AQUACULTURE EXTENSION MANUAL NO. 75 JULY 2024

Breeding, Seed Production, and Culture of AFRICAN CATFISH *Clarias gariepinus*

Josefa D. Tan-Fermin, Jebrham C. Navarro, Gemma N. Arnaldo, Rheniel Dayrit

Southeast Asian Fisheries Development Center
AQUACULTURE DEPARTMENT
Tigbauan 5021, Iloilo, Philippines
www.seafdec.org.ph

Aquaculture Extension Manual No. 75
July 2024

Breeding, Seed Production, and Culture of African Catfish *Clarias gariepinus*

Josefa D. Tan-Fermin
Jebrham C. Navarro
Gemma N. Arnaldo
Rheniel Dayrit

Southeast Asian Fisheries Development Center
AQUACULTURE DEPARTMENT
Tigbauan 5021, Iloilo, Philippines
www.seafdec.org.ph

Breeding, Seed Production, and Culture of African Catfish *Clarias gariepinus*

JULY 2024

ISSN 0115-5369

Published and printed by:

Southeast Asian Fisheries Development Center
Aquaculture Department

Cover design by Rex Delsar B. Dianala

Layout by Rossea H. Ledesma

For comments and inquiries:

Training and Information Division
SEAFDEC Aquaculture Department
Tigbauan 5021, Iloilo, Philippines

(63-33) 330 7030
(63-33) 330 7031
devcom@seafdec.org.ph, aqdchief@seafdec.org.ph
www.seafdec.org.ph

SEAFDEC Aquaculture Department Library Cataloging-in-Publication Data

Tan-Fermin, Josefa D.

Breeding, seed production, and culture of African catfish *Clarias gariepinus* / Josefa D. Tan-Fermin, Jebrham C. Navarro, Gemma N. Arnaldo, Rheniel Dayrit. Tigbauan, Iloilo, Philippines : Aquaculture Dept., Southeast Asian Fisheries Development Center, 2024, ©2024.

42 pages : color illustrations. -- (Aquaculture extension manual, 0115-5369 ; no. 75).

Includes bibliographical references.

1. *Clarias gariepinus* -- Breeding -- Handbooks, manuals, etc. 2. Clarias gariepinus -- Cultures and culture media -- Handbooks, manuals, etc. 3. Clarias gariepinus -- Diseases -- Control -- Handbooks, manuals, etc. I. Navarro, Jebrham C. II. Arnaldo, Gemma N. III. Dayrit, Rheniel. IV. SEAFDEC. Aquaculture Department. V. Title.

SH 167 .C35 T36 2024 MGO2024-01

Foreword

SEAFDEC/AQD has long implemented research and verification studies on the propagation and culture of catfish. Early efforts focused on developing breeding and seed production technologies and promotion of culture of the native Asian catfish, *Clarias macrocephalus*. It was in 1989 when the first induced spawning of wild broodstock was achieved, and the life cycle of the native species was completed in the next year. Thereafter, breeding and hatchery techniques, along with diets for different life stages, were formulated. From these research findings, manuals were also published in 2008 to promote the culture of the native species.

However, sourcing broodstock of the Asian catfish in the Philippines has progressively become more difficult and, despite efforts to promote its culture, farmers preferred the larger and faster growing African catfish, *Clarias gariepinus*. At present, practically all farmers have adopted the exotic species which has become a significant freshwater industry.

As part of efforts to boost local aquaculture production during the COVID-19 pandemic, SEAFDEC/AQD organized an onsite training course for fish farmers in the town of Zarraga, Iloilo in 2020. During discussions, problem areas among African catfish farmers were identified. This led SEAFDEC/AQD to conduct a series of farm surveys that lasted until 2021.

While the surveys successfully documented the different culture practices in Iloilo, they also uncovered gaps in knowledge and skills among farmers. The lack of science-based information was determined to be causing the low production and other problems the farmers were experiencing.

This manual documents the best practices of African catfish farmers in Iloilo as an outcome of the surveys done in 2020–2021. Where necessary, the procedures have been modified based on scientific literature and the experience of SEAFDEC/AQD with the Asian catfish.

While it is hoped that this manual would serve to improve the livelihood of farmers, SEAFDEC/AQD also reiterates that propagation of African catfish should be done responsibly in captive conditions to prevent the further entry of this exotic species in natural freshwater bodies.

DAN D. BALIAO
Chief, SEAFDEC/AQD

About the Manual

This manual summarizes the existing techniques on the induced breeding, seed production, and culture of the African catfish based on surveys done from 2020 to 2021 in Iloilo, Philippines.

SEAFDEC Aquaculture Department will present a standardized way of breeding and culturing the African catfish under captive conditions, but will not encourage growing them in natural freshwater habitats. Previous data have shown that their presence in lakes adversely affected the population of other indigenous species and may lead to a loss of biodiversity.

Contents

1 Introduction

Catfishes get their name from their long sensory organs called barbels near their mouths which resemble the whiskers of a cat. Generally, they are found in freshwater habitats. They are scaleless fishes that have elongated bodies, and some are capable of breathing air with the help of their suprabranchial organs. Catfishes are economically important fishes. Several species mostly from Families Ictaluridae, Pangasidae, Siluridae, and Clariidae are cultured for food production.

In the Philippines, the population of an endemic catfish, *Clarias macrocephalus*, started to dwindle in the latter 1900s due to pesticide poisoning from rice fields, habitat loss, and overfishing, which led farmers to try culturing another endemic species, the *C. batrachus*. However, its tough and rubbery meat, as well as its unstable supply of seed for grow-out operations further led farmers to try an introduced catfish species, the African catfish *Clarias gariepinus*. The African catfish, *C. gariepinus*, as the name goes, originated from Africa where it is naturally found in most of the continent except in the central and northwestern areas. The African catfish was first introduced to the Philippines in 1985 from Taiwan. Due to its fast growth rates, larger size, hardiness, and disease resistance, it has become an important aquaculture commodity, and was introduced to many countries outside Africa, including the whole of Southeast Asia.

Farmers were successful in culturing *C. gariepinus* as it grew faster and larger than the native species. In 2023, annual production of catfish has tripled since 2017 (**Figure 1**).To date, *C. gariepinus* can be found in almost all regions in the Philippines, with Region III (Central Luzon), Bangsamoro Autonomous Region in Muslim Mindanao, Region XI (Davao) and Region VI (Western Visayas) producing most of the African catfish which totalled 12,338.82 MT in 2023 (**Figure 2**).

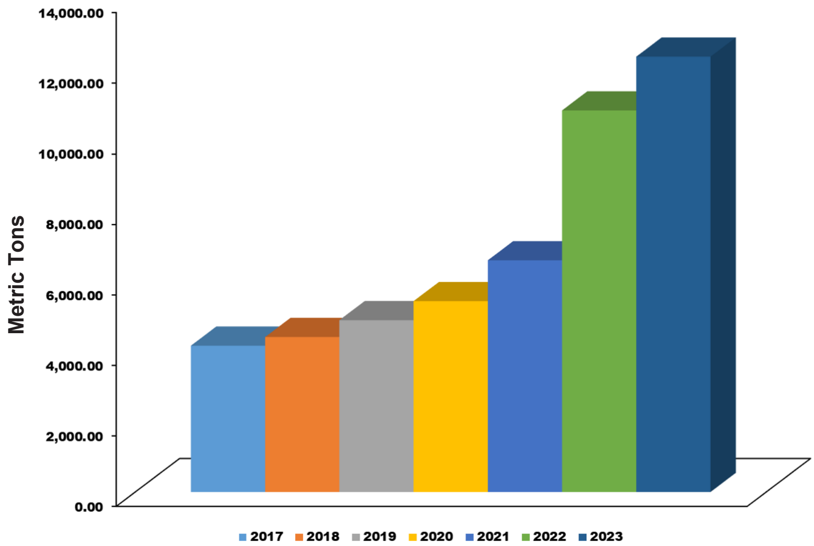

Figure 1. Annual production of catfish in the Philippines from 2017 to 2023 (PSA OpenSTAT, n.d.)

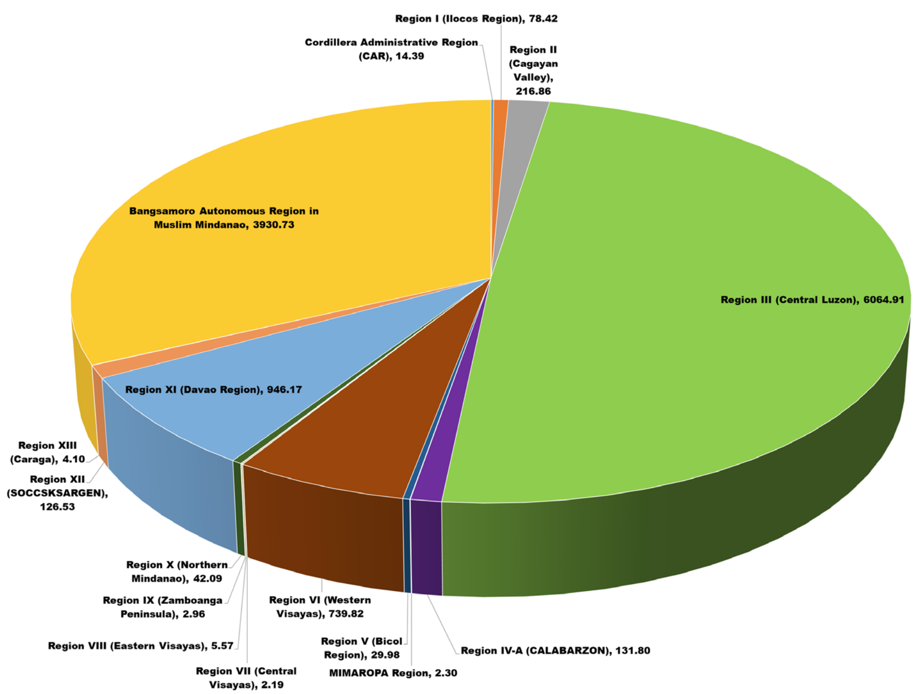

Figure 2. 2023 Aquaculture production of African catfish in the Philippines in metric tons (PSA OpenSTAT, n.d.)

2 *Biology*

The African catfish has an elongated cylindrical body that is wide at the head and tapers towards the tail (**Figure 3**). It has a large flat bony head with small eyes and the occipital process of its head is narrow and angular (**Figure 4**) compared to the rounded occipital process of *C. macrocephalus*. The pectoral fins of the catfish have spines that are large and robust enabling the fish to "walk" on land. Catfishes have four pairs of unbranched barbels which they use for hunting. An accessory respiratory organ known as the suprabranchial organ enables these fishes to breathe atmospheric air and survive on land for days.

Figure 3. An African catfish *C. gariepinus* (Burchell, 1822)

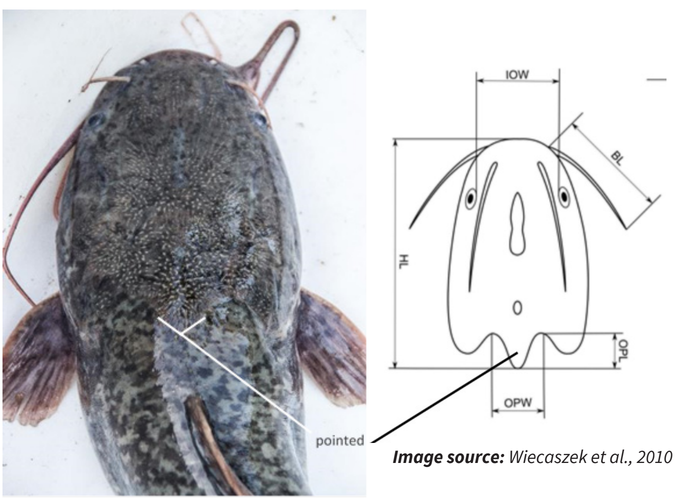

Image source: *Wiecaszek et al., 2010*

Figure 4. The pointed occipital process of the African catfish *C. gariepinus* (Burchell, 1822)

The coloration of the African catfish is light brown to greyish-black. The scaleless skin is usually marbled with shades ranging from olive green to grey (**Figure 4**). The underside of the catfish is usually white in color. African catfishes are omnivorous. The diet of the larvae and the adult in the wild consists of crustaceans, small fishes, worms, aquatic plants, worms, etc. They are also known to feed on terrestrial plants and animals that might have fallen on the water. They mostly feed at night.

Sexes are separate in African catfish and can be determined by examining the ventral side (underside) of the fish. It is male if a fleshy and elongated protrusion called urogenital papilla is present, and female if the papilla is absent (**Figure 5**).

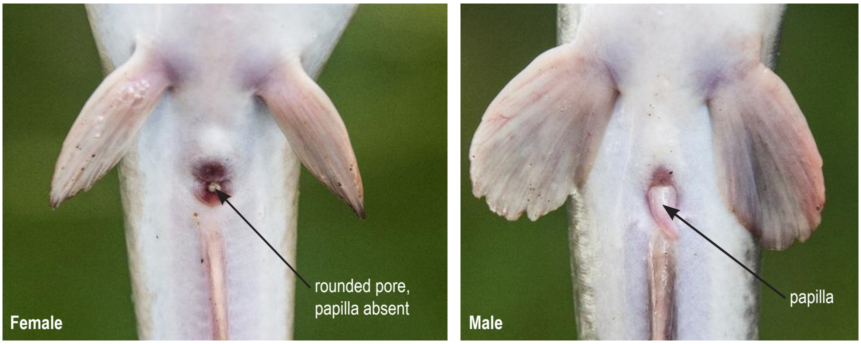

Figure 5. A female (left) and male (right) African catfish side by side. Notice that the male has an elongated structure called urogenital papilla but it is absent in females

The maturation of the gonads is largely influenced by size and age. In captivity, male and female African catfish reach sexual maturity at about 12 months old with body weights ranging from 400 to 700 g for males and 700 to 800 g for females. Under natural conditions, rainy season signals the start of spawning in catfishes.

3 Broodstock Development and Management

Source

To minimize the expression of undesirable traits in the offsprings, it is recommended to use male and female broodstock from different batches and from different places to minimize inbreeding.

Transport

Broodstock can be transported in any container made of expanded polystyrene foam (*e.g.* Styrofoam), plastic, metal, etc. The container is filled with either pond or river water just enough to cover the fish. Aeration is not provided since the catfish can utilize atmospheric oxygen due to its suprabranchial organ. Upon arrival at the site, the containers where the fishes are held are made to float on the ponds to acclimatize the fishes to the site temperature and the fishes are slowly released. Broodstock can be placed in tanks or ponds with a muddy bottom.

Feeding

The African catfish is an omnivore. In the wild, their diet consists of crustaceans, small fishes, worms, aquatic plants, etc. SEAFDEC has formulated a broodstock diet for *Clarias* sp. (**Table 1**) that can replace trash fish when fed at 3 % of the body weight.

Commercial feeds are also available but farmers should consider trying different brands to determine which will give the best yield.

Broodstock Management

Broodstock obtained from fish farms are stocked in earthen ponds at a stocking density of 0.5 to 1 per m^2. They must be fed regularly. Although some catfish mature after 6 to 8 months with regular feeding, it is preferred to use African catfish breeders that are 1 year of age to have a sustainable breeding program in the coming years.

Table 1. Composition of SEAFDEC formulated broodstock diet for catfish*

Ingredient	Composition (%)
Fish meal	15.00
Defatted soybean meal	35.00
Meat and bone meal**	22.40
Copra meal	3.44
Cornstarch	2.00
Soybean oil	3.00
Vitamin mix***	3.55
Rice bran	15.61
Total	**100.00**

*Estimated nutrient content (dry matter basis): crude protein 35–37 %, crude fat 9–10 %, crude fiber 4–5 %, crude ash 14–15 %, and nitrogen-free extract or digestible carbohydrate 30–32 %

**Not available in the market. Substitute the level with other ingredients available in the area. A suggestion is a 1:1:1 ratio of cracked corn, snail meal, and crab meal (or dried trash fish)

***Commercially available

4 *Breeding*

Under captive conditions, catfishes cannot breed naturally. Artificial propagation of catfish involves the administration of hormones. Upon reaching sexual maturity, an adult female catfish contains large oocytes in its ovaries but needs the administration of hormones to develop fully and be released as eggs from the body of the female catfish. Hormones used to induce spawning may either cause the release of gonadotropin, a hormone found in the pituitary gland and responsible for the maturation and release of eggs, or block the effects of dopamine that inhibits the release of gonadotropin. Gonadotropins are given by injecting the fish with crude pituitary gland extracts or its synthetic form called human chorionic gonadotropin (hCG) which is readily available in the market. Some companies incorporate a synthetic hormone that stimulates the release of gonadotropin such as the luteinizing hormone releasing hormone (LHRH) plus a dopamine antagonist that blocks the effects of dopamine such as pimozide or domperidone. Ovaprim and Ovatide incorporate LHRH and domperidone, and are available in the market.

In choosing breeders to be used in artificial breeding, it is preferable to use fish that weigh 0.5 to 1.0 kg and are at least 9 months to one year old. Farmers must choose larger females with bigger abdomens and males with whitish urogenital papillae. In the Philippines, artificial reproduction can be done at the onset of the rainy season in May or June.

Induced Spawning

Fish Stocking

The ponds are drained early in the morning, and catfish broodstock are obtained at a ratio of 2 males to 5 females and stocked in separate tanks covered with nets.

Hormone Preparation

It is important that farmers must know how to prepare hormones properly. If a farm operator chooses to use catfish pituitary glands (PG) for artificial reproduction, they must also know how to dissect the head of a catfish and take out the PG. PG from other species of catfish or other fishes can also be used, provided the fish is also mature so it contains a high level of gonadotropin. The total body weight (BW) of each female catfish to be injected with the hormones must be determined. If spawning did not occur, the error is most likely in the hormone preparation.

The success of induced spawning depends on the optimum dosage of hormones used and the latency period, the interval between injection and stripping of the female catfish. Several methods in terms of hormone preparation are tabulated in **Table 2**.

Table 2. Methods used in the induced spawning of *C. gariepinus* (Gbemisola and Adebayo, 2014)

Hormone	Dose given to Female
Fish pituitary gland (PG)	1–2 PG/female
Human chorionic gonadotropin (hCG)	4,000 I.U./kg
Ovaprim	0.5 ml/kg
Ovatide	0.5 ml/kg

A. Pituitary gland extracts

1. Sacrifice a sexually mature male catfish to obtain the PG, or remove the PG from mature catfish and preserve in acetone.
2. Macerate the PG using scalpel and forceps.
3. Add 1 ml of 0.9 % NaCl* solution to the PG.
4. Siphon the PG extracts using a glass syringe.

*To prepare, dissolve 0.9 g NaCl in distilled water to reach a final volume of 100 ml solution. The 0.9 % NaCl solution is also available in drugstores.

B. hCG

Dose of hCG: 4,000 IU/kg BW
Injection volume: 1 ml/kg BW

Prepare HCG by dissolving the contents of 1 vial containing 5,000 IU hCG in its accompanying solvent in the pack or in 1 ml 0.9 % NaCl.

Concentration of hCG available: 5,000 IU/1 ml (hCG Solution)
4000 IU : Volume of hCG solution needed = 5,000 IU : 1 ml
Volume of hCG solution = 4,000 / 5,000
Volume of hCG solution = 0.8 ml

A 1 kg female (1 kg x 4,000 IU/kg) will receive 4,000 IU or 0.8 ml of hCG.

C. Ovaprim or Ovatide

Dose of Ovaprim or Ovatide: 0.5 ml/kg BW

Injection volume: 1 ml/kg BW

A 1 kg female (1 kg x 0.5 ml/kg) will receive 0.5 ml of Ovaprim or Ovatide.

Hormone Injection

It is preferable to start injecting the females at 7 p.m. to 8 p.m., and stripping at least 12 hours after (7 a.m. to 8 a.m. next day).

The following procedures are followed when injecting female breeders:

1. Mix water with 5 to 10 drops of the anesthesia Quinaldine or 5 ml of 2-phenoxyethanol in a small glass bottle before adding it to a pail containing 5 liters of water.
2. With a scoop net, place each female catfish in the pail. After 2 to 3 minutes, the fish becomes relaxed and ready for injection.
3. Remove fish from pail and pat dry with a towel.
4. Inject hormones to the fish by inserting a needle at a 45° angle in its dorsal muscle (**Figure 6**).
5. Massage the injected area before returning the injected female to a holding tank.

The interval between hormone injection and stripping of injected females, called the latency period, is critical in determining the success of induced spawning. The type of hormone injected to the females determines the time when the females can be stripped. Lower water temperatures may lengthen the latency period. At 28 to 30 °C, it is best to strip females 10 to 14 hours after injection.

Figure 6. Female African catfish injected with hormones for induced spawning

Starting at 6 a.m. the next morning, females are checked by gently pressing the abdomen on the ventral side of the fish. When eggs ooze out, it means that females are ready to be stripped. Before stripping the females, males are sacrificed to obtain their testes which are dissected to collect milt, or a hydrated suspension of sperm to be used to fertilize eggs from females. Sacrifice of males is done about one hour before females are stripped of eggs.

Sacrifice of Male Catfish

1. Mix 5 to 10 drops of Quinaldine anesthesia with 5 liters tap water.
2. Place several males in the pail.
3. Remove a male from the pail after several seconds and pat it dry.
4. Dissect the ventral side of the fish (**Figure 7**) and remove the reproductive organ which consists of testes and seminal vesicles (**Figure 8**).
5. Place the testes and seminal vesicles on a petri dish and cut up into smaller pieces.
6. Place the cut-up pieces into a woven cloth and squeeze to extract the milt (**Figure 9**).
7. Mix the milt with 0.6 % saline solution (get 67 ml of 0.9 % NaCl and add 33 ml of distilled water) to have more viable sperm for fertilization.

Figure 7. Dissection of male catfish

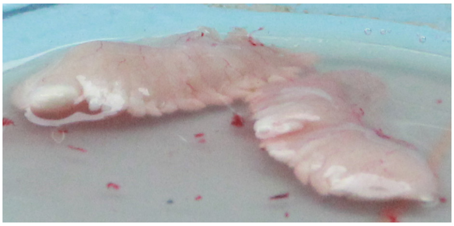

Figure 8. Dissected reproductive organ of male African catfish consisting of a pair of testis and seminal vesicles

Stripping of Females and Artificial Fertilization

When milt is ready, do the following:

1. Get the injected female from the holding tank and place in a pail containing water with anesthesia.

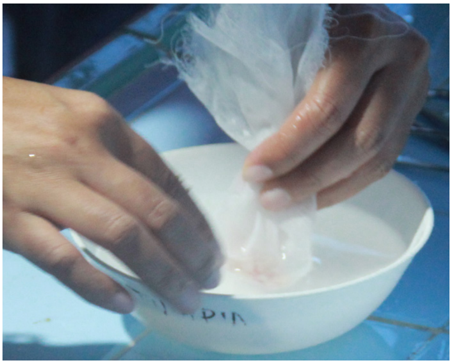

Figure 9. Placing of cut-up pieces of catfish testes-seminal vesicle inside the woven cloth

2. After several seconds, scoop the fish and wipe dry with a towel.
3. Press the lower abdomen gently and let the eggs come out into a clean and dry bowl (**Figure 10**).
4. Pour the milt extracted from the males into a bowl containing the eggs.
5. Use a feather to mix the mixture (**Figure 11**).
6. Add more water and continue mixing for 30 seconds to ensure that fertilization occurs.
7. Transfer the eggs and milt to a small dip net and gently wash with running water (**Figure 12**).
8. Place the fertilized eggs on a framed screen inside the aerated plastic basin or in a wooden trough made of marine plywood with mesh net before the water outlet.
9. Let the stripped females recover in a separate tank.
10. Return the recovered broodstock to their respective tanks/ponds.

Figure 10. A female spawner being stripped of eggs

Figure 11. Mixing of milt and eggs using a feather

Figure 12. Washing of eggs in running water

The ratio of males to be sacrificed to females to be stripped is 1:2, or at most, 2:5.

5 Hatchery

Incubation of Fertilized Eggs in Plastic Basins

Fertilized eggs can be incubated in plastic basins or in wooden troughs made of marine plywood with water inlet and outlet outside the trough, and framed net screen before the water outlet. The set-up must have aeration and a framed net screen placed slanting inside the box. To produce more eggs and larvae, it is recommended that the water inside the incubation container must not be static to prevent fouling from the presence of undeveloped eggs. It should have a flow-through system, with water inlet and a screen net before the water outlet to prevent eggs from flowing out of the incubation tank (**Figure 13**). Incubation of catfish eggs using water of low water hardness like the rainwater was observed to result in more hatched larvae. Since rain may not be available during induced spawning runs, a recirculating system with reservoir and biofilter must be developed (**Figure 14**) by catfish hatchery operators.

Figure 13. Incubation of eggs in containers made of (A) marine plywood or (B) plastic basin

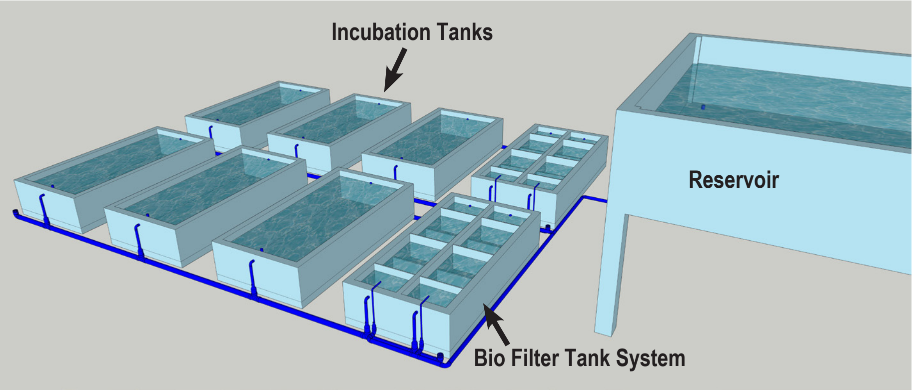

Figure 14. A recirculating flow-through system

Eggs will hatch within 24 hours under a flow-through recirculating system using rainwater. Foam typically forms in the water within 16 hours indicating that hatching has begun. However, foaming too early such as after only four hours indicates that the eggs may not be viable.

The farmer waits for 36 hours to ensure that all of the fertilized eggs have hatched. After 36 hours, gently shake the slanted framed net screen so hatched larvae will fall into the bottom of the trough, and siphon unhatched eggs to avoid water fouling.

Larval Rearing

Healthy larvae tend to congregate at the corners of the rearing container, even upon hatching. Tails of newly hatched larvae are observed to move in unison. Larvae are reared for another five days in the same container where they hatched. As much as possible, hatchery facilities must be protected from low temperatures (< 28 °C) especially during the cooler months. When larvae are about ten days old, they can be transferred to hapa nets in tanks or ponds, prepared two weeks before the start of induced spawning to grow natural foods such as *Moina* and *Daphnia*. The hapa nets serve to protect the larvae from predators in the pond and to concentrate them in a small area to maximize their consumption of feeds. After another five to 10 days, the larvae are released from the hapa nets into the ponds to enter the nursery phase.

Culture of *Moina* and *Daphnia*

Moina and *Daphnia* are small crustaceans that are used as larval food for freshwater fishes. These are found in reservoirs, ponds, ditches, etc. *Moina* is smaller than *Daphnia*. Both are cultured with these procedures:

1. Allow water to stand for 2 days in a tank or pond
2. Soak chicken manure in a sack for 1 to 2 hours before transferring to the production tank at a rate of 20 g/ton (**Figure 15**)
3. Add *Moina*/*Daphnia* starter
4. Maintain water depth at 40 to 50 cm
5. *Moina*/*Daphnia* spp. can be detected after 2 to 4 days
6. Harvest *Moina*/*Daphnia* nauplii by siphoning or draining on the 5th to 8th day of culture into an 80 to 100 micron plankton net

Figure 15. Culture of *Moina*: soaking of chicken manure in a sack; tanks covered with nylon

Feeding

The newly hatched catfish larvae contain yolk which serves as their initial food. It takes about 4 to 5 days for the yolk to be totally resorbed. Thereafter, egg custard (solidified egg emulsion) or natural food organisms such as brine shrimp *Artemia salina*, cladocerans *Moina* sp. and *Daphnia* sp. may be given. On the third day, newly-hatched nauplii of *Artemia* (10 individuals/mL) may be given for three days. Alternatively, egg custard may be administered twice a day for two days. Subsequently, catfish larvae are fed with the cladoceran *Moina* or *Daphnia* for another 4 days, and artificial feed containing 50% protein, 4% crude fat, 7% crude fiber, 15% ash, 12% moisture, and enriched with vitamin C and B complex (**Table 3**). The particle size of the feed depends on the size of the fry (**Table 4**). The artificial feed may be given in seven portions a day for 5 days at 100% of the body weight of larvae.

Table 3. Feeding scheme of larvae at different days after hatching

Days after Hatching	Food Given
0–2	none
3–5	newly-hatched *Artemia*; egg custard
5–10	*Moina*/*Daphnia*
>10	artificial feed

Table 4. Particle size of artificial feed depending on the size of the larvae/fry

Size of Larvae (mg)	Particle Size of Feed (mm)
50–100	0.35–0.50
100–250	0.50–0.75
250–1,000	0.75–1.25

Cannibalism occurs beginning around the second week when size disparity is observed. Differential growth is noted in catfish fed continuously with on artificial feeds, causing mortalities due to cannibalism. In contrast, mortalities due to cannibalism are lesser in catfish fry given live food. Cannibalism is due to endogenous factors such as nutritional state, size disparity, fish behavior, and exogenous factors such as fish density, lack of refuge, or disturbance.

6 Nursery

Nursery Pond

Nursery ponds are smaller compared to broodstock ponds. The area of the nursery pond only ranges from 100 m^2 to 500 m^2 with an average area of 200 m^2. The pond must be surrounded by a fence made of mosquito net to keep out predators.

Nursery Pond Preparation

Predator and competitor control should be given utmost importance to avoid heavy mortalities on the larvae. Ponds are prepared through these procedures:

1. Drain the pond and allow the pond bottom to dry for two days.
2. Apply lime (0.2 kg/m^2) on the pond bottom.

3. Apply chicken manure (3 kg/100 m^2) and NPK (16-16-16) fertilizer (1 kg/100 m^2) to encourage natural food growth.
4. Keep the water level in the pond between 30 to 40 cm even before the catfish fry could be stocked.

Stocking of Larvae to Nursery Ponds

A nursery pond can have high stocking densities and can accommodate about 100,000 fry. Ponds with high stocking densities should be provided with good aeration, water flow, and pond maintenance while the fry should be provided with adequate feed. The operator can attain a fry survival rate of 60 to 80 % in 4 to 6 weeks.

1. Feed the larvae with powdered supplemental feed for three days after stocking.
2. Switch to pelleted supplemental feeds after the first 3 days.
3. Increase the water depth to 60 cm 4 to 5 days after stocking
4. Provide shade to avoid stress on the fry.
5. Feed the fry at least three times a day.

Harvest of Fingerlings

Shooters may start to appear within 10 days and must be harvested or separated to avoid cannibalism. Generally, fingerlings may be selectively harvested after 15 to 18 days since the fry were stocked in ponds. Fingerlings can be selectively harvested using nets with the proper mesh sizes, depending on the target size of fingerlings to be sold. Larger fingerlings command a higher price. Those that are too small are returned to the pond. The fingerlings may also be kept in ponds until they become juveniles which fetch an even higher price. In 30 days, catfish fingerlings grow from 1 to 2 inches.

7 Grow-out

Site Selection

The site where a catfish farm is located heavily influences the success or failure of operations. There are several factors that need to be considered. The water source should be reliable and sufficient and the water coming from it should be clean. The area where the ponds are situated should be protected from natural disasters and free from any form of pollution. The soil must have good compaction and good water retention. The preferred soil types are clay, sandy-clay, and clay-loam. Sites with trees and rocks should be avoided as they will cause water seepage and leakage and other problems in the future. The soil should have a pH between 6.5 to 7.5.

It is recommended that the farm should be in close proximity with hatchery and nursery facilities. Feeds, manure, lime, and other supplies should be readily available for purchase. It is also recommended that the site where the farm would be put up is readily accessible, close to would-be buyers, and located in a peaceful and orderly environment that is free from thieves and poachers.

Pond Culture

Catfishes are commonly reared in earthen ponds. The area of the pond ranges from 1,000 m^2 to 3,000 m^2 and the suggested pond depth is from 0.7 m to 2.0 m. The sides of the pond should be hard and firm to prevent the fishes from burrowing and escaping. A central canal should be present at the bottom of the pond. The pond must have gates made of wood, cement, or pipes.

Small ponds can be managed efficiently but they are more expensive to construct while larger ponds can support more biomass, however, the water quality and other requirements are harder to maintain. In larger ponds, lower stocking densities are advised. The dikes must have grass covers to prevent runoff of mud to the ponds during the rainy season.

Pond Preparation

Pond preparation is done to enhance the decomposition of organic matter and the evaporation of toxic gases. It is also done to eradicate predators and other competitors. Pond preparation also involves disinfection of the ponds to break the life cycle of any harmful pathogen; it also neutralizes the pH of the soil. Pond preparation also prevents water quality and disease problems, and gives natural food time to grow. The following procedures are adopted for pond preparation:

1. Drain and dry pond bottom for about 2 to 3 weeks
2. Repair gates, screens, and dike for leaks and seepages
3. Eradicate unwanted species using 5 parts lime and 1 part ammonium sulfate (21-0-0)
4. Install a fence of 20 to 30 cm high made of old nets along the perimeter dike
5. Apply lime at 500 to 1,000 kg/ha
6. Place cow or chicken manure inside bags and apply at 500 to 1,000 kg/ha
7. Let water in initially at 10 to 20 cm depth
8. Apply a mixture of the inorganic fertilizers, ammonium phosphate (16-20-0) at 50 kg/ha and urea (45-0-0) at 25 kg/ha
9. Increase the water depth to 50 to 60 cm. Plant swamp cabbage or kangkong (*Epomea aquatica*) and/or water hyacinth (*Eichornia crassipes*) to serve as shelters, and maintain its growth to occupy only 10 to 20 % of the area so as not to obstruct feeding activities during culture
10. Replenish 20 to 30 % of the water and stock the fish

Fingerling Selection

The operator must select fingerlings that are healthy, disease-free, and must swim in groups. High-quality fingerlings have a uniformly dark marbled coloration. Fingerlings displaying other colorations should be avoided. Fingerlings that are big and are uniform in size are preferred as these are predicted to have a good survival rate, a shorter culture period, and a reduced occurrence of cannibalism.

Handling and Transport of Fingerlings

Fingerlings that are to be transported are not fed with anything for 24 hours to avoid them soiling their rearing water during transport.

1. Treat the fingerlings with 100 ppm formalin for 5 to 10 minutes or dip them in saltwater with a salinity of 30 ppm for 30 minutes to get rid of unwanted parasites that might have latched on.
2. Pack about 300 to 500 fingerlings in 20 in x 30 in double-lined bags. Fill the bags with 8 to 10 L of oxygenated water and tie with a rubber band. It is preferred to pack more oxygen instead of water in the bags since the commodity is an air-breather.
3. Surround the bags inside the polystyrene box with ice to lower the water temperature from 20 to 23 °C.
4. Transport the fingerlings early in the morning or late in the afternoon to avoid them being exposed to high temperatures during the day.

Acclimation and Stocking

1. Acclimatize the fingerlings to the temperature of the water by placing the bag on the water for 10 to 20 minutes and then slowly open the bag and gradually add pond water to the fingerlings.
2. Let the fingerlings swim out of the bag on their own once acclimatized.

Stocking Density

- Stocking density for grow-out culture depends on the initial size of the fingerlings. Catfish juveniles, with mean total length of 3 to 4 cm can be stocked at 80 to 100 individuals/m^2, 5 to 6 cm at 60 to 80 individuals/m^2, or 7 to 10 cm at 40 to 60 individuals/m^2.
- The recommended stocking density for an intensive culture of African catfish is 5 to 10 or more fish/m^3; 5 fish/m^3 for semi-intensive culture. A formula to help determine the number of fingerlings to be stocked in a pond is provided on the next page.

$$\text{\# of fish to be stocked} = \text{Pond area} \times \text{Stocking Density}$$

Equation 1. Formula used in calculating the number of fish to be stocked

Feeding

Feeding the fingerlings with a good diet provides the nutritional requirements needed by them to be healthy and grow optimally. In return, the operator would obtain higher yields and optimized profits resulting from minimized wastes.

When used for intensive culture, catfish fingerlings or juveniles are fed with artificial feeds containing at least 40 % crude protein. However, feeds with 30 to 32 % crude protein are acceptable to catfish when given as supplemental feed. Many catfish growers use commercial pellets or feed their fish with a combination of blanched chicken entrails and rice bran at a ratio of 9:1.

To determine the performance of the feeds, the Feed Conversion Ratio (FCR), which is the amount of food converted by the fish into its own body weight, is calculated.

$$\text{Feed Conversion Ratio} = \frac{\text{Total amount of food given (kg)}}{\text{Total biomass of fish produced (kg)}}$$

Equation 2. Formula for the FCR

Grading

African catfishes have fast growth rates, hence stocked fish should be graded and sorted every week. Grading reduces cannibalism and helps determine the adequate food ration leading to improved fish production. However, it is labor intensive and time consuming.

Sampling

Sampling is the temporary removal of fish from the culture environment. Sampling is done to check the growth, maturity, and health of the fish. The needed materials such as weighing scale, pails, scoop nets, basins, etc. are prepared beforehand. Sampling should be conducted during the cooler parts of the day.

Water Quality Management

Water quality should be given the utmost importance as it affects the growth, health, and survival of the commodity. Water quality is poor when the water is turbid and/or when the color of the rearing water changes from green to brown and the fish are exhibiting slow growth and repeated health problems.

Causes of poor water quality might be attributed to low-quality feeds, overfeeding, overstocking, and elevated water temperatures. Water parameters such as temperature, dissolved oxygen, pH, nitrate, ammonia, and phosphate levels should be regularly monitored.

Record-keeping

Keeping records of all activities in the catfish farm is vital to assess the performance of the farm and to determine if continuing the operation is still profitable. It also helps the farmers keep a record of their past mistakes and ways to solve their problems in the farm. **Table 5** shows several data that can be obtained in the farm.

Table 5. Farm record data (Coniza, Catacutan and Tan-Fermin, 2008)

Technical Data	Pond number and area, species stocked, total stock, date of stocking, sampling or harvest, source of stock, initial average weight, stocking density, kind of feed, feeding time, feed rate, fish sampling, soil and water parameters, kind and dosages of fertilizers, water management, disease problems, and prevention
Harvest Data	Survival rate, final average weight, production, feed conversion rate (FCR), price per kilo
Expenses	Pond inputs and their corresponding unit and total costs, transportation, electricity, harvesting, rental, taxes, hired labor, and other related expenses

Harvesting

- Grow-out of catfish in ponds usually lasts between 4 to 4.5 months
- The operator must do a taste test first of the commodity to make sure the flavor is not off. If some catfish have an off-flavor taste, the harvest is rescheduled to give time to determine the cause. The pond water is changed at a rate of 60 to 80 % of the total volume for 3 days. The fish may be held in tanks with running water for a few days.
- The operator must not feed the catfish before harvesting.
- Harvest of catfish should start early in the morning and must stop before the temperature during the day gets too hot.
- The pond is drained to about 50 % of the original water level, and the fish are seined (the recommended mesh size of the seine net is 3 to 3.5 cm). The pond is then drained completely and fish at the bottom of the ponds are picked by hand.
    1. Operators must start at the deep part of the pond and slowly move towards the shallow part.
    2. The net is then pulled by two people.
    3. The trapped fish are then removed from the net.
    4. The fish are rinsed well with clean water.
    5. Fish are then graded and separated according to size to avoid cannibalism. Size categories are as follows:
        - Size 3 are large fish weighing greater than 1 kg.
        - Size 2 are medium fish weighing 700 g to 1000 g.
        - Size 1 are average fish weighing 500 g to 700 g.
        - Economy size fish only weigh between 300 to 500 g.
        - Fish weighing less than 300 g are stocked in ponds for fattening.

8 Disease Management

Poor water quality and stress brought about by high stocking densities and frequent handling often result in diseases in catfish which usually occur during the cooler months of the year. It is estimated that about 50 % of the fingerlings may die after 2 weeks of stocking them in ponds due to these diseases. Origins of these diseases may be bacterial, fungal, viral, nutritional, or environmental.

The operator should always keep an eye out for warning signs of disease such as:

- Reduced feed intake
- Weight loss
- Body deformities
- Lethargic behavior
- Abnormal swimming behavior
- Body lesions
- Discoloration of body parts
- Fish gasping for air at the water's surface over a long period of time
- Fish deaths may occur gradually or all at once

Bacteria

White spots or skin lesions accompanied by abnormal swimming behavior such as swimming vertically at the surface of the pond water are warning signs of a bacterial disease.

Main bacterial pathogens may be *Aeromonas hydrophila* (**Figure 16**), *Pseudomonas*, and *Myxobacteria*. Affected stocks may be treated with oxytetracycline.

Figure 16. Dermo-muscular lesion in catfish experimentally infected with *Aeromonas hydrophila* obtained from EUS fish (Lio-Po & Inui eds., 2010)

- Broodstocks are intramuscularly injected with 50 mg oxytetracycline per kg of fish body weight per day. Injection is done for 10 days.
- If the infected fish are still eating, oxytetracycline may be incorporated in the feeds. The dosage is 2–4 g of antibiotic per kg of feed. Oxytetracycline feeding is done for 10 days.
- Fry and smaller juveniles may be placed in an oxytetracycline bath.
    1. 10 mg of oxytetracycline is dissolved in a liter of fresh water in a pail
    2. The pail is provided with vigorous aeration
    3. The fishes are placed in the pail for 24 hours
    4. After 24 hours, the fishes are placed in a new container with clean water
    5. The process is repeated for seven consecutive days.

Environment

Contaminated and polluted pond waters with abnormal levels of key water parameters increase the chances of the fish to catch diseases.

Fungi

Fishes with cotton-like growths on their skin, mouth, and barbels are infected with fungi which may have entered their bodies through skin injuries during handling or caused by ectoparasites. Severely affected fishes cannot swim properly resulting in death.

Nutrition

Spoiled and/or nutritionally deficient feeds are suspected to be linked to the occurrence of certain diseases like cracked head disease (treated with Vitamin C supplementation), open belly disease, body deformities, etc. Cracked head can be treated by adding 500 mg Vitamin C (Tiger brand: 35 %) per kilogram of feed.

Parasites

When a fish is infected with a parasite, the fish swims vertically at the surface of the water or rubs its head on the bottom of the pond. Affected fishes also turn pale in color and occasionally a grayish mucus film covers the skin. As parasites continue to thrive in their hosts, the operators may see fishes gradually die or die all at once.

Figure 17. *Trichodina* sp. (silver nitrate stain, 400x) (Lio-Po & Inui eds., 2010)

Operators must examine the fishes by getting samples of affected tissues. The scraped sample is mounted on a glass slide and viewed under a microscope.

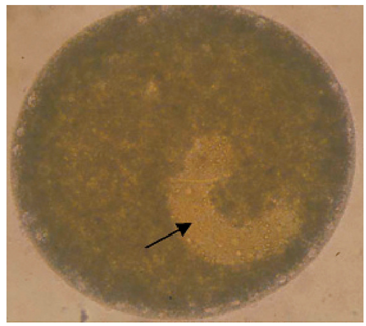

Figure 18. *Ichthyophthirius multifiliis*, mature trophont, from skin of catfish (*Clarias macrocephalus*) with its characteristic horseshoe shaped macronucleus (arrow) (400x)(Lio-Po & Inui eds., 2010)

Common catfish parasites are as follows:

- Protozoans [*Chilodonella*, *Trichodina* spp. (**Figure 17**), *Ichthyophthirius multifiliis* (**Figure 18**)]
- Trematodes (*Dactylogyrus*, *Gyrodactylus*)
- Leeches (*Hirudina*)

Fishes suffering from parasite infestation may be treated with saltwater bath or formalin bath.

- Salt bath
    1. A pail is filled with 10 L of seawater. If seawater is not available, 200 to 300 g of table salt is dissolved in 10 L of freshwater.
    2. The pail is provided with aeration.
    3. The fish is submerged in the seawater using a net for 2 to 3 minutes.
    4. Once done, the fish is transferred to a tank with clean freshwater.
    5. The process is repeated for 3 to 5 days.

- Formalin bath
    1. The operator must dissolve 0.1 mL of formalin in 10 L of freshwater.
    2. The pail is provided with vigorous aeration.
    3. The fish is submerged in the formalin solution for one hour.
    4. The fish is then transferred to a container provided with flow-through water for 15 to 30 minutes.
    5. The process is repeated for 3 to 5 days.

Disease Prevention

The fry and fingerlings must be obtained from reputable hatcheries and nurseries.

The fingerlings must be well-acclimated before transferring them to the ponds to reduce stress.

Personnel must follow bio-secure protocols.

The feeds of fishes must be of good-quality and stored in a clean and dry location, trash fish must be also of good quality and must be stored in ice.

Routine disinfection of the facilities in the farm is encouraged.

Good water quality must be maintained; Liming (5 to 10 ppm) of pond water biweekly or monthly is recommended; Sacks of charcoal are placed in the corners of the pond and will remove impurities in the water.

Water should be changed regularly.

Re-entry of effluents to the pond must not occur and the effluents should undergo treatment.
The farm should have a pest management program to keep out pests, predators, competitors, and other species that may harbor diseases.

Catfishes may be immersed in seawater with a salinity of 20 to 25 ppt for one minute every month to get rid of parasites.

The personnel should be trained in disease prevention, symptom detection, and disease treatment.

Operators must contact fish health management officials immediately for suspected disease outbreaks.

9 Economics

Financial Analyses of Catfish Broodstock, Hatchery, and Nursery Operations

I. Technical Parameters

The technical information provided here was obtained through field interviews with various backyard farmers in Northern Iloilo (3 hatchery and 7 nursery operators).

A. Broodstock and Hatchery

Backyard hatchery operations typically involve the owners managing three ponds for their breeders, with a total pond area of 540 m^2. Male and female breeders are kept in separate ponds, with an additional 180 m^2 pond serving as a holding area for female breeders after stripping. The owners maintain a breeder population of over 1,000, comprising 30 % males and 70 % females. These breeders are obtained from Zarraga, Pototan, and other Northern Iloilo locations, as well as Luzon, particularly Bulacan. However, because of the high cost of obtaining breeders from other regions, most operators typically source their breeders from local suppliers.

Each run involves an average of 27 breeders, consisting of 9 males and 18 females. A female breeder is used for up to three cycles before being sold at a price comparable to a freshly harvested marketable-size catfish. Each run lasts for an average of 5 to 10 days, and fry can be sold and stocked for nursery operations. Operators can conduct up to 10 runs annually. Each run produces approximately 500,000 larvae, of which only 40 % survive, yielding 200,000 fry. Fry are sold per hatching box and are valued at PHP 3,000 to 5,000. Each hatching box contains 30,000 to 40,000 fry.

B. Nursery

Nursery operations usually last 16 to 18 days and can be done six times a year. On average, operators manage four ponds with a total area of 560 m^2, with each pond measuring 140 m^2 and containing nearly 360 fry per square meter. In each run, 200,000 fry are stocked with a 50 % survival rate, yielding an average harvest of 100,000 fingerlings. Depending on demand, operators can re-harvest up to three times per run. If there is no demand after the third harvest, the remaining fingerlings in the pond will be cultured for grow-out. The fingerlings are priced between PHP 1 to 3 each and are sold both in bulk to brokers and by the box to individuals.

Table 6. Technical assumptions of backyard broodstock-hatchery and nursery operations

Items	Broodstock	Hatchery	Nursery
Project duration (years)	5	5	5
Days of culture/crop		5–10	16–18
Number of runs/year	12	10	6
Number of cages, tanks, or ponds	3	6	4
Size of cages, tanks, or ponds (m^2)	180	8.4	140
Age of fish (days)	360	0–5	16-18
Stocking density (pcs/m^2)	10–18	9,921	357
Number of fish/run	9 males, 18 females	500,000	200,000
Survival rate	18 females	40 %	50 %
Feeding rate (% of body weight)	3	50	20, 15, 10
Cost of diet (PHP/kg)	40	60	50
Number of fry/fingerlings produced per run		200,000	100,000
Target fry/fingerling production/ year		2,000,000	600,000

II. Investment Items, Costs, and Depreciation

The broodstock-hatchery capital outlay is PHP 135,360, and the nursery costs PHP 73,686 (**Table 7**). Hatchery building and pond development account for a significant portion of the capital outlay, as operators typically build a small hatchery facility and rent equipment to build their ponds. Pumps, electric motors, nets, and other necessary items are among the materials used. Depreciation is calculated using the straight-line method.

Table 7. Investment items, costs, and depreciation (in PHP)

Items	Broodstock-Hatchery	Nursery in Pond
Total investment cost	135,360	73,686
Depreciation cost per year	27,072	14,737
Depreciation cost per run	1,504	2,456

III. Cost and Return Analysis

The average production costs and income are presented in **Table 8**. Broodstock-hatchery operations incur an annual production cost of PHP 162,800 or PHP 16,280 per run. The nursery operation's annual production cost is PHP 143,133 or PHP 23,856 per run.

The table below provides a cost and return analysis of the broodstock-hatchery and nursery operations. Catfish fry are priced at PHP 5,000 per 30,000 to 50,000 individuals per box, while fingerlings cost PHP 1 to 3 per inch. The annual sales figures are as follows: PHP 285,714 for fry and PHP 600,000 for fingerlings. The net income for broodstock-hatchery is PHP 12,291 per run or PHP 122,914 per year, while for nursery it is PHP 76,145 per run or PHP 456,867 per year. The nursery operations have the highest gain due to the value of the fingerlings sold.

The return on investment (ROI) is 41.22 % and 210.71 %, while the payback period (PP) is 1.99 and 0.46 years for broodstock-hatchery and nursery operations, respectively. Break-even points for price are PHP 0.08/fry and PHP 0.20/fingerlings while break-even production is 1.14 million fry and 119,278 fingerlings.

Table 8. Cost and Return Analysis (in PHP except otherwise indicated)

Items	Broodstock-Hatchery	Nursery in Pond
Revenue per year		
Sale of fry/fingerlings	285,714	600,000
Total cost per run	*16,280*	*23,856*
Total cost per year	*162,800*	*143,133*
Economic Indicators		
Income per run	12,291	76,145
Income per year	122,914	456,867
Return on Investment (%)	41.22 %	210.71 %
Payback Period (years)	1.99	0.46
Break-even price	0.08	0.20
Break-even production (pcs)	1,139,600	119,278

Discounted economic indicators show the profitability and viability of broodstock and nursery backyard operations (**Tables 9A and 9B**). Both operations yield positive net present values. The internal rate of return (IRR) for broodstock-hatchery and nursery operations is 110 % and 642 %, respectively, with benefit-cost ratios (BCR) of 1.68 and 4.08.

Table 9-A. Financial Investment Analysis of Broodstock and Hatchery Operations (in PHP except for IRR and DBCR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Gross income*		285,714	291,429	297,257	303,202	309,266	1,486,869
Investment cost	135,360						135,360
Variable & fixed costs, less depreciation		135,728	138,443	141,211	144,036	146,916	706,334
Total cost investment & operating costs**	135,360	135,728	138,443	141,211	144,036	146,916	841,694
Net income plus depreciation	(135,360)	149,986	152,986	156,046	159,167	162,350	645,175
Net Present Value (NPV)							412,895
Internal Rate of Return (IRR)							110 %
Discounted Benefit-Cost Ratio (DBCR)							1.68

*****2 % annual increase in sales value due to some factors such as improved operations and skills, a higher survival rate, and a probable price increase
******1 % annual increase in cost due to a probable increase in the prices of materials and labor

Table 9-B. Financial Investment Analysis of Nursery Operations in Pond (in PHP except for IRR and DBCR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Gross income*		600,000	612,000	624,240	636,725	649,459	3,122,424
Investment cost	73,686						73,686
Variable & fixed costs, less depreciation		128,396	130,964	133,583	136,255	138,980	668,177
Total cost investment & operating costs**	73,686	128,396	130,964	133,583	136,255	138,980	741,863
Net income plus depreciation	(73,686)	471,604	481,036	490,657	500,470	510,480	2,380,561
Net Present Value (NPV)							1,618,208
Internal Rate of Return (IRR)							642 %
Discounted Benefit-Cost Ratio (DBCR)							4.08

*****2 % annual increase in sales value due to some factors such as improved operations and skills, a higher survival rate, and a probable price increase
******1 % annual increase in cost due to a probable increase in the prices of materials and labor

Financial Analysis of Catfish Backyard Grow-out Operations

I. Technical Parameters

Seven backyard grow-out operators were interviewed for this analysis. Fish farm operators can have up to three runs per year, each lasting 120 days or four months. With a pond area of 400 m^2, 6,000 fingerlings per run, or 15/m^2 can be stocked. The survival rate is 70 to 90 %. The average body weight (ABW) of a marketable fish is 120 to 150 grams, and it is priced between PHP 150 to 180 per kilo (**Table 10**).

II. Cost and Return Analysis

The average investment for catfish farming operations is shown in **Table 11**. The capital outlay includes pond development, equipment, the construction of a caretaker's house, nets, and other supplies. The grow-out stage requires a capital investment of PHP 50,500. Depreciation amounts to PHP 5,567 per year or PHP 1,856 per crop. Using a straight-line depreciation method, a salvage value of PHP 27,000 can be obtained after project operation.

In a backyard setup, catfish are fed commercial feed and market-available chicken entrails. Feed costs make up 62 % of total production costs. Fingerlings cost PHP 1 to 3 per inch, depending on supply. However, fingerlings are priced at PHP 2 per piece in this analysis.

A single operation could cost about PHP 91,000. Marketable-sized catfish is worth PHP 180 per kilo, yielding a gross profit of PHP 113,400 per crop. The total annual net profit is PHP 65,838. The return on income (ROI) is 130.37 %, with a payback period of 0.71 years. The discounted financial indicators are PHP 224,484, 142 %, and 1.22 for net present value, internal rate of return, and benefit-cost ratio, respectively (**Table 13**). **Table 14** shows how the financial indicators may change as a result of the sensitivity analysis.

Table 10. Technical assumptions

Items	
Project duration (year)	5
Days of culture/crop	120
Number of runs/year	3
Total farm area (ha)	0.04
Stocking density (pcs/m^2)	15
Total stocked (pcs/crop)	6,000
Average body weight at stocking (g)	3.5–5.0
Average body weight at harvest (g)	150
Survival rate	70 %
Feeding rate (% of body weight)	3.5–5.0
Cost of diet (PHP/kg)	40
Number produced per run (pcs)	4,200
Target production/year (pcs)	12,600

Table 11. Investment items, costs, and depreciation

Items	Value (PHP)	Economic Life (year)	Depreciation (PHP)	Salvage Value (PHP)
Pond Development	20,000	20	1,000	15,000
Water pump	9,000	10	900	4,500
Caretaker's house	15,000	10	1,500	7,500
Nets	5,000	3	1,667	
Other supplies	1,500	3	500	
Total investment	50,500			
Depreciation/yr			5,567	
Depreciation/crop			1,856	
Salvage value after the project's duration				27,000

Table 12. Cost and Return Analysis

Items	Quantity	Price/unit (PHP)	Total Cost (PHP)
A. Revenue			
Catfish production (kg)	630	180	113,400
B. Operating cost			
Variable costs			
Fingerlings/ha/crop (pcs)	6,000	2	12,000
Feeds (kg)	1,260	45	56,700
Pond preparation (PHP 30,000/ha)			1,200
Electricity/Transportation cost (PHP 400/month)			1,600
Fuel			1,200
Repair and maintenance (10 % investment)			5,050
Miscellaneous expenses (5 % revenue)			5,670
Subtotal			**83,420**
Fixed costs			
Family labor/crop (days)	10	350	3,500
Depreciation/crop			1,856
Interest rate/crop (50 % bank loan, 12 %/yr)			2,678
Subtotal			**8,034**
Total Cost			***91,454***
Financial Indicators			
Annual net profit (PHP)			65,838
Return on investment (ROI)			130.37 %
Payback period (yr)			0.71
Break-even price (PHP)			145
Break-even production (kg)			508

Table 13. Financial Investment Analysis of Catfish Grow-out Operations (in PHP except for IRR and DBCR)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Gross Income*		340,200	347,004	353,944	361,023	395,243	1,797,414
Investment Cost	50,500						50,500
Variable & fixed costs, less depreciation		268,795	274,171	279,655	285,248	290,953	1,398,821
Total cost investment & operating costs**	50,500	268,795	274,171	279,655	285,248	290,953	1,449,321
Net income plus depreciation	(50,500)	71,405	72,833	74,290	75,775	104,291	348,093
Net Present Value (NPV)							224,484
Internal Rate of Return (IRR, %)							142 %
Discounted Benefit-Cost Ratio (DBCR)							1.22

*2 % annual increase in sales value due to some factors such as improved operations and skills, a higher survival rate, and a probable price increase
**1 % annual increase in cost due to a probable increase in the prices of materials and labor

Table 14. Sensitivity Analysis of Catfish Grow-out Operations

	Net Profit (PHP)	Break-even Price (PHP)	Break-even Production (kg)	ROI	PP	NPV	IRR	DBCR
Survival rate (%)								
60	44,503	153	458	88.12 %	1.01	148,246	99 %	1.16
50	23,167	163	407	45.88 %	1.76	72,008	55 %	1.09
40	1,832	178	357	3.63 %	6.83	-4,231	7 %	0.99
Price of fish (PHP/kg)								
170	47,902	145	536	94.86 %	0.94	160,393	106 %	1.16
160	29,966	144	568	59.34 %	1.42	96,301	69 %	1.10
150	12,030	144	603	23.82 %	2.87	32,210	31 %	1.03
Average body weight (g/pc)								
140	55,882	148	485	110.66 %	0.82	188,906	122%	1.20
130	45,925	152	461	90.94 %	0.98	153,329	102%	1.17
120	35,969	156	437	71.22 %	1.22	117,751	82%	1.14
Increase in variable cost (PHP)								
20 %	14,785	172	603	29.28 %	2.48	42,055	37 %	1.04
10 %	40,312	159	555	79.82 %	1.10	133,270	91 %	1.12

10 References

Adan, R. I. Y. (2000). Catfish Culture in Southeast Asia. SEAFDEC Asian Aquaculture, 22(1): 16-17.

Agbeko, E., Asmah, R., Anani, F. A., and Mensah, E. T. D. (2017). A Training Manual for Grow Out Pond Culture of African Catfish. Western Region Coastal Foundation: Ghana, Africa.

Baidya, A. P. and Senoo, S. (2002). Observations of Oocyte Final Maturation and Eggs on African Catfish *Clarias gariepinus* under Artificial Rearing Conditions. Suisanzoshoku, 50(4): 415-422.

Coniza, E. B., Catacutan, M. R., and Tan-Fermin, J. D. (2008). Grow-out culture of the Asian Catfish *Clarias macrocephalus* (Gunther). Southeast Asian Fisheries Development Center Aquaculture Department: Iloilo, Philippines.

Diogo, R., Chardon, M., and Vandewalle, P. (2003). Functional Morphology of Catfishes: Movements of Barbels. in: Arratia, G. *et al*. Catfishes: Volume 1 & 2. pp. 203-220. Enfield Publishing & Distribution Co.: USA.

Duong, T., Nguyen, T., and Pham, T. (2017). Morphological differentiation among cultured and wild *Clarias macrocephalus*, *C. macrocephalus* x *C. gariepinus* hybrids, and their parental species in the Mekong delta, Viet Nam. International Journal of Fisheries and Aquatic Studies, 5(1): 233-240.

FAO. (n. d.). Introduction. Retrieved on July 13, 2020 from http://www.fao.org/3/w3595e/w3595e02.htm

Gbemisola, O.B. and Adebayo, O.T. (2014). Sperm quality and reproductive performance of male *Clarias gariepinus* induced with synthetic hormones (Ovatide and Ovaprim). International Journal of Fisheries and Aquaculture, 6(1), 9-15.

Guerrero, R. D. III. (2014). Impacts of Introduced Freshwater Fishes in the Philippines (1905–2013): A Review and Recommendation. Philippine Journal of Science, 143 (1): 49-59.

Iwalewa, M., Akinwale, M., Adewole, M., Okihiria, E., Ebonwu, B., Iheanacho, E. B., and Bede, O. C. (2017). Improving Breeding Performance of Fingerlings of *Clarias gariepinus* Through Intraspecific Hybridization. Agronomie Africaine Sp., 29(2): 109-114.

Jin, Y., Liu, S., Yuan, Z., Yang, Y., Tan, S., & Liu, Z. (2016). Catfish genomic studies: progress and perspectives. Genomics in Aquaculture, 73–104. doi:10.1016/b978-0-12-801418-9.00004-4

Juin, S. K. and Nath, P. (2018). Time requirement for sexual maturity of the African catfish *Clarias gariepinus* (Burchell, 1822) in captivity. Indian Journal of Experimental Biology, 56: 75-82.

Khedkar, G. D., Jadhao, B. V., Chavan, N. V., & Khedkar, C. D. (2003). FISH | Demersal Species of Tropical Climates. Encyclopedia of Food Sciences and Nutrition, 2438–2442. doi:10.1016/b0-12-227055-x/00472-7

Lio-Po, G. D., & Inui, Y. (Eds.). (2010). Health Management in Aquaculture (2nd ed.). Tigbauan, Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center.

Locara, L. (2000). Marketing of Catfish in Iloilo. SEAFDEC Asian Aquaculture, 22(1): 27 and 34.

Maina, J. N. and Maloiy, G. M. O. (1986). The morphology of the respiratory organs of the African air-breathing catfish (*Clarias mossambicus*): A light, electron and scanning microscopic study, with morphometric observations. J. Zool., Lond., 209: 421-445. doi: https://doi.org/10.1111/j.1469-7998.1986.tb03602.x

Martinez-Chavez, C. C., Al-Khamees, S., Campos-Mendoza, A., Penman, D. J., & Migaud, H. (2008). Clock-Controlled Endogenous Melatonin Rhythms in Nile Tilapia (*Oreochromis niloticus niloticus*) and African Catfish (*Clarias gariepinus*). Chronobiology International, 25(1), 31–49. doi:10.1080/07420520801917547

Ngugi, C. C., Bowman, J. R., and Omolo, B. O. (2007). A New Guide to Fish Farming in Kenya. Oregon State University: USA.

Philippine Statistics Authority. (n.d.). Database: Agriculture, Forestry, Fisheries. PSA OpenSTAT. https://openstat.psa,gov.ph/PXWeb/pxweb/en/DB/DB_2E_FS/0072E4GVAP0.px/table/tableViewLayout1/?rxid-bdf9d8da-96f1-4100-ae09-18cb3eaeb313

Potongkam, K. and Miller, J. (2006). Manual on Catfish Hatchery & Production. Retrieved on July 13, 2020 from http://www.fao.org/3/a-ak505e.pdf

Radhakrishnan, K. V., Lan, Z. J., Zhao, J., Qing, N., and Huang, X. L. (2011). Invasion of the African sharp-tooth catfish *Clarias gariepinus* (Burchell, 1822) in South China. Biol Invasions, 13: 1723 – 1727. doi: 10.1007/s10530-011-0004-0

Romanova, E. M., Lyubomirova, V. N., Romanov, V. V., Mukhitova, M. E., and Shlenkina, T. M. (2018). Seasonal studies of caviar production and growth rate of the African catfish (*Clarias gariepinus.* Burchell, 1822). Egyptian Journal of Aquatic Research, 44: 315 – 319. doi: https://doi.org/10.1016/j.ejar.2018.09.005

Sahoo, S. K., Giri, S. S., Sahu, A. K. (2005). Effect of Breeding Performance and Egg Quality of *Clarias batrachus* (Linn.) at Various Doses of Ovatide During Spawning Induction. Asian Fisheries Science, 18: 77-83.

Santi, S., Gennotte, V., Toguyeni, A., Mélard, C., Antoine, N., & Rougeot, C. (2016). Thermosensitivity of the sex differentiation process in the African catfish, *Clarias gariepinus*: Determination of the thermosensitive period. Aquaculture, 455, 73–80. doi:10.1016/j.aquaculture.2016.01.009

Santiago, C. B., Basiao, Z. U., Tan-Fermin, J. D. (1999). Research on Freshwater Fishes. ADSEA '99 Proceedings.

Shirai, N. (2011). Fish Sources of Various Lipids Including n-3 Polyunsaturated Fatty Acids and Their Dietary Effects. Omega-3 Oils, 61–71. doi:10.1016/b978-1-893997-82-0.50006-2

Skelton, P. H. and Teugels, G. C. (1991). A review of the clariid catfishes (Siluroidei, Clariidae) occurring in southern Africa. Rev. Hydrobiol. Trop., 24(3): 241-260.

Subramoniam, T. (2017). Sexual Systems. Sexual Biology and Reproduction in Crustaceans, 57–103. doi:10.1016/b978-0-12-809337-5.00003-4

Tan-Fermin, J. D. (2003). Catfish aquaculture. SEAFDEC Asian Aquaculture, 25 (4): 1-3.

Tan-Fermin, J. D., Fermin, A. C., Bombeo, R. F., Evangelista, M. A. D., Catacutan, M. R., and Santiago, C. B. (2008). Breeding and seed production of the Asian catfish *Clarias macrocephalus* (Gunther). Southeast Asian Fisheries Development Center Aquaculture Department: Iloilo, Philippines.

Tan-Fermin, J. D., Marte, C. L., Ueda, H., Adachi, S., Yamauchi, K. (1999). Effect of Season on Oocyte Development and Serum Steroid Hormones in LHRHa and Pimozide-injected Catfish *Clarias macrocephalus* (Gunther). Fisheries Science, 65(6): 865-870.

Turan, F. and Turan, C. (2016). Natural and Non-natural Distribution of African Catfish *Clarias gariepinus* (Burchell, 1822) in Turkey. LIMNOFISH-Journal of Limnology and Freshwater Fisheries Research, 2(3): 173-177. doi: https://doi.org/10.17216/limnofish.280413

Van Oijen MJP, 1995. Key to Lake Victoria fishes other than haplochromine cichlids, Appendix I. In: Witte F, Van Densen WLT, eds. Fish Stocks and Fisheries of Lake Victoria. A Handbook for Field Observations. UK: Samara Publishing Limited, 209-300.

Weicaszek, B., Krzykawski, S., Antoszek, A., Kosik, J., and Serwotka, P. (2010). Morphometric Characteristics of the Juvenile North African Catfish *Clarias gariepinus* (Burchell, 1822) from the Heated Water Aquaculture. EJPAU, 13(2).

Zakaria, M., Gambo, B. G., Peter, I. D., Gazali, Y. A., and Stephen, J. (2016). Anatomical studies of the testes of wild African catfish (*Clarias gariepinus*) in spawning and non-spawning seasons in Maiduguri, Nigeria. International Journal of Fisheries and Aquatic Studies, 4(3): 272-277.

Acknowledgment

The authors would like to thank the Management of SEAFDEC/AQD for prioritizing the publication of this manual. We would also like to thank Ms. Rossea H. Ledesma and Mr. Rex Delsar B. Dianala, both of the Development Communication Section of the Training & Information Division of SEAFDEC/AQD for their assistance with the figures and excellent proofreading. Finally, we are thankful to Mr. Wilson Balingit, the president of Catfish Operators & Growers Association in the Municipality of Estancia, Iloilo for his valuable inputs to improve the manual, and to the catfish hatchery operators and growers in Panay whose continued interest in breeding and culturing the African catfish inspired us to write this work.

About the Authors

Dr. Josefa D. Tan-Fermin is currently a consultant under the Breeding and Seed Production Section. She is a former scientist and head of the Breeding Section at SEAFDEC/AQD. She first worked as a research assistant under the Milkfish Broodstock Development Project in June 1979, eventually becoming a research associate in 1982. She finished her BSc in Biological Sciences in 1977 from the University of the Philippines in the Visayas (UPV), MSc in Zoology in 1982 from UP Diliman, and Doctor in Fisheries Science in 1997 from the Faculty of Fisheries, Hokkaido University. Dr. Tan-Fermin has worked on the different aspects of the reproductive biology and digestive physiology of milkfish, shrimp, sea bass, grouper, goldfish and catfish. These works were published mainly in refereed journals.

Mr. Jebrham C. Navarro has been with SEAFDEC/AQD since 2019 and is currently a Technical Assistant at the Technology Verification and Extension Division. He earned his Bachelor of Science in Molecular Biology and Biotechnology degree (*Cum laude*) from the University of the Philippines Diliman in 2018.

Ms. Gemma N. Arnaldo has been with SEAFDEC/AQD since 2000 and she is currently a Senior Technical Assistant at the Technology Verification and Extension Division. She earned her Bachelor of Science in Fishery Education from the Iloilo State College of Fisheries in 1989.

Mr. Rheniel Dayrit has been with SEAFDEC/AQD since 2016 and is currently a technical assistant at the Technology Verification and Extension Division. He earned his Bachelor of Science in Economics degree from the University of the Philippines Visayas in 2016.

ABOUT SEAFDEC

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 to promote fisheries development in the region. The member countries are Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

The policy-making body of SEAFDEC is the Council of Directors, made up of representatives of the member countries.

SEAFDEC has five departments that focus on different aspects of fisheries development:

- The Training Department (TD) in Samut Prakan, Thailand (1967) for training in marine capture fisheries
- The Marine Fisheries Research Department (MFRD) in Singapore (1967) for post-harvest technologies
- The Aquaculture Department (AQD) in Tigbauan, Iloilo, Philippines (1973) for aquaculture research and development
- The Marine Fishery Resources Development and Management Department (MFRDMD) in Kuala Terengganu, Malaysia (1992) for the development and management of fishery resources in the exclusive economic zones of SEAFDEC member countries, and
- Inland Fishery Resources Development and Management Department (IFRDMD) in Palembang, Indonesia (2014) for sustainable development and management of inland capture fisheries in the Southeast Asian region.

AQD is mandated to:

- Conduct scientific research to generate aquaculture technologies appropriate for Southeast Asia
- Develop managerial, technical and skilled manpower for the aquaculture sector
- Produce, disseminate and exchange aquaculture information

AQD maintains four stations: the Tigbauan Main Station and Dumangas Brackishwater Station in Iloilo province; the Igang Marine Station in Guimaras province; and the Binangonan Freshwater Station in Rizal province. AQD also has an office in Quezon City.

www.seafdec.org.ph