AQUACULTURE EXTENSION MANUAL NO. 70 NOVEMBER 2022

NURSERY AND GROW-OUT CULTURE OF Rabbitfish *Siganus guttatus* IN BRACKISHWATER PONDS

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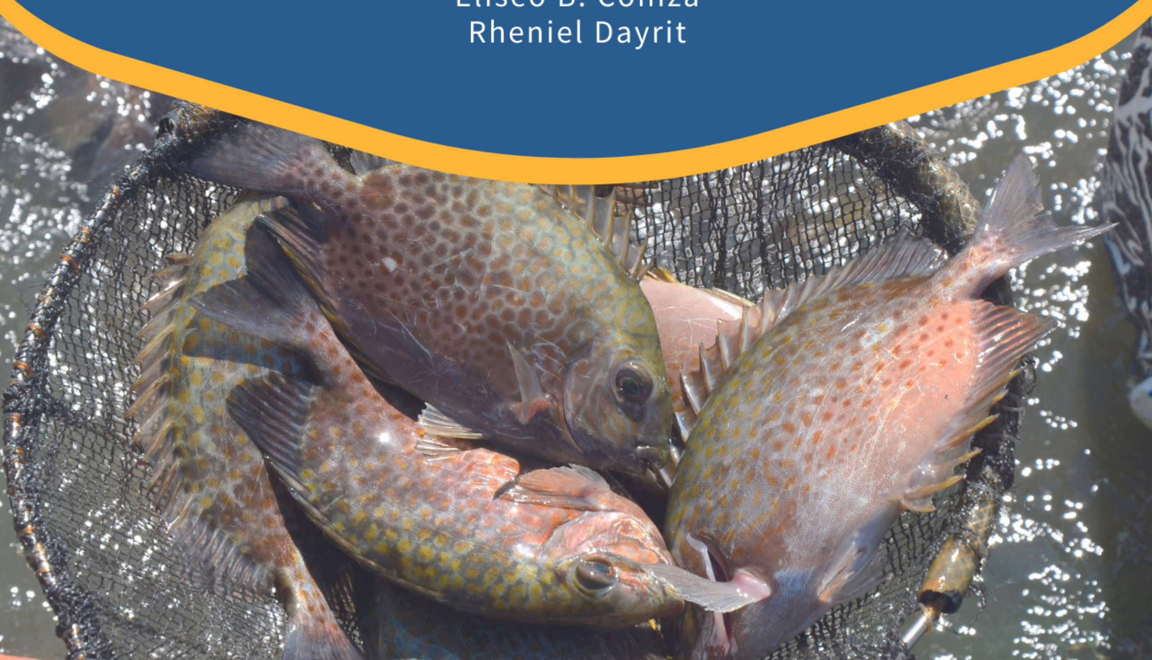

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Foreword

Since 1983, rabbitfish has been one of the species SEAFDEC/AQD is working on. Through its research efforts, SEAFDEC/AQD developed science-based breeding and hatchery technologies on rabbitfish.

Moving forward, recognizing the aquaculture potential of rabbitfish, which is included in the 2020 top seven species for aquaculture production in brackishwater ponds with a total volume of 62 metric tons (BFAR, 2021), SEAFDEC/AQD also conducted studies on the nursery and grow-out culture of this species.

To further boost the promotion of rabbitfish culture in the aquaculture industry, SEAFDEC/AQD came up with this manual on the nursery and grow-out culture of rabbitfish which is the product of research and verification studies conducted by the institution.

Through this manual, we are looking forward that the science-based culture techniques we developed will reach more stakeholders from the private sector, the academe, and government agencies.

DAN D. BALIAO
SEAFDEC/AQD Chief

About the Manual

Rabbitfish *Siganus guttatus* is a promising aquaculture species due to its tasty meat and commands a higher price than some aquaculture species. Moreover, it has a low protein requirement, resulting in a low-cost feed input. In the 1970s, rabbitfish farming in fishponds began in the Philippines. In 1998 and 2014, SEAFDEC/AQD published manuals titled "Biology and Culture of Siganids" and "Seed Production of Rabbitfish *Siganus guttatus*," respectively. However, there has been no recent publication on the nursery and grow-out culture. As a result, this manual will provide an update on the current techniques for nursery and grow-out culture operations of rabbitfish.

Research studies, particularly on diets and culture techniques, have been conducted and verified before being disseminated through this publication. The biology of *Siganus guttatus* is covered, as well as the brackishwater culture management techniques such as site selection, pond preparation, nursery operation, grow-out culture technique, production data, common diseases and preventions, and economic analysis.

The authors hope this manual will provide fish farmers, farm operators, feed millers, aquaculturists, technicians, and students with the basic knowledge of science-based aquaculture techniques for rabbitfish and how rabbitfish farming can become profitable.

Contents

1 Introduction

Rabbitfish or siganids belong to the Family Siganidae and are usually found in the Indo-Pacific Region. They are locally known as “samaral,” “malaga,” “danggit,” “kitong,” “mobead,” “ngisingisi” or “balabis.” Siganids usually inhabit seagrasses, coastal and mangrove areas, and also in the vicinity of coral reefs. This fish species is herbivorous and feed on filamentous algae and seaweed. In captivity, siganids are omnivorous, ingesting a ready variety of food. Siganids are generally active during the day (diurnal), whereas *Siganus guttatus* are active at night (nocturnal). In the Philippines, siganid fry are abundant in coastal waters, but are now becoming scarce due to overfishing.

Siganids have a total of 28 species belonging to the genus of *Siganus*. One of the promising potential species for aquaculture is the *Siganus guttatus* because of its faster growth rate, large size, hardiness, and tolerance to physical factors. According to some research, this species can be reared in brackishwater ponds, cages, and pens. Fish fed only filamentous algae had a slower growth rate and a longer culture period, but fish fed a formulated diet performed better. Furthermore, siganids fed a combination of filamentous algae or *Gracilaria* seaweed “gulaman” and commercial diet had comparable growth results to formulated diet alone, thus lowering farm feed costs, as practiced by traditional growers in Region 1 and 2, Philippines.

Hatchery technology for *S. guttatus* has already been established. Spawning of *S. guttatus* both in the wild and captivity is reported all year round in the Philippines. The SEAFDEC/AQD hatchery produces fry throughout the year. Fish reach an early juvenile stage (1 in size) after 45–60 days from hatching. Thereafter, these are stocked in nursery pond-based net cages for three (3) months and fed with formulated diets to reach its ideal size of 30–50 g average body weight for grow-out culture. In ponds, fish juveniles are reared for 4–5 months until they reach the marketable size of an estimated 250–300 g average body weight to harvest.

Philippines and Indonesia are the top producers of siganid *Siganus* spp. both from the wild-caught and cultured environment since 2000 (FAO 2018). In 2018, siganid aquaculture production in the Philippines was higher in mariculture fish cages, mainly from Region XI, than in brackishwater ponds that were mostly from Region I & II (PSA 2019). Hatchery technology has been published and disseminated however, no information was published on the nursery and grow-out culture. Thus, this manual will help and guide fish farmers, farm operators, feed millers, aquaculturists, technicians, and students promoting rabbitfish farming.

2 Biology

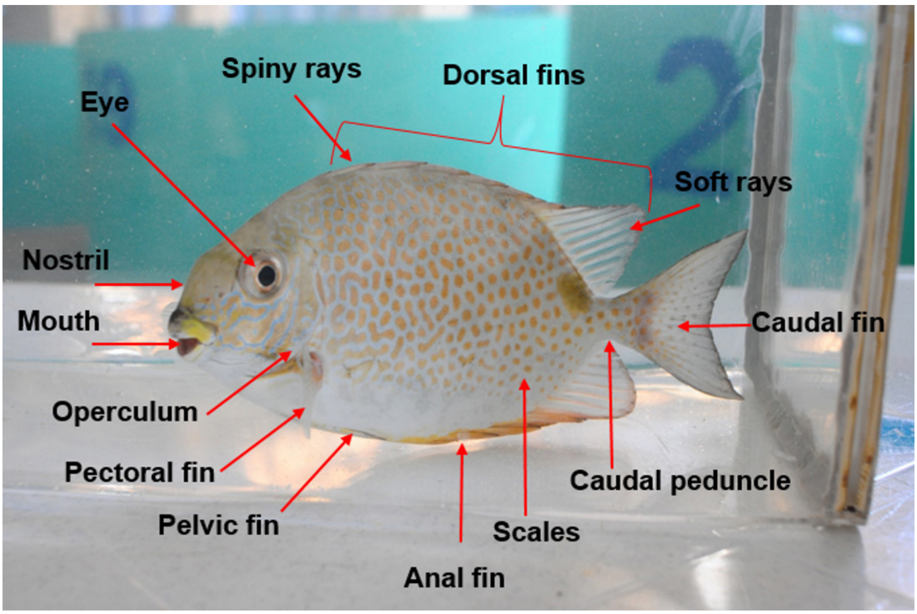

Figure 1. External parts of rabbitfish *Siganus guttatus*

Identification

Orange-spotted spine foot, *Siganus guttatus*, are perciform fishes belonging to Family Siganidae. It has different names at various places in the Philippines such as "samaral," "danggit," "malaga," and "kitong"; "belais" or "ketang" in Malaysia; and "birra" or "samadar" in Indonesia. Siganids have deep, compressed bodies, rabbit-like mouths, 13 pungent spines in the dorsal (back) fin, seven spines in the anal fin, and two spines in the ventral fin. Siganid fin spines are equipped with well-developed venom glands. The skin is leathery but the scales are smooth, small, and closely adherent.

Behavioral traits and habitat

This species inhabits turbid inshore reefs among mangroves and can tolerate low salinities. At the juvenile stage, they settle among mangrove roots in shaded areas, shallow bays, and river mouths. They then enter and leave rivers with the tide during the adult stage. Adults are also found on the drop-offs of inshore fringing reefs down to 6 m. This species is an herbivore feeding mainly on benthic algae.

Distribution

Siganus guttatus is widely distributed in the Eastern Indian Ocean and Western Pacific like the Andaman Islands, Thailand, Malaysia, Singapore, Indonesia (including Irian Jaya), Viet Nam, Ryukyus or Southern Japan, Southern and Eastern China Sea, Philippines, and Palau.

Why rabbitfish culture?

Rabbitfish farming in the Philippines is popular in mariculture floating net cages but can also be cultured either alone or with milkfish and crabs in brackishwater ponds. They are herbivorous, thus inputs in grow-out culture are low, but they can also be trained to feed on formulated feeds when reared in captivity. This fish commands a higher price in the market than milkfish and is a good alternative to milkfish for grow-out culture.

3 Brackishwater Pond Culture Management

Site selection

In selecting a good site for fishponds, the following factors should be considered: Buffer, soil, water supply, topography, availability of inputs, labor, markets, and peace and order.

- **Buffer.** A buffer is a space (mangrove area) between the aquaculture area or the pond and the source of water supply or the sea. For brackishwater aquaculture, required buffer zone of at least 100 meters from the sea to the main peripheral dike and 50 meters along the river banks (for typhoon prone areas). However, for non-typhoon areas, 50 meters from the sea and 20 meters along the river banks shall be required. This zone shall be left undisturbed for ecological reasons and physical protection from flooding and wave action.

Figure 2. Brackishwater ponds at SEAFDEC/AQD's Dumangas Brackishwater Station

- **Soil.** The type of soil should be clay, clay loam, silty clay loam, silt loam, and sandy clay loam because of its water retention properties which are good for dike construction. Soil pH of 6.5–7.5 is ideal. Avoid acidic soil, areas with a rocky bottom, and plenty of decaying roots.
- **Water Supply.** The water supply should be adequate year-round, clean, free from flooding, and free from sources of pollution (domestic,

agricultural, and chemical). The supply should ideally move through the pond without additional energy input. Maintain a water depth of 1 m or higher.

- **Topography.** This refers to the shape of the land. Land that is sloping but not exposed to soil erosion is suitable for a fishpond. Level ponds that are slightly sloping towards the gate are recommended to facilitate total draining during harvesting and drying of the ponds during the pond preparation.
- **Availability of Inputs.** Farming includes fish juveniles, supplementary feeds, fertilizers, lime, and other pond accessories. Operators should know where to obtain these inputs locally.
- **Labor.** Both skilled manpower and casual laborers must be available to manage the pond, especially on large-scale farms. However, in a small-scale backyard pond, family labor is enough.
- **Markets.** The site must be close to markets and accessible by road for ease of transportation.
- **Peace and Order.** The fishpond must be kept from any poaching of marketable fish. A peaceful and orderly environment for the site must be considered.

Pond preparation

The productivity of the pond lies in good preparation. It removes the noxious gases such as ammonia and sulfides; and eliminates pests, predators, and unwanted species thus promoting good growth and a high survival rate of fish.

Figure 3. Drying of the pond

1. Drain and dry the pond for about 2–3 weeks until it cracks. Remove the sludge and till the pond soil if necessary. This exposes the soil bottom to the heat of the sun and releases toxic chemicals such as ammonia and sulfides. Then, soil-seal the pond gate by filling mud between rows of the slabs to avoid the entry of water.

2. Elimination of unwanted species in the pond. Eradication of pests, predators, competitors, and other unwanted species inside the pond must be done following the procedure:

Figure 4. Liming

- Apply a 5:1 ratio mixture of hydrated lime $Ca(OH)_2$ and ammonium sulfate (21-0-0) to the pond bottom when there is intense sunlight. The estimated dosage depends on the remaining water volume inside the pond at 3–4 kg 21-0-0 plus 15–20 kg lime for every ton of pond water volume. Avoid application of these chemicals during rainy days or if there are leakages and seepages in the dike since it will result in the dilution of the chemicals with water that will affect its potency.
- Flood and flush the pond bottom. Flood the pond to a depth of 30 cm and hold the water for 1–2 days. Then drain the pond to remove toxic substances.

3. Apply hydrated lime at 0.5–1.0 ton/ha to the pond bottom. Expose the pond bottom with lime for about 3–5 days. Lime neutralizes the acidity of the soil which accelerates the decomposition of organic matter and improves the efficiency of fertilizers needed for the growth of plankton.

Figure 5. Water management during spring tide

4. Let water into the pond. Bring to about 30–40 cm depth, enough to soften the soil bottom for easy bamboo bridge construction.
5. Construct a bamboo bridge from the perimeter dike to the feeding area in the pond. The bamboo bridge serves as a walkway for personnel during feeding, sampling, monitoring of stocks, and as support of the net cages installed in the pond. Hence, the bamboo bridge is important both in the nursery and grow-out culture.

6. Add pond water up to 80–100 cm depth. Replenish 20–30 % of the water volume during spring tide. Maintain 1 m water depth to minimize fluctuations of the water parameters that can cause stress to cultured fish.

Figure 6. Bamboo bridge construction

Nursery operation in net cages

Rear fry in pond-based nursery cages until they reach a weight of 40–50 g, the ideal size for grow-out culture. The nursery set up should be covered with recycled nets to reduce the penetration of direct sunlight because fry are sensitive to ultraviolet rays from the sunlight. Hence, shading must be provided during this stage.

7. Install net cages (5 mm mesh size) with a dimension of 4 m x 3 m x 1.5 m or 5 m x 5 m x 1.5 m prior to stocking (**Figures 7 and 8**). Using net cages in the nursery is recommended for ease in harvesting juveniles.

Figure 7. Pond nursery set up at SEAFDEC/AQD's Dumangas Brackishwater Station

Figure 8. Black net cage with a dimension of 4 m x 3 m x 1.5 m

8. Stock the fish with 1-inch body length into the cage at a density of 150 pieces per cubic meter during the cooler part of the day. Allow them to acclimatize for 20–30 minutes by letting the transport bag float in the water while adding pond water gradually into the transport bag before releasing them into the cage (**Figure 9**).

9. Feed the fish with commercial feeds (crude protein: 35–37 %; crude fat: 7–8 %) three times daily at 9:00 a.m., 12:00 p.m., and 5:00 p.m. Calculate the daily feeding ration using the formula below. Adjust the feeding ration every month based on the average body weight (ABW) during sampling (**Table 1**). If *Gracilaria* (**Figure 10**) or filamentous algae are abundant in the area, siganids can be fed a 50 % mixture of these algae and commercial diet.

Figure 9. Stocking of fish in net cages

Figure 10. *Gracilaria* sp. "*gulaman*" natural food

Daily feeding ration of feeds

= Total number of fish x average body weight x feeding rate

***Example:* Daily feeding ration of feeds** = 900 pcs x 0.5 g x 12 %
= 54 g/day

Daily feeding ration of "gulaman"

= Total number of fish x average body weight x feeding rate x feeding percentage / dry weight (16 % constant)

***Example:* Daily feeding ration** = 900 pcs x 0.5 g x 12 % x 50 % / 16 %
= 169 g/day

Table 1. Feeding rate and feed type according to fish body weight in the nursery phase

Estimated average body weight (g)	Feeding rate (%)	Feed type
0.5–10	12	crumble
11–20	10	starter
21–30	7	starter
31–60	6	starter

Harvest/packing/transport of juveniles

10. Harvest the fish when they reached 30–50 g average body weight. Fish may be sold to buyers or transferred from the nursery to grow-out ponds. Harvesting and transporting juveniles should be done early in the morning or late in the afternoon to minimize fish stress.

    Release the bottom rope and place a bamboo pole (floater) beneath the net cage during harvest. Concentrate the fish on one side of the net cage by rolling the bamboo pole (**Figure 11**). Scoop the fish and sort them by size using a scoop net (**Figure 12**).

Figure 11. Harvesting of fish in the net cage

Figure 12. Sorting of juveniles

If sold to buyers, prepare the materials for juvenile packing prior to harvest. Fill the double-lined transport bag (20 in x 30 in) with 4–5 liters of clean pond water and place it inside a styrofoam box (16 in x 23 in x 18 in). This size styrofoam box will hold about 2–3 transport bags filled with water (**Figure 13**). Pack the fish at a density of 5–6 juveniles per liter and oxygenate until the air space is the same volume as the water (1:1) to meet the requirements during transport. To keep the cool temperature inside the styrofoam box during transport, add 150–200 g of ice wrapped in newspaper and place it between the double-lined transport bags. Packing tape should be used to secure the box.

Figure 13. Packing of fish for buyers

Transfer of juveniles from nursery to grow-out ponds

11. Juveniles can be transported from nursery to grow-out ponds using an improvised-mobile net cage (**Figure 14**), pails, and fish tubs “banyera” (**Figure 15**) without aeration. The improvised-mobile net cage can only be used when transporting fish adjacent to ponds or within the pond, whereas pails and fish tubs “banyera” can be used throughout the farm. The density of live transport using fish tubs and pails is 10 pieces per liter, whereas the density of live transport using an improvised-mobile net cage is 100–150 pieces per cubic meter.

Figure 14. Transferring of juveniles using improvised-mobile net cage

Figure 15. Transferring of juveniles using fish tub “banyera” (200 L capacity)

Grow-out culture in pond

Rear fish in the pond from juveniles (30–50 g body weight) to marketable size (250–300 g average body weight).

Figure 16. Grow-out culture of siganid in a brackishwater pond at SEAFDEC/AQD’s Dumangas Brackishwater Station

12. Stock the juveniles in the grow-out ponds at a density of 5,000 per hectare (semi-intensive) during the cooler part of the day (**Figure 17**). Acclimatize the fish for 20–30 minutes prior releasing to the pond (refer to **Bullet No. 8**).

13. Feed the fish 2–3 times per day (**Figure 18**). Calculate the daily feeding ration using the formula on **page 8** and the feeding rate and feed size from **Table 2**. When feeding, you may train the fish to respond to sounds, such as bamboo tapping, to attract them to the feeding area. Because bigger fish are more dominant than smaller ones, broadcast the feeds in a 360-degree circle around the feeding area.

Figure 17. Stocking of juveniles in the pond

Figure 18. Feeding of fish

Table 2. Feeding rate and feed size according to fish body weight in grow-out culture

Estimated average body weight (g)	Feeding rate (%)	Feed type
31–60	4.5	starter
61–100	4.0	grower
101–150	3.5	grower
151–350	3.0	finisher

14. Stock is sampled on a monthly basis to adjust feeding rations and monitor health. Collect 50-100 fish samples from the pond using a seine net (**Figure 19**). Weigh the samples in bulk to estimate the biomass feeding adjustments (**Figure 20**).

15. Monitor the water quality daily by checking water parameters such as salinity, transparency, temperature, pH level, and dissolved oxygen (**Figure 21**) to ensure that they are within the optimum range (**Table 3**).

Figure 19. Seining

Figure 20. Weighing of fish samples

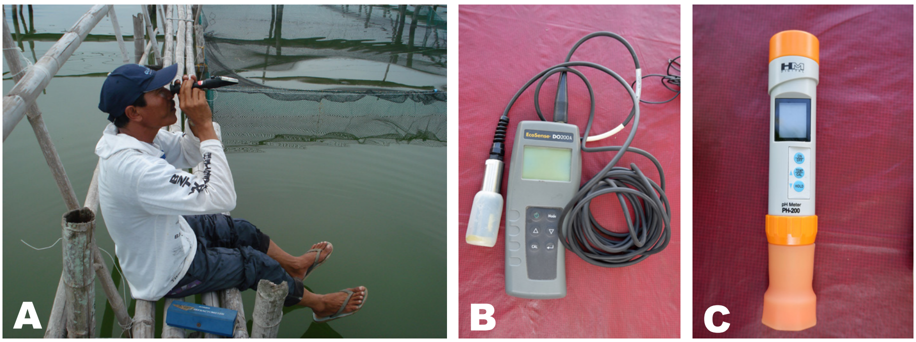

Figure 21. Instruments used in monitoring water parameters: refractometer for salinity (**A**), D.O. meter for dissolved oxygen and temperature (**B**), and pH meter for pH level (**C**)

Table 3. Recommended water parameter levels for rabbitfish culture in ponds

Parameters	Ranges for best growth
Pond depth	≥1 m
Salinity	20–32 ppt
Temperature	25–32 °C
pH	6.5– 8.5
Dissolved oxygen	4.0– 6.8 ppm
Unionized ammonia (NH_3–N)	<1.0 ppm
Nitrite nitrogen (NO_2–N)	0–0.05 ppm

16. Aeration is needed for semi-intensive culture. One paddlewheel aerator (1 hp) (**Figure 22**) is used when the fish biomass reaches ≥500 kg and especially during bad weather conditions where the dissolved oxygen drops below 4 ppm. An additional 1 hp paddlewheel can be installed when the fish biomass reaches ≥1,000 kg. Paddlewheels can be operated from 6:00 p.m. to 6:00 a.m. of the next day when there is no sunlight.

17. It is best to check the pond and cages to avoid the escape of stocks in the culture system. In a pond culture system, seepages and leakages (**Figure 23**) occur mostly in sandy loamy soil or due to the presence of unwanted species such as eel and crabs. This should be repaired immediately to avoid loss of water. Moreover, screens in the gate should also be checked regularly.

    In a net cage culture system, it should be checked and cleaned monthly during sampling to prevent the growth of fouling organisms and promote good water exchange.

18. Harvest the fish when they attain the average body weight of 250–300 g. Harvesting should be done after water replenishment during high tide. Avoid feeding them for 24 hours before disposal to allow them to defecate or discharge feces. Partial harvesting by selecting the good sizes can be done by seining and placing them temporarily in a net cage in the pond (**Figure 24A**) at a density of 3–5 pc/m^2. Prices may differ according to their size. Bigger sizes command a higher price than the smaller ones. When harvesting, wear appropriate gloves to prevent being stung by the spines of the rabbitfish that secrete venom. Observe the

Figure 22. Electric-powered paddlewheel (1 hp)

Figure 23. Repair of leakages and seepages in the dike near the gate

3 C's in handling the fish namely, **CARE**, keep **CLEAN** (**Figure 24B**), and maintain them in a **COOL** (**Figure 24C**) environment. To preserve freshness, chilling should be done by using 3–4 blocks of ice per ton of fish during disposal.

Figure 24. Harvest of rabbitfish held temporarily in net cages in the pond (**A**), cleaned rabbitfish (**B**), and chilling of the harvested fish (**C**)

19. Count the total remaining stock of fish and weigh 10 % of the stock, which will serve as the sample size in determining the average body weight. Then compute for specific growth rate (SGR) and feed conversion ratio (FCR) using the formulas below:

Average body weight (ABW) $= \dfrac{\text{Total weight of fish}}{\text{Number of fish}}$

Survival rate (%) $= \dfrac{\text{Final number of live fish}}{\text{Total number of fish stocked}} \times 100$

Specific growth rate (SGR) $= \dfrac{\ln \text{final ABW} - \ln \text{initial ABW}}{\text{Days of culture}} \times 100$

Feed conversion ratio (FCR) $= \dfrac{\text{Total feed used}}{\text{Final biomass} - \text{Initial biomass}}$

Biomass (kg) $= \dfrac{\text{ABW (g)} \times \text{number of survivors}}{1\,000}$

Table 4. Rabbitfish nursery culture in pond-based net cages fed SEAFDEC-formulated diet

Culture system	Total area (m^2)	Initial weight (g)	Initial stock (pcs)	ABW (g)	ATL (cm)	Survival (%)	Biomass (kg)	Feed consumed (kg)	SGR	FCR	DOC
Net cages (5 m x 5 m x 1 m)	25	3.5	1,127	34	11	98	38	46	4	1.35	60
Pond culture	700	9.1	1,600	43	12	93	63	71	3	1.5	45

Table 5. Record of ABW (initial weight during stocking and at harvest), survival, biomass, feed consumed, specific growth rate (SGR), feed conversion ratio (FCR), and days of culture (DOC) of rabbitfish grow-out pond culture fed commercial and SEAFDEC-formulated diet

Initial weight (g)	Initial stock (pcs)	Total area (m^2)	Feed Type	ABW (g)	ATL (cm)	Survival (%)	Biomass (kg)	Feed consumed (kg)	SGR	FCR	DOC
37	350	700	[1]S	260	22	87	82	177	1.7	2.6	150
37	800	1,600	S	249	22	100	199	411	1.6	2.5	150
50	2,100	4,200	S	273	23	96	551	1,117	1.3	2.5	135
*63	2,096	4,200	[2]C	251	21	100	526	929	1.6	2.3	105
*63	2,032	4,200	S	270	21	100	549	975	1.7	2.3	105
*63	640	4,400	S	319	23	84	172	359	1.6	2.3	105
85	350	700	S	238	22	97	83	130	1.0	2.4	105
99	2,470	8,400	S	258	22	99	611	1,404	0.9	2.3	105

*Stocks tested positive for Viral Nervous Necrosis disease through nested-PCR
[1]**S** - SEAFDEC/AQD formulated diet
[2]**C** - Commercial diet (Santeh)

4 Common Diseases and Preventive Measures

Disease	Source of infection and risk factors	Affected organs	Signs	Effects	Preventive measures
Viral Nervous Necrosis (VNN)	• Poor environmental condition • Infected breeders • Feeding of infected fish bycatch	• Brain • Eyes • Spinal cord • Liver • Intestines and other internal organs	• Dark coloration • Whirling swimming • Lethargy • Hyper-inflated swim bladders	• High mortality	• Pre- and post-spawning screening of breeders • Disinfection of fertilized eggs using ozone or iodine • Remove the head part of fish-by catch prior feeding to cultured species or breeders • Strict implementation of biosecurity protocols
Caligids or sea lice infestation	• High stocking density • Contamination • Water turbidity • Poor water exchange • High salinity (≥30 ppt)	• Fins • Skin • Eyes • Gills • Mouth	• Skin erosion • Hemorrhagic eyes and fins • Sluggish • Loss of appetite • Excessive mucus	• High or mass mortality	• Sufficient water exchange • 10–15 minutes freshwater bath • Bath treatment with 150 ppm hydrogen peroxide (H_2O_2) for 30 minutes • Lower the salinity to 20–25 ppt • 200–250 ppm formalin bath for 1 hour

Disease	Source of infection and risk factors	Affected organs	Signs	Effects	Preventive measures
Trichodiniosis	• High stocking density or intensive culture • Poor water exchange • High levels of organic matter in the water culture facilities • Poor handling	• Skin • Gills	• Skin and gill lesions • Fin rot • Lethargy • Swim at the surface • Loss of appetite	• High or mass mortality • Respiratory problem • Secondary infection	• Freshwater bath for 1 hour for 3 days • 200 ppm formalin bath for 30–60 minutes with strong aeration • 25–30 ppm formalin bath for 1–2 days
Nematode infection	• Horizontal transmission by feeding infected fish bycatch	• Intestines • Stomach	• Internal bleeding • Loss of appetite	• Heavy infection can cause mortality	• Avoid feeding infected fish bycatch • Eliminate intermediate hosts (copepods) • Dry the pond bottom • Disinfection of culture facilities with quicklime to destroy the egg of nematode • Water filtration

5 Economic Analysis

This section presents the economic analysis of rabbitfish juvenile production in earthen ponds using net cages and a semi-intensive grow-out operation.

Nursery production in pond-based net cages

Table 6 shows the technical information of the nursery operations in pond-based net cages. In nursery operations, 6,000 fry are stocked in net cages in a pond with a total area of 4,000 m^2. Each net cage having a dimension of 2 m x 3 m x 1.2 m is stocked with 100 fry with an average body length (ABL) of 2.5 inches. In the 60-day culture period, it is expected that 98 % of the total fry stocked in the pond-based nursery net cages will survive, hence 5,880 pieces of juveniles are to be recovered. Juveniles have an average body weight (ABW) of 50 grams with an average body length of 5 inches. Juveniles are sold at Php 4.50/inch, hence, harvested juveniles are sold at Php 22.50 per piece.

Table 6. Technical information of rabbitfish nursery in pond-based net cages

Project duration (years)	3
Total pond area for stocking (m^2)	4,000
Number of cages (2 x 3 x 1 m)	10
Total volume of cages (m^3)	60
Number of crops/year	5
Stocking density (pcs/m^3)	100
Total number of stock per crop	6,000
ABL at stocking (in)	2.5
Days of culture	60
Feed conversion ratio	1.35
Survival rate (%)	98
Total recovery at harvest per crop (pcs)	5,880
ABW at harvest (g/pc)	50
ABL at harvest (in)	5
Selling price per inch body length (Php)	4.5
Farm-gate selling price (Php/pc)	22.5
Gross value of harvest per crop (Php)	132,300

Table 7 shows the investment items that must be acquired before the operation and their corresponding costs. These items are necessary for the smooth operation and production of rabbitfish juveniles. It is required in a nursery operation to invest at least Php 85,000 for the construction of a field hut, procurement of water pump and motor, nets, bamboo, and other necessary items. It is an advantage if a farmer owns or rents a pond for a long duration to save costs from renting and the money saved can be used to acquire a new set of equipment. The economic life of each item is also listed in the table. Depreciation is calculated using a straight-line method in which the salvage value (Php 10,800) of other items is also considered. Annual depreciation amounted to Php 24,733.

Table 7. Investment Items, Costs, Depreciation and Re-investments

Items	Cost (Php)	Economic Life (years)	Depreciation	Salvage value after 3-year project duration
Field hut	30,000	3	10,000	0
Water pump (1 hp)	27,000	5	5,400	10,800
Nets	20,000	3	6,667	0
Bamboos	3,000	3	1,000	0
Miscellaneous items (basins, pails, etc)	5,000	3	1,667	0
Total (Php)	**85,000**		**24,733**	**10,800**

The cost and return analysis of nursery operation is shown in **Table 8**. The table shows the production costs on a cropping basis and is multiplied by the number of runs per year (5 runs) to obtain the annual production costs. It is expected that Php 132,300 would be gained from selling juveniles per crop leading to an annual gross revenue of Php 661,500. Costs of production consist of variable and fixed costs. Variable costs include costs of juveniles, feeds, hired labor, miscellaneous items, and maintenance and repairs. Fixed costs consist of pond rent, depreciation, labor, and interest. As shown in the table, the main driver of cost is the price of juveniles which constitutes 44 % of the total costs, followed by 20 % dedicated to the salary of pond aide. Feeds, on the other hand, only account for 18 % of the total costs as FCR is only 1.35. The total production cost per crop amounted to Php 101,297, hence the annual production cost amounted to Php 506,486.

The net income per crop is Php 31,003 and the annual net income is Php 155,014. Hence, return on investment (ROI) is equal to 182.37 % and the payback period is equal to 0.55 years. The amount initially invested can be recovered after 3 runs only assuming other things are held constant. Break-even points for price and production are Php 17.23/pc and 4,502 pcs./crop, respectively.

Considering a 3-year continuous operation, the net present value (NPV) at a social discount rate of 10 % amounted to Php 347,056. The NPV is greater than 0 and is positive, thus, the rate of return is more than the discount rate used (10 %), and therefore, the investment would be economically feasible. The internal rate of return is 208 % and the discounted benefit-cost ratio is 1.42 hence, the investment is economically viable and feasible (**Table 9**). The net profit margin is estimated to be at 23 % which can be deliberately increased up to 45 % for a backyard farm or a family business.

Hence, rabbitfish nursery production, as shown in the economic analysis, is a feasible and profitable business venture.

Table 8. Cost and return analysis

Gross revenue per year	661,500
Yield per crop (pcs)	5,880
Price per piece	22.5
Gross revenue per crop	132,300
Number of crops per year	5
Costs	
A. Variable costs	
Fry	45,000
Feeds	17,861
Miscellaneous items (Php 5,000/ha)	2,500
Maintenance and repairs, 2 % of investment costs	1,700
Hired labor/harvester (Php 400/day)	4,000
Total variable cost per crop	***71,061***
Total variable cost per year	***355,303***

B. Fixed costs	
Rent of pond (Php 20,000/ha)	2,000
Permits and licenses (Php 5,000/yr)	1,250
Depreciation cost	4,947
Pond aide salary (Php 10,000/month)	20,000
Interest on investment cost	2,040
Total fixed cost per crop	***30,237***
Total fixed cost per year	***151,183***
Total production cost per crop (Php)	***101,297***
Total production cost per year (Php)	***506,486***
Economic efficiency indicators	
Gross revenue per year (Php)	661,500
Net income per year (Php)	155,014
Return on investment (ROI, %)	182.37
Return on variable costs (%)	43.63
Return on feed cost (%)	867.92
Payback period, years	0.55
Break-even price of juveniles (Php/pc)	17.23
Break-even production (pcs/crop)	4,502

Table 9. Financial Investment Analysis

	Year 0	Year 1	Year 2	Year 3	Total
Gross Income (Php)		661,500	674,730	688,225	2,024,455
Investment Cost	85,000	0	0	0	85,000
Variable & fixed cost, less depreciation	0	481,753	486,570	491,436	1,459,758
Total cost investment & operating costs	85,000	481,753	486,570	491,436	1,544,758
Net Income, including earnings from depreciation	-85,000	179,748	188,160	196,789	479,696
Net Present Value (NPV)					347,056
Internal Rate of Return (IRR, %)					207.82
Discounted Benefit-Cost Ratio (DBCR)					1.42

Semi-intensive grow-out operation in earthen ponds

In this section, an economic analysis of a grow-out culture in semi-intensive operation is discussed. **Table 10** shows the technical information of the grow-out culture of the two types of operation. As shown, in a semi-intensive operation, the total pond area needed per operation is one hectare and must be stocked with 5,000 juveniles (50 g ABW). With a survival rate of 95 %, 4,750 pieces of marketable size rabbitfish are expected to be recovered during harvest. Semi-intensive operation has a feed conversion ratio of 2.5. It is expected that rabbitfish can reach the weight of at least 300 grams after 135 days of culture in a semi-intensive operation. Hence, 1,425 kilograms per crop is expected in a semi-intensive operation.

Table 10. Technical information on semi-intensive grow-out operation

Project duration (years)	3
Total pond area for stocking (ha)	1
Number of crops/year	2
Stocking density (pcs/ha)	5,000
Total number of stock per crop	5,000
ABW at stocking (g)	50
Days of culture (DOC) at harvest	135
Feed conversion ratio	2.5
Survival rate (%)	95
Total recovery at harvest per crop (pcs)	4,750
ABW at harvest (g/pc)	300
ABL at harvest (cm)	14
Farm-gate price per kg body weight (Php)	300
Volume of production (kg)	1,425

Meanwhile, **Table 11** shows the different items that must be considered for the grow-out culture. In a semi-intensive operation, a total of Php 93,476 is needed to be invested for the construction of the field hut, acquisition of bamboo poles for walkways, nets, and other miscellaneous items, water pump and motor, and paddlewheel. Annual depreciation amounted to Php 22,000 using a straight-line method.

Table 11. Investment Items, Costs, Depreciation, and Re-investments

Items	Cost (Php)	Economic Life (years)	Depreciation	Salvage value after 3-year project duration
Field hut	30,000	3	10,000	0
Bamboo poles for foot walk	3,000	3	1,000	0
Seine net	3,000	3	1,000	0
Miscellaneous items (basins, pails, etc)	2,476	3	825	0
Water pump (1 hp)	27,000	5	5,400	10,800
Paddle wheel (1 hp)	28,000	5	5,600	11,200
Total (Php)	**93,476**		**23,825**	**22,000**

Table 12 is showing the cost and return analysis of the grow-out operation. As the harvest is valued at Php 300 per kilogram, the gross revenue per crop is Php 427,500, thus, annual gross revenue is Php 855,000.

The costs of production include items similar to that of the nursery operation. However, in grow-out culture, the feed cost accounts for 43 % of the total cost and the labor cost accounts for 14 % of the total cost. The cost of juveniles occupies 33 % of the total costs. The total production cost per crop amounted to Php 344,794, while the annual production cost amounted to Php 689,589.

Semi-intensive operation has an annual income of Php 165,411 or Php 82,706 per crop. Return on investment (ROI) and payback period are 176.96 % and 0.53 years, respectively. The net profit margin is at 19 %, which means that each operation has a profitability ratio equivalent to 0.19 for every peso gained from selling the harvested rabbitfish.

The discounted economic values in **Table 13** such as net present values are Php 365,141, while IRR is 199 % and benefit cost-ratio is almost close to Php 1.23, respectively.

As shown by this analysis, engaging in this operation would result in a profitable and feasible production of market-size rabbitfish.

Table 12. Cost and return analysis for grow-out operation

Gross revenue per year (Php)	855,000
Yield per crop (pcs)	4,750
Price per kilogram	300
Gross revenue per crop (Php)	427,500
Costs	
A. Variable costs	
Juveniles	112,500
Feeds	147,844
Fuel	3,000
Miscellaneous items (pond preparation and predator eradication) (Php 5,000/ha)	5,000
Maintenance and repairs, 2 % of investment costs	1,870
Hired labor/harvester (Php 400/day)	4,000
Total variable cost per crop	***274,213***
Total variable cost per year	***548,427***
B. Fixed costs	
Rent of pond (Php 20,000/ha)	10,000
Permits and licenses (Php 5,000/yr)	2,500
Depreciation cost	11,913
Pond aide salary (Php 10,000/month)	45,000
Interest on investment cost	1,168
Total fixed cost per crop	***70,581***
Total fixed cost per year	***141,162***

Total production cost per crop (Php)	***344,794***
Total production cost per year (Php)	***689,589***
Economic efficiency indicators	
Net income per crop (Php)	82,706
Net income per year (Php)	165,411
Return on investment (ROI, %)	176.96
Return on feed cost (%)	111.88
Payback period, years	0.53
Break-even price (Php/kg)	241.96
Break-even volume of production (kg/crop)	3,831

Table 13. Financial Investment Analysis for Semi-intensive Operation

	Year 0	Year 1	Year 2	Year 3	Total
Gross Income (Php)	0	855,000	872,100	889,542	2,616,642
Investment Cost	93,476	0	0	0	93,476
Variable & fixed cost, less depreciation		665,763	672,421	679,145	2,017,330
Total cost investment & operating costs	93,476	665,763	672,421	679,145	2,110,806
Net Income, including earnings from depreciation	-93,476	189,237	199,679	210,397	505,836
Net Present Value (NPV)					365,141
Internal Rate of Return (IRR, %)					199.04
Discounted Benefit-Cost Ratio (DBCR)					1.23

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

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- 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
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