability to react to any stimuli and are easily caught
Defensive reflex	Toss about and flab about when laid on a table	Sluggish and motionless
Tail reflex	The caudal fin stretched in the shape of a fan	The caudal fin hangs vertically downward
Ocular reflex	Hard to keep eyeball in normal position	Loss of reflex

Table 3. Characterization and differentiation of sick and healthy fish.

In general, check the levels of dissolved oxygen, ammonia, nitrite and pH during a minimum water quality screening associated with a fish disease outbreak. The parameters of significance include total alkalinity, total hardness, nitrate (saltwater systems) and chlorine (if using city water).

Keeping daily records is important because it will be a reference point to trace what might have gone wrong and for general management. Records should include the dates fish were stocked, size at stocking, source, feeding rate, growth rate, daily mortality and water quality. Good records also include a description of behavioral and physical signs exhibited by sick fish and results of water quality tests. These will provide a complete case history for easy diagnosis and information about management and for preventing future cases.

4.5. Common diseases among catfish

Although they also affect other species, the diseases listed in this section are the most common found among catfish.

4.5.1. Enteric septicaemia

Enteric septicaemia, or hole in the head disease, is caused by the bacterium *Edwardsiella ictaluri*, which belongs to the Enterobacteriaceae family. A highly infectious bacteria disease, it affects many catfish families, including *Ictaluridea*, *Plotosidae*, *Clarrdea*, *Siluridae*, *Pangasiidae*, *Ariidae* and ictalurids. Infected fish often show lethargic swimming, abnormal behavior that alternates between listlessness and chaotic swimming, disorientation and swimming in spirals. Other signs of infection include loss of appetite and protruding the head from the water. Gross pathological signs in the chronic encephalitic form of the disease include ranulomatous inflammation of the brain and swelling on top of the head, which occasionally progresses to the erosion of connective tissue and exposure of the brain (a hole in the head). Gross pathological signs in acute cases includes the following: pale gills, darkened skin (observed in species other than channel catfish), multiple small white spots on the skin, raised skin patches progressing to shallow ulcers on the flanks and head, exophthalmos (pop eye), swollen abdomen (potbelly), ascites (fluid in the abdominal cavity) and also hemorrhage at the base of the fins, around the mouth, and on the throat, operculum (gill cover) and abdomen.

4.5.2. Columnaris

Columnaris is caused by *Flexibacter columnaris*. Stress predisposes fish to this infection. Outbreaks generally result from temperature fluctuations and trauma from poor handling, especially in younger fish. Poor water quality, crowding and poor nutrition increase the severity of the disease. Infected fish generally show lethargy, anorexia, weakened swimming and mortality. Raised white patches appear on the skin or fins and can later develop into ulcers. Certain antibiotics, copper sulfate and potassium permanganate are effective as temporary treatments.

4.5.3. Aeromonas

Aeromonas (*Aeromonad septicemia*) is another bacterial disease that has significantly impacted production in farms. This disease is caused by the bacteria *Aeromonas hydrophila*. Aeromonas shows clinical signs of generalized hemorrhagic septicemia, such as lethargy, weakness and loss of appetite, as well as red discoloration at the anus and base of the fins, and hemorrhagic eyes, gills, internal organs or muscle. Other signs include blood-tinged abdominal fluid and a swollen kidney, spleen or liver. Aeromonas generally affects systems that have systemically poor water quality or overcrowding. The bacteria temporarily responds to antibiotic therapy. But if a farm has Aeromonas, then it needs to either change its source of fish seed or improve its husbandry. Always avoid getting fish from infected stocks at all costs.

4.6. Diseases from environmental deficiencies

4.6.1. Oxygen depletion

Oxygen depletion, or hypoxia, is a common effect of eutrophication in water. The direct effects of hypoxia include mortalities, especially in fish that need high levels of dissolved oxygen. Low dissolved oxygen can result in high mortality of fish seed and, consequently, serious financial problems for commercial fish operations.

Sometimes it is difficult for fish farmers to determine whether catfish are coming to the surface due to low dissolved oxygen levels and when they are just swimming normally. When the water system is normal, catfish dart back and forth across the surface, but when dissolved oxygen is low they tend to swim slower and look suspended in the water, as if in a hanging position. Although fish can show such behavior when fully fed, it is important for farmers to distinguish between catfish hanging because they are fully fed and those hanging from low dissolved oxygen. Fish gasping at the surface of a water are likely oxygen starved (Plate 23), while poorly oxygenated ponds emit foul odors from decaying vegetation, excess fish waste and other organic matter.

Fish production can be greatly affected by excessively low or high pH. Extreme pH values can kill fish and also reduce the growth of natural food organisms. Critical pH values vary according to the fish species, the size of fish and other environmental conditions. The purpose of measuring the level of un-ionized ammonia is to manage pond pH. If the pH level is above 8.5 at sunrise, use acid fertilizers. If it is below 6.5 at sunrise, use lime and alkaline fertilizers.

Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity. Low phytoplankton density in ponds means less food and dissolved oxygen for the fish. On the other hand, too much phytoplankton (algal bloom) leads to minimized sunlight penetration, causing algal deaths. Less phytoplankton and decomposing plankton also leads to less food and dissolved oxygen for the fish. Good water quality requires maintaining an optimal plankton level. Visibility in a pond with the right plankton density should be about 30 cm (Plate 14).

4.7. Diseases from nutritional deficiencies

4.7.1. Dietary essential amino acid deficiency and toxicity

Excessive heat treatment of feed proteins during feed manufacture can lead to poor feed formulation if manufacturers use disproportionate amounts of feed proteins with natural specific deficiencies of dietary essential amino acids (EAAs). Nutritional pathologies also arise from consuming feed proteins containing toxic amino acids. Some feed proteins contain toxic amino acids that affect fish growth and efficiency and can even lead to death. Symptoms of toxicity include scoliosis, deformed opercula, scale deformities, scale loss, and spongiosis of epidermal cells. These occur when the dietary content of leucine is higher than 13.4%. Some general symptoms of protein deficiency are dorsal or caudal fin erosion, cataract, decreased carcass lipid content and renal calcinosis.

4.7.2. Dietary essential fatty acid deficiency and toxicity

When fish are given feed deficient in essential fatty acids (EFAs), they tend to display reduced growth and poor feed efficiency. This can be due to poor feed formulation or from the use of live food organisms that are deficient in EFA. Dietary excess of EFA can exert a negative effect on fish growth and feed efficiency. Cyclopropenoic

Plate 14. Monitoring pond turbidity.

is a toxic fatty acid found in the lipid fraction of cottonseed products. It can be toxic to fish. This toxic fatty acid can reduce growth rate, cause extreme liver damage, increase glycogen deposition, decrease protein content, and lower the activity of several key enzymes.

4.7.3. Hypervitaminosis and hypovitaminosis

Hypervitaminosis is a condition that occurs when fish have accumulated too much of a vitamin in their body. It is caused by fat-soluble vitamins, such as vitamins A and D, because they are stored in the body longer than the water soluble vitamins. Under certain conditions, the amounts are so high that they become toxic. Most recorded cases of hypervitaminosis in fish have occurred under experimental conditions, so they are fortunately rare under normal catfish culture conditions.

Hypovitaminosis, on the other hand, is vitamin deficiency that can be caused by numerous factors: (a) inadequacies in nutrients, (b) malabsorption of nutrients from feed, (c) the presence of dietary anti-vitamin factors, (d) dietary antibiotic addition, (e) effects of pharmacological agents, and (f) abnormalities of vitamin metabolism or use in the metabolic pathways, feed processing and storage. Fish with a vitamin deficiency show symptoms such as scoliosis, lordosis, reduced growth, poor healing, internal/external hemorrhage, caudal fin erosion, exophthalmia, anemia and reduced egg hatchability.

4.7.4. Dietary essential mineral deficiency and toxicity

Macro minerals are required in large quantities. Although they are equally important in the diet, microminerals are only needed in minute quantities. A mineral deficiency in fish can lead to physiological functions. Symptoms include skeletal deformity, abnormal calcification of bones, cranial deformity, reduced growth, poor feed efficiency, bone demineralization, low carcass ash, calcium and phosphorus, anemia, anorexia, sluggishness and muscle flaccidity. Mineral toxicity in fish is usually associated with the use of unconventional dietary feed ingredients that could have heavy metal contaminants, including copper, cadmium, mercury, arsenic and lead.

Post-evaluation questions

1. Which of the following is not an internal factor that affects fish health?
   a) cleaning
   b) geology
   c) water exchange
   d) maintenance

2. Which of the following is not a type of disease?
   a) fungi
   b) symbiosis
   c) bacteriophage
   d) virus

3. Which of the following is not a sign of sickness in fish?
   a) voracious feeding
   b) gasping at the surface
   c) abnormal body confirmation
   d) lethargy

4. Are parasites considered a primary or secondary problem?

5. What would you recommend to a fish farmer with a pH problem reading above 9 in the morning?

6. What are some effects of diseases in fish?

7. What is the remedy for a water pH reading below 6.5?

8. Is the following statement below correct or incorrect? "Some fish diseases are infectious while others are not."

9. Which of the following is not an external factor that affects fish health?
   a) geology
   b) sewage
   c) soil
   d) virus

10. Potassium permanganate can be used to control water turbidity. True or false?

Module 5: Business plan development

Pre-evaluation questions

1. What is capital?
2. What is a loan?
3. What is a grant?
4. Why is it important to have a business plan?
5. What is a brand?
6. What are market demographics?
7. What is competition?
8. What is market segmentation?
9. What is profit?
10. What is a business profile?

5.1. Purpose of a business plan

A business plan is a step-by-step blueprint of how a business owner will operate their business. It provides direction for every decision. A business plan has two main purposes. First, it is used to run a business with a clear and consistent vision. Second, it is required to gain access to funding, such as loans and grants for businesses.

A business plan is used to manage a business by stating the goals, how they will be achieved and when. The plan also summarizes what the business is about, why it exists and where it will go. It serves as a point of reference for partners, investors, employees and management to assess progress with reference to its objectives.

5.2. Business profile

A business profile is a list of basic details about a company. It highlights the strength of the company to prospective clients and customers. It is a form of a résumé that communicates a company's values, objectives, services, products and current status. A simple business profile format includes the name of the business, the address of the head office, phone number, website, company status and the contact information of the person in charge (name, phone number and email address).

5.3. Organization and products

Business organization details include the date of registration and the start of business, main areas of business activity, main product lines, services and the principal customer in industries and across geographical boundaries. Another important part is business capacity, which covers labor, finance and technical ability. These details include the business organization and number of employees, the financial circumstances of the business (optional) and the company's capacity for projects in terms of staff qualifications and certification. They also cover references to success stories in a similar project.

5.4. Description of management team

The management team is the group of individuals that organize the business strategy and ensure the business objectives are met. They operate at a high level of an organization and are responsible for day-to-day managing of other teams or individuals. A description of a management team helps third parties recognize what sets the business apart from others.

5.5. Market analysis

A market analysis is a qualitative and quantitative assessment of a market's attractiveness and its dynamics. These include market size (volume and value), buying patterns or preferences of customers, degree of competition, economic environment (including demand and supply forces) and various customer segments. A market analysis helps gain insight and understanding of potential customers and competitors. It is useful in identifying a niche for a business or in developing a marketing strategy. The process of a market analysis involves several factors: demographics and segmentation, target market, a market need assessment, and competition.

5.5.1. Demographics and segmentation

Demographics and segmentation is the division of the market according to age, race, gender, family size, religion, ethnicity, education and income. All of these give direct information on market size. They point to the target market and market need. The first step in the process of a market analysis is measuring the market size. Market size refers to the maximum total quantity of sales or number of customers a business has or the total potential number of customers or quantity of sales in a given year. There are two approaches for measuring market size: volume and value. Volume deals with the number of customers while value is the estimated monetary worth of the proposed business. The number of customers available to buy fish in an area can be compared with the value they attach to fish in that area.

Consider this example: Two areas have potential customers in the form of small-scale catfish farms that are willing and capable of buying catfish fingerlings. The first area has 100 farms, which are able to pay USD 0.08 per fingerling. The second area has two farms, which are able to pay USD 0.05 per fingerling. It might be better to establish the business in the first area where there is a larger volume, even though it has lower value and higher competition. The market appears stable and accessible.

5.5.2. Target market

A target market is the group of potential customers a company wants to sell its products or services to. No small business can effectively target every potential customer, so it is wise for small businesses to target a niche market that enables them to compete with large established ones.

5.5.3. Market need assessment

A market needs assessment deals with why customers buy the product. Some customers might buy catfish fingerlings because they grow fast, while others might buy them because of the taste, price, health factors or resistance to disease.

5.5.4. Competition

Competition between companies selling similar products and services is a daily occurrence in business. A quick way to do a market analysis is to compare your competitors with your business using a simple table containing important drivers of demand (Table 4). This will give a reasonable view of businesses you are competing with and will enable you to determine their weaknesses, which your company can use to better position itself in the market.

Barriers to entry are obstacles or hindrances that make it difficult for a new company to enter an existing market. An analysis of barriers will answer two main questions:

1. What prevents new entrants from coming in and taking a good percentage of your customers?
2. What makes you think you will be able to break the barriers and successfully enter the market?

Company	Competitor 1 (sales of fingerlings)	Competitor 2 (sales of juveniles)	Competitor 3 (sales of *Heteroclarias* fingerlings)	My company
Revenues	USD 272	USD 408	USD 1902	USD 326 (first year target)
Employees	2	5	7	4
Size	1 farm sales	1 farm	1 farm	1 farm
Price	Low	High	Low	Average
Quality	Average	Low	Low	Superior
Delivery	Free	No	USD 2.72	Discounted

Table 4. Hypothetical analysis of competitors.

There are many barriers to entry. The following are barriers that fish seed production businesses, specifically, could face:

- Cost of investment: Investment in fish seed production is capital intensive.
- Location: The ability to secure a suitable location for fish seed production and other geographical factors will determine a successful enterprise.
- Brand loyalty: This covers consumer attachment to existing fish seed producers or their products.
- Brand cost: The marketing cost is high for a business to reach a certain level of recognition.
- Economies of scale: Existing fish seed producers benefit from a lower average cost due to the scale (size) of production. Inputs can be acquired in bulk, resulting in a lower appreciable cost of production.
- Being "the first mover": Some companies earn a strong position because they are the first to enter and dominate a market.
- Regulations: These are rules and guidelines made by governing bodies to control production activity or processes. A fish seed producer is expected to comply with these regulations, which can affect production activities. Regulations vary from one country to another.

5.6. Financial analysis

A financial analysis is the evaluation of the viability, stability and profitability to merit investment in the business or project. It is used to build a long-term plan to draw business activities. There are several methods of financial analysis. This module focuses on cost-benefits analysis (CBA), profit margin and return on investment (ROI), as shown in Table 5.

Quantity of broodstock stocked	Size of broodstock stocked	Mortality rate @1%	Qty remaining after mortality	Cost of feed	Other production cost (USD)
120 fish	2 kg	2 fish	118 fish	USD 4750.3	2929.35
Total production cost					**7679.65**

Breakdown of feed grade and amount (branded and compounded feed) to produce 450,000 fingerlings						
Feed grade (mm)	**Brand name**	**Unit price (kg)**	**Unit price per bag (USD)**	**Bag size (kg)**	**Feed required (kg)**	**Total cost (USD)**
0.1	Skretting Wean	USD 40.76	40.76	1	25	1019
0.3	Skretting Wean	USD 2.15	21.47	10	100	215
0.5	Skretting Wean	USD 2.12	21.20	10	230	487.6
0.7	Skretting	USD 1.85	18.48	10	477	882.5
1	Skretting	USD 1.38	20.65	15	740	1021.2
1.8	Skretting	USD 1.25	18.75	15	900	1125
						4750.3

**Number of fingerlings raised = 450,000*

Revenue and profit	
Items	**Amount (USD)**
Average weight	3 g
Expected yield	USD 300,000
Selling price/fish	USD 0.05
Revenue	USD 15,000
Profit	USD 6322.09
Return on investment	95.3
Cost benefit analysis	1.95

Breakdown of other production costs	
Items	**Amount (USD)**
Labor (6 staff)	978.26
Transportation	108.70
Electricity	16.30
Water	326.09
Unexpected costs	1500
Total	**2929.35**

Table 5. Financial analysis of catfish fingerling production in Nigeria.

5.6.1. Cost-benefits analysis

A CBA is a process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles. The model is built by identifying the benefits of an action as well as the associated costs and then subtracting the costs from benefits. This is often used in capital budgeting to analyze the overall value of money for undertaking a new project. The CBA produces a ratio called the cost-benefit ratio (CBR), which is an indicator of the relationship between the relative costs and benefits of a proposed project. It can be expressed in either monetary or qualitative terms.

The CBA process covers a detailed or exhaustive list of all the costs and benefits associated with the project. It includes both direct and indirect costs. Direct costs cover labor involved on the farm, equipment and machinery, seed cost, feed cost and all forms of farm inputs. Indirect costs concern electricity, overhead costs from management, rent and utilities.

If a project has a CBR greater than 1.0, this means that benefits outweigh costs. It implies that the business is feasible and worth investing in. For example, a CBR of 1.20 means that for every dollar spent in costs there is a financial gain of an additional USD 0.20.

Net present value (NPV) is the difference in the sums of discounted benefits and discounted costs. A positive NPV means the project is feasible while a negative one means it is not worth investing in and should not be considered.

The following are two rules guiding the use of an NPV or CBR:

1. If separate, unrelated projects are being assessed and the budget for funding the projects *is not limited*, use an NPV or CBR.
2. If separate, unrelated projects are being assessed and the budget for funding the projects *is limited*, the projects should be ranked with a CBR, not an NPV.

For businesses that have small to mid-level capital expenditures and a short to intermediate time to completion, an in-depth CBA could be dependable for a making sensible decisions. For large businesses with a long-term time horizon, a CBA helps calculate the current value of money through discounting. The CBR is computed as a ratio of the discounted benefit stream divided by the discounted stream of costs. Inflation is accounted for by deflating prices using price indices.

5.6.2. Profit margin

Profit margin is the amount by which revenue from sales exceeds costs in a business. There are four levels of profit margins: gross profit, operating profit, pre-tax profit and net profit.

Profit Margin = Net Profit/Revenue

A company takes in sales revenue, which covers the direct costs of the products or services. The gross profit margin is what is left over after the cost of the product or service is subtracted from sales revenue. Next, advertising, which is an indirect cost, is also subtracted, leaving the operating profit margin. Interest on debt and any unusual charges or inflows unrelated to the company's main business are then subtracted, which leaves the pre-tax profit margin. The net margin, also known as net income, is what is left over after taxes are paid. This is considered the company's bottom line.

The profit margin covers the following:

- It measures the degree to which a company or a business activity makes money, by dividing income by revenue.
- It is expressed as a percentage and indicates how much profit has been generated for each dollar of sales.
- The most significant and commonly used margin is net profit margin, which is a company's bottom line after all expenses, including taxes and other costs, have been subtracted from revenue.
- Profit margin is used by creditors, investors and businesses as an indicator of a company's financial health, management skill and growth potential.

5.6.3. Return on investment

This is a financial metric of profitability used extensively to measure the profit or gain an investment can realize. The ROI is a simple ratio of the gain from an investment relative to its cost. It is useful in evaluating the potential return from a stand-alone investment. It can also be used to compare returns from several investments.

Feed size (mm)	Fish size (g)	Fish biomass per cycle (kg)	Feed quantity per fish (g)	Feed required for 4500 fish (kg)	Bags (kg)	Price/ bag (USD)	Price for required bags (#) (USD)
1.8	10.0–15.0	45–67.5	4	18	4 (5 kg/bag)	18.34	73.37
2	15–40	67.5–180	22.5	101.3	6 (15kg/bag)	21.47	128.80
3	40–150	180–675	99	445.5	30 (15 kg/bag)	15.49	464.67
4.5	150–900	675–4050	750	3375	225 (15 kg/bag)	11.41	2567.93
5	900–1500	4050–6750	660	2970	198 (15 kg/bag)	11.41	2259.78
Total feed cost							5494.57
Taking other cost as 30%							2354.81
Total cost of production							7849.38
Total income		Price of fish number harvested	1.90*5000				9510.87
Net profit							1661.49
ROI in %							21.16716123
Assumptions							
6000 fingerlings stocked per cycle							
83% survival rate yields 5000 fish							
Upper limit of 6 months per cycle							
Average weight of 250 g							
Price of fish is 700/kg							
5 t in 1 year							
Locally made feed is fed to fish when they reach at least 100 g in weight to reduce production cost							
Feeding takes 70% of production cost							
Two production cycles are completed in a year							

Table 6. ROI analysis of catfish fingerling production in Nigeria.

The ROI can be positive or negative. A positive ROI means that net returns are good because total returns exceed total costs. A negative ROI means that the investment produces a loss because total costs exceed total returns. Calculating an accurate ROI requires including total returns and total costs. It is better to express ROI as a percentage because it is easier to understand and make deductions from.

The following are the steps involved in calculating ROI:

- Calculate all costs and all income.
- Add all the costs to generate the total cost of production.
- Add all income to generate the total income.
- To calculate net income, subtract the total cost of production from the total income.
- To calculate the ROI, divide the net income by the total cost of production and multiply it by 100.
- To prevent omissions, it is important to know which factors to consider when calculating the cost.

5.7. Sourcing capital/grants

A capital-intensive project or business like catfish seed production is usually difficult to start. This is a significant barrier to entry, so potential business owners must consider this challenge. If business owners do not have the funds to start or improve an existing business, the other available options are to look for a grant or get a loan.

There are many ways to secure the funds required to complete a project:

- Personal fundraising: The first investor in a business should be the business owner. This can be in the form of cash, in-kind, or collateral on assets. This signifies to potential investors that you have a long-term commitment for the project you are embarking on.
- Partnerships: This is an agreement between two or more parties to advance their mutual interest (sharing management and profits). The partners can be individuals, non-governmental organizations, businesses and community-based organizations. Check if there are other organizations, either not-for-profit or commercial, that could partner with you in sharing the capital costs of the project. Depending on the agreement and arrangement, they could join in management (sharing or dividing responsibilities) or be passive. It is advantageous when the partners are trained and equipped in different fields, because it increases the chance of success.
- Government or public funding: This depends on the country and agricultural policies. Government grants and subsidies could be available for low-interest loans expected to boost agricultural production. Check the lists of available government grants or loans either online or at government offices in charge of such funding.

Post-evaluation questions

1. What is the difference between a loan and a grant?

2. Is competition an advantage to a fish feed business?

3. What are the advantages of branding?

4. What are barriers to entry?

5. What are the safest forms of sourcing funds?

6. What are the challenges of sourcing personal funds?

7. What is the advantage of partnership funding?

8. What is the disadvantage of partnership funding?

9. Which of the following is not considered a direct cost?
   a) seed
   b) equipment and machinery
   c) feed
   d) rent

10. Which of the following is not considered an indirect cost?
    a) seed cost
    b) overhead costs from management
    c) electricity
    d) rent

Module 6: Practical experiences of catfish breeders in Nigeria

6.1. Fish breeder A

This fish breeder embarks on exclusive catfish breeding, producing more than 12 million catfish fingerlings per year using tarpaulin hatching troughs, fiber incubation tanks and circular fry tanks.

6.1.1. Infrastructure

- A borehole with four tanks at a capacity of 5000 L for the hatchery
- One hatchery building with five hatching troughs (about 20 cm deep) made of tarpaulin with an aluminum sheet below to transmit heat from a gas stove
- Two water filters to remove all mineral solids and debris from the water
- Buckets to transport the larvae
- A small water testing kit
- 40 fiber incubation tanks (2 m^3)
- 10 circular fry tanks (30 m^3)
- 18 fingerlings ponds (700 m^2–1000 m^2)
- Several big diesel water pumps to pump water from the river into the ponds.

6.1.2. Procedures

- Treat the borehole water in the tanks to raise the pH from 6.5 to between 7.5 and 8, as eggs clog together in pH below 7.5. Use soda ash to raise the pH (28 tablespoons in 5000 L). When the eggs clog together, only the outer eggs are oxygenated and hatch. A pH of 7.5 maintains the eggs as loose individuals and produces higher hatchability.
- Make sure the two filters are working to remove the rest of the debris from the water. Eggs stick on any debris, which lowers hatchability.
- Strip about 20 females (42 kg) to get between 4 kg (cold season) and 7 kg (adequate warm season) of eggs. Expect about 300,000 fingerlings for 4 kg of eggs, and 600,000 for 7 kg.
- Spread the fertilized eggs evenly on hatching trays (spawning mat).
- Set the gas stove to an adequate flame to maintain the temperature in the hatching troughs.
- Remove the hatching trays into different hatching troughs (to continue hatching if necessary) after 24–36 hours.
- Siphon the hatched larvae into transportation buckets. Since dead eggs are lighter than larvae, stir the water to make them come up and then siphon the larvae.
- Transport the larvae to the incubation tanks and leave them there for 3 days. Do not allow water flow-through and do not disturb the water during that time.
- The water used in these tanks is pumped from the river into a buffer pond and then pumped into the larvae incubation tanks.
- After 3 days, transfer the larvae into the fry tanks. Feed them for 5 to 8 days. These fry tanks of 30 m^3 each are constructed in a circular form with the outlet in the middle. The tanks slope from the outside into the outlet and measure 0.8 m at the perimeter to 1 m in the center. A small collection point for fry is constructed at the exit.
- Transfer fry into earthen ponds. Prepare the ponds by turning the soil using hoes. A gutter is created in the middle of the pond to the exit for easy collection of fingerlings.
- Prepare and treat the ponds with 500 g of BactoSafe S into the pond water. Fill the ponds with water a day before bringing the fry. Pump the water directly from the river into each pond. If needed, add 5 mg of probiotics to 1 kg of fry feed. If water is treated with potassium permanganate, do not add the antibiotic. Add inoculation into the pond for fast growth of plankton, introduce water from a previously fertilized pond, using potassium fertilizer or NPK mixed with poultry or pig manure in a big basin before stocking the fry. Cover the ponds with a net to avoid predators.
- Introduce the fry into the pond the next morning to avoid the presence of predators. After 2 weeks, open the ponds for grading. No exchange of water is necessary during this period. At 8 days old, fry are big enough to eat the eggs of most predators and colonize the ponds.
- Stock 100,000 fingerlings in each pond (150 x 100 m^3).

- The best performers are hybrids that cross male *Heterobranchus* sp. with female *Clarias gariepinus* at a ratio of 1 male with as many as 20 females.

6.1.3. Marketing

- The fish breeder sells fingerlings weighing between 1.5 and 5 g:
  - USD 0.027 for 1.5–3 g *Clarias species*
  - USD 0.041 for for 1.5–3 g *Hetero-Clarias hybrid*
  - USD 0.08 for 5 g *Clarias species*
  - USD 0.095 for 5 g *Hetero-Clarias hybrid*.
- No publicity is used. The quality of fingerlings produced is the only marketing strategy adopted by the fish breeder. All batches of 300,000 to 600,000 fingerlings produced per cycle are sold before they reach 60 days old.

6.2. Fish breeder B

This fish breeder produces over 3 million fingerlings annually with production cycles spread out throughout the year. The breeder uses earthen ponds with concrete walls, because concrete walls solve some predator problems and also help to stabilize the water temperature. The ponds are covered with nets that have a mesh size of about one finger. Each pond produces 300,000 fingerlings. Each pond has six aerators of 45W because of the high stocking density. A big hole is at the exit of each pond for collecting fingerlings.

6.2.1. Infrastructure

- Fry grow-out station
- Earthen ponds (100 x 25 feet) with concrete walls.

6.2.2. Procedures

- The procedure for hatching is the same as it is for fish breeder A. After hatching, siphon all the larvae and transfer them into clean tanks for 3 days. Do not allow flow-through in the tanks so that the water remains undisturbed. Feed fry with decapsulated artemia in flow-through tanks for 5 days after they absorb their yoke sacs. Do not allow flow-through during the feeding period, otherwise all the decapsulated artemia will drain out of the system.
- Treat the ponds with hydrated lime the day before stocking. Wash the lime off in the morning, then net the pond, pump fresh water into the pond from the river (in addition to what comes out naturally from the ground) and then stock the ponds with fry in the evening. Feed the fry around the walls/edges of the earthen pond for the first week because all fry come to the walls at this time. Spread feed to the center during the second week. Treat the water with potassium permanganate. Common treatment rates are 2 ppm or mg/L for an indefinite pond application or 10 mg/L for a 10-minute tank treatment. Grade fingerlings after 2 weeks.
- For better performance of broodstock, always stock the males separate from the females. Stocking broodstock in the same pond causes the males to release sperm and females to absorb eggs.

6.2.3. Marketing

- The farm has 20 concrete tanks (1–2 m^3) for holding fingerlings for sale.
- Fingerlings and juveniles are sold at a rate of USD 0.027—0.095.
- The farm produces only the *Hetero-Clarias* hybrid, which grows faster, is more resistant to infection and disease and has a better FCR.

Conclusion

Catfish farming is becoming increasingly popular in Africa. The provision of high-quality catfish fingerlings and adoption of BMPs in fish farming on the continent can substantially contribute to solving the fish protein crisis, which would lead to improved nutrition.

Key terms

Term	Meaning
Algae	Photosynthetic organisms that possess photosynthetic pigments, such as chlorophyll. However, they lack true roots, stems and leaves that are characteristic of vascular plants.
Artificial breeding	A process in which some stimulants, hormones or pituitary extracts are injected into broodfish (which do not spawn in captivity) to cause them to spawn.
Better management practice (BMP)	Any program, procedural technique, method of operation, skill, measurement or device that maximizes the health and well-being of cultured species, minimizes environmental effects and promotes an efficient and economic aquaculture operation.
Biosecurity	A strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) that analyze and manage risks in the sectors of food safety, animal/fish life and health, and plant life and health, including associated environmental risks.
Broodstock/breeders	A group of mature individual fish used in aquaculture for breeding purposes.
Cost-benefit analysis (CBA)	A process by which organizations analyze decisions, systems or projects, or determine a value for intangibles.
Cost-benefit ratio (CBR)	An indicator that shows the relationship between the relative costs and benefits of a proposed project.
Dissolved oxygen	The amount of gaseous oxygen (O_2) dissolved in the water. Oxygen enters the water through direct absorption from the atmosphere, from rapid movement or as a waste product of plant photosynthesis. Dissolved oxygen levels below 5 mg/L can cause stress to aquatic life.
Feed conversion ratio (FCR)	Amount of dry feed required to grow 1 kg of fish. For example, if 2 kg of feed are required to grow 1 kg of fish, the FCR would be 2. This means that when a feed has a low FCR, it takes less feed to produce 1 kg of fish than it would if the FCR was higher. The lower the FCR, the better the feed performance and vice versa.
Fertilization	The fusion of haploid gametes, egg and sperm to form the diploid zygote. During the spawning season, the male fish seek out the nests of fish eggs that the females have laid. When they find one, they swim over the nest and fertilize the eggs with their semen. This allows conception to take place, and immediately the eggs start to become fish.
Fingerlings	Fish eggs that hatch into larvae and grow up to the size of a finger. Usually they are no more than 8 weeks old.
Fry	Freshly hatched fish no more than 4 weeks old.

Term	Meaning
Fungi	A group of living organisms that are classified in their own kingdom. This means they are not animals, plants or bacteria. Unlike bacteria, which have simple cells, fungi have complex cells, like animals and plants.
Genital papilla	A small, fleshy tube behind the anus in some fish from which sperm or eggs are released.
Gonad	A mixed gland that produces the gametes (sex cells) and sex hormones of an organism. In female fish, the reproductive cells are the egg cells, and in the males the reproductive cells are the sperm.
Gonadal maturity	Both male and female fish gonads undergo marked cyclic morphological and histological changes before reaching full maturity and becoming ripe.
Gravid	When female fish are full of eggs that are then laid and fertilized externally.
Hatchery	An indoor or outdoor structure built for fish reproduction. A hatchery provides sanctuary for fish seed production and rearing before transferring them to nursery ponds or selling them.
Hatchlings/larvae	Freshly hatched fish no more than 5 days old. Fish larvae eat smaller plankton, while fish eggs carry their own food supply. Both eggs and larvae are eaten by larger animals.
Hormone	A regulatory (chemical) substance produced in an organism and transported through tissue fluids such as blood or sap to stimulate specific cells or tissues into action. Hormones can be natural (e.g. African catfish pituitary) or synthetic (e.g. Ovaprim).
Hybridization	The mating of genetically differentiated fish species either as individuals or groups and can involve crossing individuals within a species (also known as line crossing or strain crossing) or crossing individuals between separate species.
Hypodermic syringe	A hollow needle attached to a syringe. It pierces the skin and injects substances into the bloodstream and is also used to extract liquids such as blood from the body.
Hypophyzation	The technique of breeding fish by administering pituitary gland extract through injection. It is also known as induced breeding.
Incubation of fish eggs	The maintenance of fertilized fish eggs in a body of water or in a fish breeding apparatus until the fry hatch. The fertilized eggs are incubated in a body of water (non-plant method) or in fish breeding plants (plant method).
Incubation trough	Containers used for hatching fish eggs in a hatchery.
Juveniles	Hatched fish no more than 12 weeks old. Typically, they are between 25 and 50 mm long.
Milt	The semen or sperm of a male fish.
Milt sac	Sperm sac or testis.
Optimal temperature	The temperature at which a procedure is best carried out, such as the culture of a given organism or the action of an enzyme.
Ovulation	The release of eggs from the ovary.
Parasites	Disease-causing organisms in fisheries that are of public health importance. Examples include roundworms (nematodes), flatworms or flukes (trematodes) and tapeworms (cestodes).
Pathogens	Infectious agents that cause fish disease. They are always present in an aquaculture system, but not always at sufficient levels to cause a disease.

Term	Meaning
pH	The power or potential of hydrogen ranging from 1 (highly acidic) to 14 (highly alkaline).
Physico-chemical parameters	Parameters that measure water quality, such as temperature, pH, dissolved oxygen, conductivity, salinity, Secchi disk depth, nitrate, nitrite, sulfate, chloride, total hardness, calcium and magnesium.
Pituitary gland	The major endocrine gland. It is a pea-sized body attached to the base of the brain that is important in controlling the growth, development and functioning of the other endocrine glands.
Post-juveniles	Hatched fish no more than 15 weeks old. They are also known as sub-adults.
Productivity	Total fish biomass in a production system.
Profit margin	Amount by which sales revenue exceeds costs in a business.
Prophylactic treatment	A medication or treatment designed and used to prevent a disease from occurring.
Quarantine	A state, period or place of isolation in which fish that have arrived from elsewhere or been exposed to an infectious or contagious disease are placed.
Return on investment (ROI)	A performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. To calculate ROI, divide the benefit (or return) of an investment by the cost of the investment.
Saline solution	A mixture of salt and water. A normal saline solution contains 0.9% sodium chloride (salt), which is similar to the sodium concentration in blood and tears. Saline solution is usually called normal saline.
Shooters ("jumpers")	Fish seed that usually grow at geometric rates while others grow at arithmetic rates. They constitute 18%–22% of a freshly hatched fish population.
Siphoning	To draw off or convey water by means of a tube in a hatchery operation. This can be done manually (mouth siphoning) or mechanically (pressure tube operation).
Spawning	The deposition of eggs and sperm so that they can unite.
Spermatozoa	The mature motile male sex cell of an animal by which the ovum is fertilized, typically having a compact head and one or more long flagella for swimming.
Stock	Subpopulations of a particular species of fish.
Stocking density	The number of fish kept on a given unit of area. In a monoculture pond, the stocking rate is the same as the stocking density because there is only one kind of fish.
Stripping	The process of applying moderate pressure on the flank of a spawner to release fish eggs. Distilled water is then added to the mixture of eggs and milt.
Stunted growth	Reduced growth rate. Fish of this sort constitute 18%–22% of freshly hatched fish population and should be sorted and disposed.
Water quality management	The systematic collection of physical, chemical and biological information, and the analysis, interpretation and reporting of those measurements in comparison with the expected maximum fish yield in aquaculture.
Wild/natural water bodies	Naturally occurring waterbodies, such as rivers, streams, lakes and lagoons.
Zooplankton	Microscopic animal organisms drifting in oceans, seas and bodies of freshwater.

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WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

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