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Better management practices for African catfish (*Clarias gariepinus*) spawning and fingerling production in the Democratic Republic of Congo

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Authors

Rose Komugisha Basiita and Francois Rajts

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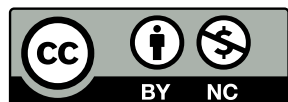
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Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia.
Email: fish@cgiar.org

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Introduction

In the Democratic Republic of Congo (DRC), there is growing demand for African catfish (*Clarias gariepinus*) as food. Currently, the country's main sources of African catfish are rivers such as the Congo River. Other sources include formal and informal fish imports from neighboring regions in Uganda, Zambia and Rwanda, as well as other countries.

Coupled with this demand is the potential to culture African catfish within the DRC. However, this potential is contingent on (1) building and equipping facilities to be able to produce seed/fingerlings and (2) farmers being able to access them in various regions throughout the country. Until recently, the DRC had hardly any catfish hatcheries nor the associated capacity to produce fingerlings. However, recent interventions by government, private sector and development partners have led to the establishment of a few hatcheries, and the building capacity for these hatcheries will contribute to the growth of the catfish industry in the DRC.

Catfish fingerling production could be successful in the DRC if proper guidelines and better management practices (BMPs) are followed. BMPs are necessary for such important aspects as broodstock feeding and handling, egg and larval rearing, fry nursing and fingerling grading, and water quality management. Wherever BMPs are not adhered to, losses in hatcheries can reach as high as 100%. The objective of this document is to provide information on BMPs to prevent certain common mistakes during commercial production. This will minimize losses, especially at the larval, fry and fingerling stages of the production cycle.



Photo credit: Rose Komugisha Basitza/WorldFish

Harvesting mature catfish to select breeders.

1. Catfish seed production

In captivity, catfish do not reproduce in a spontaneous and natural way. They require manipulation of the environment and the broodstock to mimic the conditions in their natural habitat. Because of this, commercial fry production of catfish in hatcheries can be done using either semi-artificial or artificial induced spawning methods, both of which require proper broodstock conditioning. For commercial catfish hatcheries,

artificially induced spawning is recommended, so most of this document will concentrate on this method of fingerling production. Section 2 outlines the requirements of a catfish hatchery, as the production facility, and the associated practices of broodstock handling, sexing and conditioning. Further details are provided on egg incubation, hatching and larval rearing, fry and fingerling production.



Catfish fry, 18 days old, reared in hapas in a nursery pond.

2. Catfish hatcheries

For African catfish, a controlled environment is required, and the best way to do it is by using an indoor hatchery as the production facility.

2.1. Site selection

The selection of a site for installing a hatchery should consider the following:

- Good quality water must be available in sufficient quantities. An elevated water source is advantageous because gravity can supply the water for the hatchery tanks and ponds.
- Pre-treating water from all surface sources is necessary before it enters the hatchery.
- The hatchery site should be situated above the highest flood level previously experienced in the area.
- Soil quality should allow for construction of ponds with good water retention. In case of permeable soils, then pond liners can be used.
- Ensure that there is sufficient space for broodstock and nursery ponds.
- A good road connection is required to ease access to inputs and for selling fry and fingerlings produced by the hatchery.

- A constant power supply is necessary, preferably one from a country grid line or a reliable alternative, such as solar energy.

Make sure to adapt the design of the hatchery building to the climatic conditions of the actual site. The ideal water temperature is 25°C–30°C. With this range, the latency time of breeders is fast, and embryonal and larval development happens quickly. Maintaining optimally warm temperatures minimizes stress to the larvae and reduces susceptibility to diseases. Dark cover is needed for holding breeders and rearing larvae in indoor tanks to protect the fish from direct sunlight. Breeders held in darkness are less aggressive, and larvae tend to thrive better in conditions of continuous darkness or low light intensity.

For biosecurity and sequential hatchery activities, divide the hatchery building into several parts. These include the breeder treatment area, hatching unit, fry rearing area, fry conditioning and packaging area, equipment storage, chemical storage, and a small office. Given that a dedicated and skilled hatchery attendant is required 24 hours a day, an adjacent restroom is also necessary. For the same reason, the owner or the hatchery manager should live onsite.



Photo credit: Francois Rajis

Catfish fingerlings, 35 days old, reared in a nursery pond.

2.2. Hatchery components

A typical catfish hatchery will have the following seven components:

1. a water reservoir, which can be located outside
2. a breeder area with tanks and enough space for injecting and stripping breeders
3. tanks and/or aquariums for egg incubation and larval rearing (hatching unit)
4. a biofilter for the hatching unit
5. fingerling production tanks or aquariums (fingerling production unit)
6. a biofilter for the fingerling unit
7. conditioning/holding tanks for marketing the fry/fingerlings that are produced.

2.2.1. Reservoir

The water reservoir for the hatchery can be located outside. From the reservoir, the water should flow to hatchery tanks using gravity. The outside water reservoir should have a greenhouse-type covering to maintain proper water temperature (Plates 1a and 1b). Heating the water using electrical heaters is expensive, so it is important to make sure that there is enough sunlight for places in the hatchery where it is impossible to maintain proper water temperature naturally. This can be done using an adapted roof with large windows on the south side and by shielding the outside tanks or small ponds with a greenhouse cover.



Plate 1a. A greenhouse cover on the reservoir tank provides heated water for the hatchery in Kalambo, DRC.



Plate 1b. A solar-heated broodstock pond ensures early breeding in the season.

Hatchery	Tanks	Number	Dimension (cm)	Water depth (cm)	Operational water volume (l)
Catfish	Breeder tank	2	100 x 100 x 100	40	800
	Hatching tank/aquariums	4	125 x 80 x 45	350	1400
	Biofilter hatching unit	1	270 x 80 x 70	60	1300
	Fingerling unit production tank	4	120 x 100 x 75	50	2400
	Biofilter fingerling unit	4	40 x 60 x 60	55	530
Total					6430

Note: Hatchery tanks installed at the International Center for Tropical Agriculture (IITA) Kalambo catfish hatchery. Design and material provided by Fleuren & Nooijen BV in the Netherlands.

Table 1. An example of the specifications and water volume of hatchery tanks.

2.2.2. Breeder tanks

A catfish hatchery should have designated tanks for breeders. A minimum of two or more is recommended. The tanks should have inlet and outlet piping for water exchange and for maintaining good water quality (Plate 2). When filling the tanks with water, make sure there is no more than 30–40 cm of water to prevent fish from jumping out. In addition, a net is recommended to cover the tank. Keep females and males in separate tanks to minimize aggression, especially from the males. The usual density of breeders in the tanks is three breeders per square meter for males and two for females.

2.2.3. Tanks and aquariums for egg incubation and hatching

Hatching aquariums serve to hold fertilized eggs, larvae and hatchlings (Plate 3a). Hatchery operators must make hatching trays using a wooden or plastic hollow frame that can float and then attach a 0.5 mm mesh material to the bottom of the frame (Plate 3b). This allows the eggs, when placed and spread on the tray, to be submerged in 5–10 cm of water. Material from a hapa or a mosquito net can be used as a mesh depending on availability.



Plate 2. A simple breeder tank, with inlet and outlet pipes, holding breeders at the IITA station in Kalambo.



Plate 3a. An aquarium for hatching and rearing fry for about 10 days.

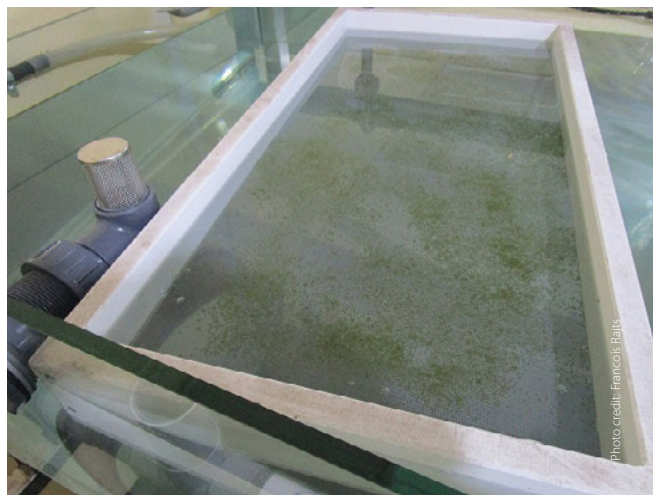


Plate 3b. Eggs incubating on a hatching tray.

3. Water quality

Mature African catfish have air-breathing organs, so they can survive and grow under extremely harsh water quality conditions. In hatcheries, however, young larvae require good water quality because they lack accessory breathing organs, which only develop at approximately 10 days after hatching. In addition, larvae and fry are stocked at very high densities, which can increase the risk of disease and water pollution. If not mitigated, these risks will lead to high mortalities, resulting in severe losses.

The major water quality parameters for hatcheries are dissolved oxygen (DO), temperature and the amount of metabolic wastes. Continuous water exchange and using a biofilter in recirculation systems are critical for managing these parameters. The amount of water exchange should ensure a DO level of at least 3 mg/l when measured at the outlet of the tank.

It is necessary to maintain an optimal temperature (25°C–29 °C) in the incubation and hatching tanks. This is important because the temperature of the water in the incubators affects the amount of time required for embryo and larval development as well as the quality and survival rate of the hatchlings. Maintaining optimal temperature conditions is vital for the following reasons:

- Low temperatures in the hatching and incubation unit result in slow development, so a longer period is necessary for larvae to reach the fry stage.
- At low temperatures, pathogens can damage eggs/larvae more easily, causing mortalities at this stage of development.
- At temperatures above 30°C, development is faster, but deformities can occur.

3.1. Improving water quality into the hatchery

3.1.1. Water supply

A hatchery's water supply can be sourced from a surface water body or underground through a borehole. A water holding and storage tank is required to ensure a continuous water supply to the hatchery. The storage tank also enables uniform water quality maintenance prior to

distributing the water to the specific sections of the hatchery. The required quality of water is shown in Table 2.

Water from a borehole or from a spring frequently contains high levels of carbon dioxide and often lacks sufficient amounts of DO. To remove carbon dioxide and increase the DO, pump the water through an aeration tower before it enters the hatchery reservoirs (Plate 4).



Plate 4. An aeration tower on the top of a hatchery reservoir.

The ideal water temperature for African catfish hatcheries is between 25°C and 30°C. Heating the water is absolutely necessary in some hatcheries, particularly where the climate is cooler due to high altitudes. In Bukavu, the average yearly air temperature is about 20°C, and the monthly temperature never exceeds 21°C. Lower water temperatures, like those recorded in Bukavu, reduce the metabolism of breeders, slows the development of embryos and larvae, and lowers the growth of hatchlings, fry, fingerlings and grow-out fish. Generally, lower temperatures result in slower growth, reduced resistance to diseases and low survival.

To increase the temperature of the water in the reservoir, use a greenhouse cover for the tank. In hatchery tanks, electric water heaters are used to adjust the temperature. It is beneficial if the roof of the hatchery is made from material that allows sunlight to penetrate the hatchery and heat the

Chemical and physical feature	Unit	Desired or allowed levels	Remark
Temperature	°C	25–30	Heating is frequently required to maintain water temperature at optimal levels.
Salinity	mg/l	100–8000	Salinity is usually not a problem except around the coastal areas.
Dissolved oxygen	mg/l	Minimum 6 in hatching tanks	A minimum of 3 mg/l is necessary in the biofilter.
pH		6.5–8.5	In the event of acidic levels, correct the pH by adding sodium bicarbonate.
Carbon dioxide	mg/l	max. 10	High CO ₂ levels are common in borehole or spring water. In this instance, pass the water through an aeration or de-gassing tower before entering the hatchery (Plate 4).
Calcium hardness	mg/l as CaCO ₃	min. 20	When the hardness is low, calcium rich elements should be included in the biofilter media, such as mollusk shells, coral chips from seashores, or limestone (CaCO ₃) chips.
Ammonia (un-ionized)	mg/l	max. 0.05	If the biofilter breaks down and there is excess ammonia, do a partial water exchange.
Nitrite	mg/l	0.2	Do a partial water exchange when nitrite levels are high.
Nitrate	mg/l	100	Do a partial water exchange when nitrate levels are high.
Iron		max. 0.5	Aeration will help settle down the iron particles, which can then be then siphoned out. This should be done in the water storage tank.
Hydrogen sulfide	mg/l	0	This is highly toxic to fish and should be avoided.

Source: modified after Boyd 1998.

Table 2. Water quality requirements of catfish hatcheries.

water. The water should be stored in an elevated reservoir. The quantity of water in the reservoir should be enough to supply the hatchery for about four hours without refilling, as security in the event of a power outage or mechanical failure.

3.2. Using biofilters

Water is typically recirculated to minimize water replacement and to maintain good water quality conditions, such as temperature and DO, which could be different from the source of the water supply. Recirculating water is also useful in places where there are insufficient quantities to maintain a constant flow through the system. Recirculation while maintaining good water quality can only be achieved through aeration and the use of a

biofilter. Biofilters remove solid particles, toxic wastes like ammonia, and nitrite. This purifies the water for reuse. A basic biofilter is comprised of a sedimentation unit for physical cleaning and for filtering media or substrate to support nitrifying bacteria.

It is important to note that water released from the incubation and larval rearing tanks in the hatchery is polluted with nitrogenous compounds. These include the metabolic wastes from egg and larval incubation, eggshells and dead eggs/larvae, faeces and the remains of uneaten feed. Cleaning the hatchery tanks of any debris should be done daily. This removes dead fish and feces, as well as excess feed at the bottom.

The sedimentation chamber is responsible for the physical cleaning of the biofilter, while the bacteria colony removes nitrogenous wastes from the water. The bacteria grow on substrate material kept in the biofilter, such as oyster shells, coral debris or a special plastic structure (Plates 5a and 5b). These are particularly useful in soft water where hardness is lower than 50 mg/l. They provide calcium, which promotes water hardness and is useful in the development of nitrifying bacteria and also for correcting the pH of water in acidic conditions (Table 2). In modern hatcheries, a floating bed biofilter is preferred because it performs better. However, it also requires continuous water circulation, so it is more viable for large and commercial hatcheries that remain in production year-round.



Plate 5a. Oyster shells are useful if the water is soft.



Plate 5b. Plastic media.

Aeration is maintained to support ammonia removal from the water by bacteria through oxidation. Nitrosomonas bacteria metabolize ammonium hydroxide in the presence of oxygen, transforming ammonia into nitrite (NO_2). The latter is highly toxic to fish. Another bacteria, Nitrobacter, transform nitrites into nitrates (NO_3). There is a danger that toxic elements can accumulate in the water if partial water exchange is not done from time to time. Make sure the level of ammonia (NH_3) does not exceed 0.05 mg/l, the level of nitrite remains below 0.2 mg/l and the nitrate level does not exceed 80 mg/l. Measure these parameters using a water quality test kit or meter at least once weekly.



Note: Nitrate (NO_3) is not toxic up to about 100 mg/l.

Since the biofilter needs oxygen for nitrifying bacteria, the water should be recirculated continuously. A few hours of continuous circulation every day is necessary to maintain the film of bacteria, even when the hatchery is not in operation. Always ensure that the DO level does not drop below 3 mg/l.

It is important to get the biofilter prior to operating a hatchery or before a production cycle, because it takes about 1 week for Nitrosomonas bacteria to develop. Growing a colony requires adding a few milliliters of ammonium hydroxide or a few grams of ammonium chloride daily, or simply some organic matter like fishmeal that give off ammonia while decomposing. The amount ammonia added daily should be about 3 mg/l for about 10 days. The daily amount added should ensure that no ammonia is detectable in the system the next day. This will signal the readiness of the biofiltration system for hatchery operations to begin.

Developing a Nitrobacter colony takes about 1 month, so it is necessary to develop the nitrification bacteria colonies before beginning induced breeding. The fry will die from ammonia/nitrite intoxication or pathogen bacteria if the biofilter is not properly set up and managed.

4. Biosecurity

Biosecurity entails practices that (1) minimize the risk of introducing and spreading infectious agents to other fish within the hatchery and (2) reduce the risk of diseased fish or infectious agents leaving the hatchery and spreading out to other sites.

As part of these practices, it is important that the entrance to the hatchery has a footbath and a hand washing station to prevent pathogens from either getting into or out of the hatchery via individuals coming or going. The footbath should be filled with a disinfectant solution, which should be changed often.

Before each production cycle, disinfect all surfaces to reduce any chance of fungal and other infections that can result in mass mortalities as a result of pathogens from a previous cycle. Use a commercially available bleaching agent (such as Chlorox) for households to disinfect the equipment, tanks and floor. To make the disinfecting solution, add 100 ml of Chlorox per liter of water.

In addition to these practices, it is necessary to pay extra attention to factors that pose a risk at different stages of incubation, larval rearing and nursing in the hatchery, including the following:

- Check the incoming water quality into and within the hatchery tanks for DO, pH, temperature, ammonia, etc. It is important to assess and monitor these parameters on a regular basis.
- Check the quality of inputs, especially feeds. Check that the size of feed is proportionate to the size of the larvae and fry. This will avoid large feed particles, which the fish cannot ingest, from remaining uneaten and polluting the water. Check also the expiry date of the feed. Never feed fish expired feed or feed with mold.
- Ensure that only healthy broodfish free of parasites, deformities and disease are brought into the hatchery.
- Check new broodstock sourced from other farms beforehand, and quarantine them to avoid mixing them with the on-farm stocks until it is confirmed that the new broodstock are healthy and free of disease.
- Disinfect equipment, such as nets and scoops used for fish eggs, larval and fish handling, because these come into direct contact with the fish. Make sure each compartment has its own equipment and materials. In the absence of enough equipment for every compartment, disinfect equipment between facilities (ponds and tanks) and also in the different sections of the hatchery to avoid cross-contamination and disease transfer.
- Disinfect vehicles accessing the farm. Use wheel dips at the farm entrance to disinfect the tires. This is critical because the cars could have accessed other farms, feed companies, etc.
- Ensure employees follow proper hygiene practices within the hatchery, and keep a record of visitors. All visitors and workers should disinfect their shoes and wash their hands to minimize the transfer of pathogens from one section of the farm to the other. Hatchery operators must wash their hands regularly, especially those that handle the fish directly at different stages.
- Handle dead fish on the farm properly. Some fish mortalities could arise from disease, so if carcasses are not handled well they will become contagious to the other fish.
- Effluent water from the hatchery should not be discharged directly to natural open-water bodies such as rivers and lakes. Effluent treatment is recommended prior to discharge into the natural water systems.

5. Broodstock ponds

Broodstock ponds should have both an inlet and outlet to allow for adequate water exchange. Broodstock conditioning is usually done in large ponds measuring 200–1000 m³ to ensure that the fish have enough space to allow for proper feeding, uniform growth and gonad development. In the absence of large ponds, multiple smaller ponds, at least 100 m² in size, can serve the same purpose. Pond bottoms should be soft and smooth to prevent fish from bruising their bellies. Ponds should also have enough sunlight and wind, so do not grow trees too close to the ponds. Fencing is required around the broodstock pond to prevent the fish from leaving the pond when it rains, particularly during breeding seasons.

5.1. Pond preparation and stocking broodfish

It is recommended that a catfish fingerling producer develops batches of broodfish that are stocked and kept in several ponds or tanks for sustainable production. Label the ponds and keep a record of the number and weight of females and males.

When preparing to stock a pond with a new batch of fish, drain and clean the broodstock pond properly. After draining the pond, line the

wet pond bottom with hydrated lime Ca(OH)₂ at 50–200 g/m² to kill all fish and other aquatic organisms that remain in holes or depressions from the previous stock. Lime used in powdered form works for best distributing it across the pond. For operators, take care when spreading the lime on the pond bottom to ensure that the wind blows from behind (Plate 6). Wear a mask to minimize or avoid any health hazards associated with inhaling lime dust. Gloves will also ensure that the operator's hands are protected.

Begin filling the pond a few days after drying the pond bottom. Firmly secure the inlet and outlet pipes with a net mesh “filter” to prevent stray fish from entering the pond and broodstock from escaping through the outlet (Plate 7).

Maintain the water depth at an average of 1–1.5 m so that fish do not unnecessarily expend energy swimming up from a great depth to feed. On the other hand, the pond should not be too shallow such that fish are exposed to predatory birds. To ensure good gonadal development, stocking densities should not exceed 0.2 kg of biomass per cubic of water.



Plate 6. Liming the pond bottom.



Plate 7. Filtering bag at the pond inlet.

6. Broodstock feeds and feeding fish

Feed should be stored on palletes in a dry, cool room. The quality of commercial feed is generally guaranteed for 2 months after it is made, though some feed companies might guarantee up to 6 months. Beyond this period, the feed can become rancid and begin to lose vital nutrients like vitamins. Never feed rotten or moldy pellets to broodfish.

Broodstock particularly require high quality feed, preferably 4–6 mm pellets depending on the size of the fish. Since catfish are generally bottom feeders, a nutritionally complete, slow sinking feed could be of better benefit than a purely floating feed. This would also save energy spent from swimming when feeding. Catfish are omnivorous and prefer food of animal origin, so under pond

culture they require feed with a high protein content (35%–40%), especially when the fish are stocked at a high density. Be sure to feed the fish an amount equivalent to at least 1%–2% of their weight, divided into two feedings per day. It is recommended to feed catfish at about 10:00 and 16:00 daily, when the water is warm.

When using feed that is high in protein, excess blooming of phytoplankton can frequently occur in ponds. Although catfish are omnivorous, they do not eat phytoplankton. Stocking tilapia with catfish can reduce algal bloom. Tilapia can survive and grow only on plankton, so they can be stocked in large-meshed cages without having to feed them, thus providing an additional crop.



High quality pellets for broodfish.

7. Selecting and sexing broodfish

Producing quality fingerlings starts with healthy broodfish, so it is important to select sexually mature and healthy fish with no deformities. Stop feeding breeders a day prior to selection. Mature catfish show sexual dimorphism where males can be clearly differentiated from females (Plate 8). Mature broodfish are then conditioned through proper feeding from this pool of conditioned fish, from which gravid females ready to spawn and running males are selected. Readiness for breeding

is indicated by a swollen belly and reddish or pink genital papilla. Male fish are killed to extract the testes during hatchery operations. The pituitary from the dead males can also be removed and secured for induction (Plate 9a), so it is necessary to recruit males frequently to build up male stocks. Females are stripped of eggs and unlike males, which are killed at each breeding time, can be used several times for 3–5 years.

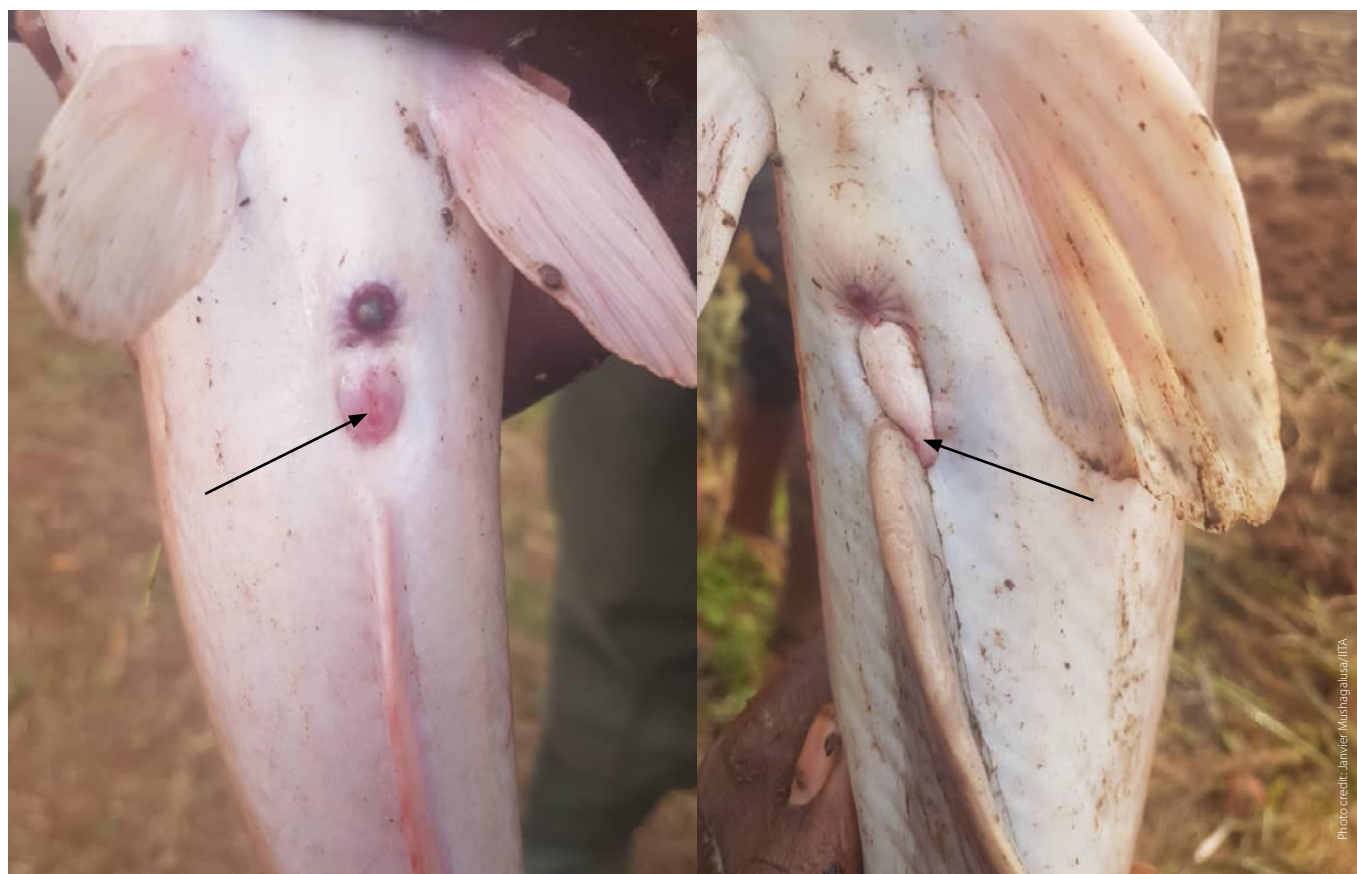


Plate 8. Rounded opening of females (left). The nipple-like and elongated papilla of male broodfish (right).

8. Preparing fish for spawning

Gravid females and running males are selected from mature broodfish conditioned through proper feeding. The conditioning process is considered successful when both males and females are “running.” Readiness for breeding is indicated by a swollen belly and reddish or pink genital papilla. A gravid female will release greenish-yellow eggs when gentle pressure is applied on the underbelly from the pectoral fins toward the gonadal papilla. Using a small tube inserted into the ovaries, a sample of the eggs can be taken to check if the nucleus has migrated to the side and if the eggs have reached a diameter of at least 1 mm.

8.1. Recordkeeping

It is important to record all data on the weights of females and to take water temperature readings in the hatchery tanks at intervals. The weight data is useful to calculate the appropriate dose of hormone required for successful induction. Regular temperature records are also used to calculate the latency time in relation to temperature. Keep records for every spawning attempt that will help calculate the latency period, spawning, fertilization and hatching success and time. This data can be used in future operations.

Weigh gravid females (breeders) to estimate the number of eggs each one carries (Table 1). From industry practice, the weight of the eggs should be 5%–15% of the weight of a gravid female fish. A 1 kg female catfish carries about 50–150 g of eggs. One gram contains approximately 700 eggs, so a gravid female African catfish weighing 1000 g could have 35,000–105,000 eggs. It is important to collect for every spawning event. Over time, this generates the average fish performance for a particular hatchery.

8.2. Induced spawning and hormone preparation

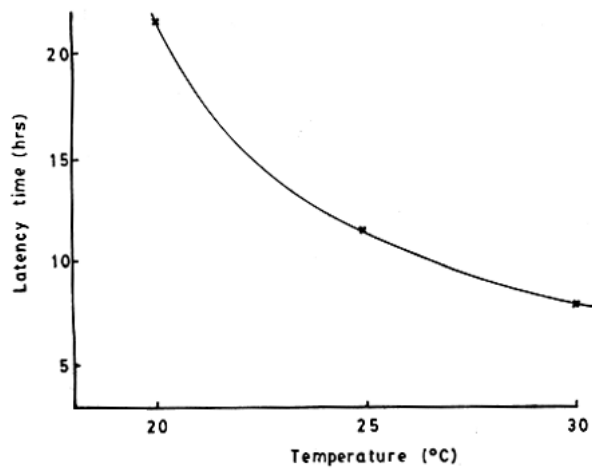
To induce African catfish to spawn, administer either a Gonadotropin releasing hormone (GnRH) by itself or in combination with a dopamine antagonist. In addition to the prevailing water conditions, such as temperature (Figure 1), the choice of hormone will affect the latency period, mass of eggs, ovulation rate, fertilization percentage, hatching rate and survival rate. Pituitary extract or a synthetic option, such as ovaprim, can be also used. Pituitary extract can either be obtained fresh or as dried/stored pituitary from other sexually matured fish, such as catfish, common carp or tilapia.

Breeders		Hormone administration: May 28				Stripping: May 29				Hatched: May 30		
Sex	Weight (g)	Time	Type	Dose	Total dose	Time hours, min	Latency period hours	Eggs		Fertilization	Time hours	Number of larvae
				ml/kg	ml			Weight (g)	Number	(%)		
♀	300	17.45	Ovaprim	0.5	0.15	8 h 40 s	14 h 55 s	10	6000	80	8 h 30 s	4800
♀	500	17.50	Ovaprim	0.5	0.25	8 h 45 s	14 h 55 s	20	12,000	75	8 h 30 s	9000
♀	650	17.55	Ovaprim	0.5	0.325	8 h 55 s	15 h 00 s	50	30,000	80	9 h 00 s	24,000
♂	900	18.10	Ovaprim	0.25	0.23							
♂	800	18.15	Ovaprim	0.25	0.2							
									48,000			83,000

Note: Average temperature 23.75°C.

Source: modified from WorldFish/IITA report 2019.

Table 1. A sample of records taken during a spawning exercise at the hatchery in Kalambo, DRC.



Source: Jansen 1985.

Figure 1. Decrease in latency time of African catfish injected with pituitary gland solution (4 mg/kg of weight) in relation to increasing water temperature.

To obtain fresh pituitary, knock the fish out with a single blow on the head, without smashing it, or use an anesthetic like MS222, Clove oil or Clove solution. Separate the lower jaw from the upper jaw. Wash the blood off the skull and then access the pituitary gland from the ventral side of the open skull, taking care not to crush it. Remove the pituitary gland carefully (Plate 9a).

8.2.1. Preserving the pituitary gland

Keep the extracted gland in acetone or 95% ethanol for 12 hours. After this period, change the solution to a fresh one to further remove moisture and oil from the gland. Place the dry gland on a tissue paper to allow for the ethanol or acetone to evaporate. For prolonged preservation, keep the dry pituitary gland in a desiccator for a few days to fully remove any traces of water or moisture, and then keep it in an airtight container to prevent any mold from forming. Group the glands by size and record and label them accordingly so that the appropriate gland size is used at the time of induction.

8.2.2. Preparing the pituitary solution and induction

Crush the gland (Plate 9b) and add a saline solution to it. The size of the crushed gland should also be selected in relation to the size of the female fish that is going to be induced. For example, if the gland weighs 2 mg and the dose required is 10 mg for a 2.5 kg female catfish, then five glands weighing 2 mg will be needed to make up the required dose for induction.



Plate 9a. Pituitary gland from a donor catfish.



Plate 9b. Pituitary gland crushed in a pestle.

For a fresh pituitary from a fellow catfish, the ratio of the weight of the female to the weight of the pituitary donor is usually 1:1. To induce ripening, inject the pituitary solution into the muscle of the female or in the body cavity at the base of pelvic fins (Plate 10a). Intra-peritoneal injection is easier, but take care to ensure the needle does not penetrate too deep to avoid damaging the internal organs. Intramuscular injection is safer, but the solution frequently flows out of the fish.

8.3. Stripping

Gently press the belly of the female (Plate 10b) to slowly release the ripe eggs into a bowl. Next, mix the eggs with milt from the male to fertilize the eggs. The duration between injection of the pituitary extract and stripping depends on the temperature. For example, injecting 6 mg/kg of pituitary extract at 25°C could provide good results in 17 hours. Stripping too soon will result in a very dry egg mass that is too difficult to strip completely, while stripping late will result in the fish spilling too many of her eggs in the holding tanks. Some trial and error might be needed to determine the suitable waiting period for each local environment. Introducing a male into the tank could help to indicate the readiness of the female to spawn. Once the appropriate waiting time is attained, hold the female with a blanket/towel wrapped around the head. Press the belly gently over a bowl to discharge and collect the eggs.

8.4. Egg fertilization

It is recommended to extract the milt from the male prior to stripping the female. Kill and then cut the male open to access and extract the milt sac, and then cut open the testes to release the sperm. The cut testis can also be put in a clean cloth and the milt gently squeezed out. Add a saline solution (0.65%–9%) to the milt and testes, and keep the solution under cool temperatures (preferably in the refrigerator) in preparation for fertilization. Once the eggs are stripped and collected in the bowl, pour the prepared milt solution onto the stripped eggs. Mix gently but thoroughly, and add fresh clean water to make the sperm active and to initiate/trigger external fertilization.



Plate 10a. Hormone injection carefully administered at the base of the pelvic fin.



Plate 10b. Stripping catfish eggs.

8.5. Egg incubation

Less than 1 minute after fertilization, quickly spread the fertilized eggs on 1 mm mesh net trays suspended in the incubation tanks or aquariums. If this process is delayed, the eggs tend to cluster together in sticky patches, which will result in death. Good quality fertilized eggs that develop properly are greenish-brown in color (Plates 11a and 11b). Immediately remove any dead eggs that look white (Plate 11b). If most of the eggs turn white, the batch has to be discarded. Incubation happens in a slow-moving stream of water (1–3 l per min). The hatchlings appear as small strings with an attached yolk sac (Plate 12). Hatchlings tend to swim and cluster around the dark corners of the trough.



Plate 11a. Eggs are spread and kept on floating trays for incubation in a shallow circular incubation nursing tank.

8.6. Larval rearing

8.6.1. Yolk sac stage

When catfish larvae hatch, the eggshells, unhatched eggs, dead larvae and other debris get deposited and trapped on the bottom of the hatching tray. Normally, only the hatchlings will go through the mesh to the bottom of the tank. If some debris escapes through the tray, remove it gently using a siphon, without agitating and stressing the hatchlings.

8.6.2. Feeding larvae

Upon hatching, larvae carry their yolk sac with them and derive all their nutrition from it for the first 2–3 days after hatching. Once the yolk sac is

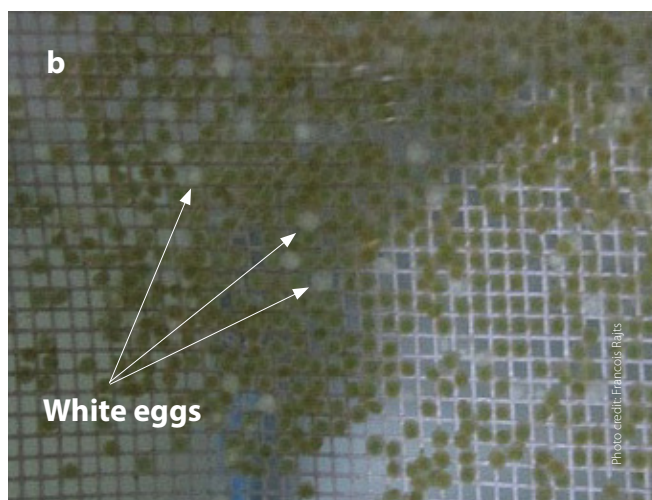


Plate 11b. Fertilization rate is close to 100%. The arrows point to the few white eggs, which have not been fertilized.



Plate 12. Advanced catfish hatchlings at the bottom of the tank.



Plate 13. Newly hatched catfish larvae in a drop of water.

reabsorbed, the larvae must find external sources of nutrition. If feed is not provided, the larvae will begin to cannibalize each other. During this phase, 4–6 days after hatching, catfish prefer live, highly nutritious food. The most common are artemia nauplii, rotifers and moina. Instead of hatching the artemia cysts, some hatcheries decapsulate the cysts and then feed them directly to the larvae. Since artemia are not produced in Africa, they must be sourced from input aquaculture suppliers in the region that import them directly from Asia, America and Europe.

Add formulated dry feed in small amounts together with live feed and gradually increase it until the 10th day after hatching. Then continue feeding using only dry feed. Artemia nauplii or decapsulated artemia cysts are widely used during the first 10 days after hatching.

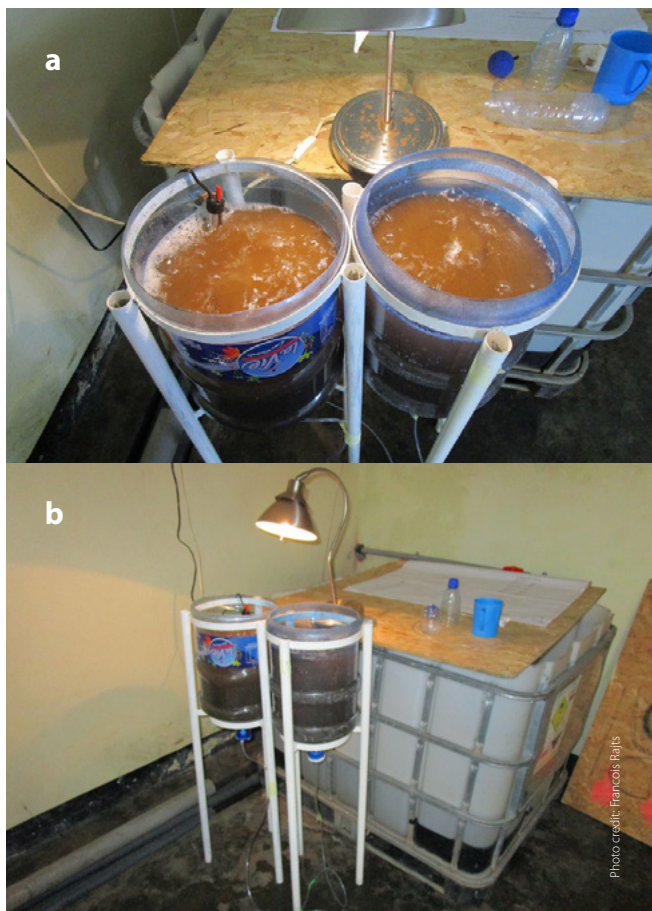
Artemia cysts can be easily hatched on-farm using a hatching unit designed for artemia (Plates 15a and 15b). At least three artemia incubators are required to ensure daily availability of fresh nauplii.

The incubation jars are fitted with light bulbs (Plate 15b), because without light the artemia cysts will not hatch.

Rotifers, cladocerans and copepods are just as good as artemia for feeding catfish fry in the early stages of development. Zooplankton can also easily be produced and fed, either live or frozen, to catfish fry. Feeding frozen zooplankton is preferred because it makes dosing simple, and they are regarded as safe and free of contamination from pathogens or parasites.



Plate 14. A tin of artemia cysts.



Plates 15a and 15b. Locally made artemia incubators made from drinking water bottles.



Plates 15c and 15d. Harvesting artemia nauplii by siphoning (top). Filtering Artemia nauplii for feeding catfish fry (bottom).

Administer live feed frequently, up to 6 times a day in small quantities, which should be consumed within 10 to 15 minutes (Plate 16b). When feeding, temporarily stop the water flow and resume it after each feeding. In addition to live feed, add formulated dry feed beginning on the fourth day and gradually increase it until the 10th day, after which continue feeding using only dry feed. Good quality formulated starter feeds should be used during the weaning phase of larvae. The feed must

be high in protein and have a fine texture, with a particle size less than 0.5 mm (Plate 17) to suit the small mouths of catfish larvae and for both digestibility and nutrition requirements at this stage. These feeds are currently produced by several commercial feed companies. They include Gemma wean manufactured in France by Skretting, Rannan super starter feeds manufactured by an Israel company, and the Koudjis starter feeds for catfish fry and fingerlings, among other feeds.

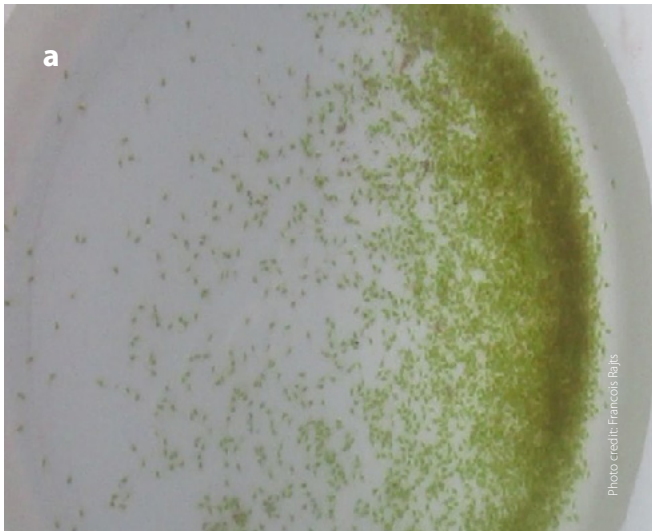


Plate 16a. Newly hatched catfish larvae.



Plate 16b. Feeding artemia to catfish fry.

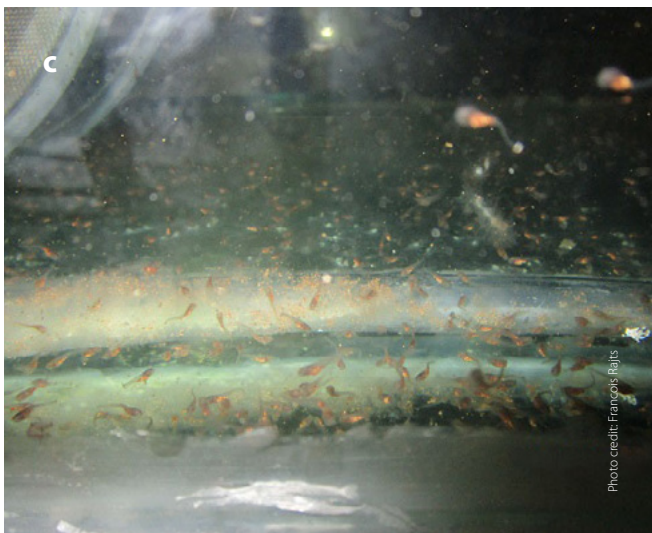


Plate 16c. Hatched larvae fed with artemia. Orange bellies show the injected live feed.



Plate 16d. Cleaning aquarium sieves.

If using hatching aquariums, transfer the fish after 10 days to the nursing tanks. This allows more space for good water quality and more intensified feeding.



Plate 17. Starter and fry feed in airtight containers. Larval fine powder under 0.5 mm (left) and fry feed 0.5–1.5 mm (right).

8.7. Nursing catfish fry

A key constraint in catfish fingerling production is the low survival rate in hatchery and nursing ponds. The high mortality rates of fry are caused by starvation, cannibalism, disease and predation. Nursing fry properly and using an acceptable feed for larvae and fry during this critical period are the most important factors affecting the survival of catfish fry.

After hatching, transfer the fish into nursing tanks 10 days later (Plate 18a) or into hapas after 14 days. If using earthen ponds for nursing, apply lime to the wet pond bottom at 200 g/m² for clay and acidic soils. Sandy soils require much less lime. Put a screen over the inlet pipe, then fill the nursery pond with water and fertilize the pond. Stock fish into the newly filled nursing ponds no more than 5 days later to avoid the accumulation of predator insects, which prey on the fry and can lead to very low fry and fingerling survival rates. Using hapas set in ponds for nursing will also be helpful in minimizing possible predation when larvae are directly stocked into open ponds.

The stocking density in these ponds/tanks depends on the age of the fish and the intensity of the management protocol deployed. Typically, however, it ranges from 60 to 2000 fish/m³. In highly

regulated indoor nursing tanks, high densities of fish are maintained (5000–15,000 fry per cubic meter), and these require daily water exchange and good quality feed to provide all the required nutrients. During this phase, the feed should contain about 50% crude protein to attain fast growth and high survival in the absence of natural food. Clean the nursing tanks daily to remove any excess feed and debris at the bottom. Aeration is also required, especially at high stocking densities.

Although most hatcheries nurse fingerlings to 1 g average weight to stock in grow-out ponds, raising them to 5 g will ensure higher survival rates in grow-out systems. Grade fry and fingerlings frequently to ensure uniform size and to reduce cannibalism (Plate 18b). Hatcheries should make sure to supply healthy and uniform fingerlings to grow-out farmers.



Plate 18a. Fry in an indoor nursing tank.



Plate 18b. Grading catfish fingerlings using a wooden grader.

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