MASS PRODUCTION OF QUALITY MARINE FISH FINGERLINGS BY IN-POND FLOATING RACEWAYS

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INTRODUCTION

Recent development of marine fish farming in coastal waters of Vietnam demands more quality fingerlings for stocking. Consequently, tremendous effort has been invested in establishing reliable hatchery production for several popularly-cultured species such as the Asian seabass *(Lates calcarifer)*, groupers *(Epinephelus spp.)* and cobia *(Rachycentron canadum)*. While a significant number of fingerlings have been produced by the local hatcheries, the fish are still too small for stocking in grow-out ponds or net cages. Tank production of large-sized fingerlings is possible, but is costly and requires large nursing area. Meanwhile advanced nursing in ponds is often associated with poor survival and very limited management over fish health. To address this problem the CARD VIE062/04 Project adopted the principles of in-pond floating raceway and successfully developed effective methods for grow-out production in Australia and mass production of large-sized marine fish fingerlings with high quality at low costs in Vietnam.

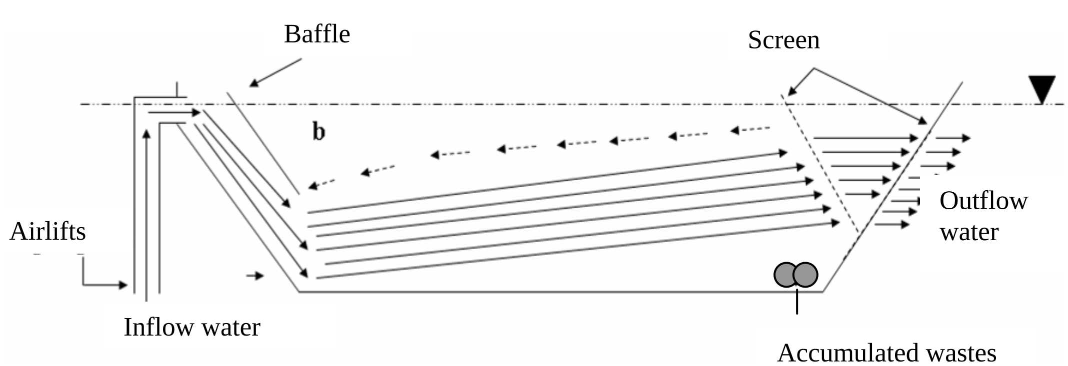

Figure 1: Working principles of in-pond floating raceway

Floating raceways (FRs) have been experimented successfully for freshwater fish farming in USA (Masser & Lazur 1997), Germany (Gottschalk et al. 2005) and Australia (Burke et al. 2007). Basically, FR is a long, narrow tank; either self-floating or supported to float in a reservoir pond or sheltered waters. Water is circulated continuously through the raceway by an air-lift system, which also helps increase dissolved oxygen level. Thanks to high water exchange rate fish can be stocked as high density, up to 70 kg/m^3. Since the cultured fish are condensed in the raceway observation, feeding and handling (e.g. examining fish health, grading, harvesting, etc.) are all convenient and effective, requiring much lesser labour. Using in-pond floating raceways for nursing fish fingerlings at early stages can also make use of natural foods, if available in the reservoir pond.

In this report we present the design of the SMART (Sustainable Mariculture Technology) floating raceway system and nursing protocol, developed by the CARD VIE062/04 Project “Intensive in-pond raceway production of marine finfish”. Results of different trials, both experimental and commercial, are used intermittently to further portray the system.

2. NURSING SYSTEM DESIGN

The nursing system was designed for mass production of large-sized marine fish fingerling of popularly-cultured species such as the Asian seabass, groupers and cobia. It consists of a set of floating raceway units, supporting facilities and a reservoir pond. The size of reservoir pond depends on the biomass of nursed fish, estimated as (total number of fish to produced)/(3*nursing density for pond).

2.1 Reservoir pond

A standard system includes a 2000-m^2 coastal reservoir pond (Fig. 1). Pond sides can be lined with plastic sheet. Pond water depth should be 1.7 – 2.0 m. However, shallower ponds with water depth about 1.2 m are also possible. The reservoir pond is partitioned by a plastic wall placed right in the middle of the pond, creating a circle for water flow within the pond. Water is circulated around the pond with the aid of a 2-hp paddle wheel.

2.2 Floating raceway units

Depend on production scale either SMART-1 or SMART-2 raceway is used. Both versions are made of fiberglass, but SMART-2 (6 m^3) is larger than SMART-1 (3 m^3) in terms of working volume. Fiberglass was selected as the material to build raceways in Vietnam as it is durable, weather proof and easy to clean or move around.

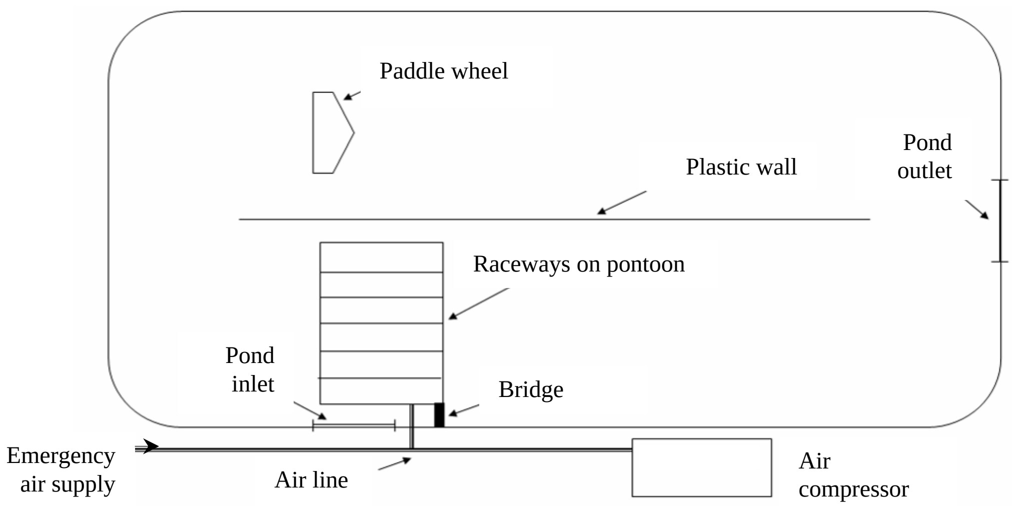

Figure 1: Pond and in-pond floating raceways

2.2.1 SMART-1 raceway

SMART-1 is the first version designed by the CARD VIE062/04 Project for advanced nursing of marine finfish in abandoned shrimp ponds along the coast. Its design was detailed in Hoang et al. (2007) and Luu (2006). Each unit has a working volume of about 3 m^3 (Fig. 2). The inlet end of SMART-1 is equipped with an airlift system, which pumps water through the raceways continuously at circa 350 L/min. A baffle is placed 20 cm right after the airlifts, directing water flows to the bottom. This helps clean the raceway, facilitate waste collection and create a quiet surface area after the baffle for feeding. Shade cloth is used to cover the raceway surface keeping fish from escaping and predators from intruding. A wooden-framed plastic net (mesh size 2 mm, V-shaped with two wings) is attached on the raceway outlet to keep the nursed fish inside and away from water flow pressure (Fig.2).

The airlift system is made of ∅90-mm PVC pipes. Each set included four airlifts connected to each other by an air-feeding pipe made of ∅21-mm PVC (Fig.3). This pipe is constructed like a frame to support the four airlifts and ensure equal air pressure among the releasing holes. Holes of 3.0 mm in diameter were drilled on the lower part of the air-feeding pipe to release air into each of the airlifts. The distance from water surface to these holes is 80 cm. Water exchange rate is 100% every 15 minutes.

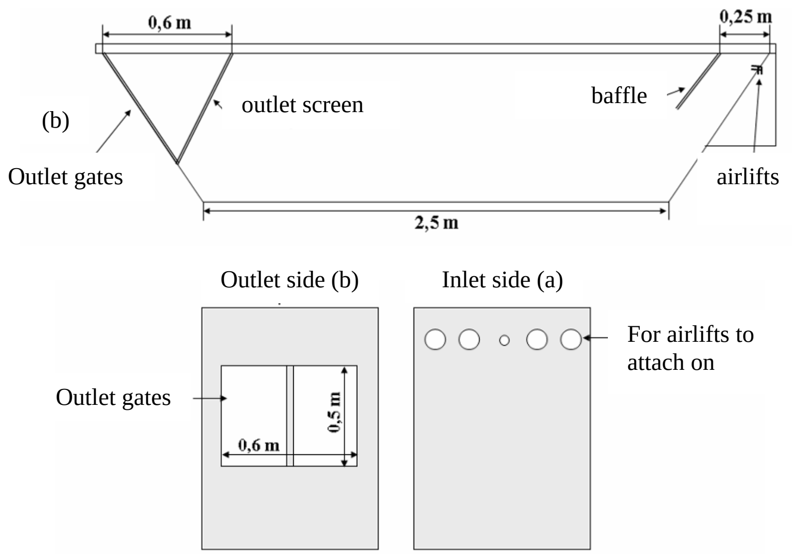

Figure 2: SMART-01 design – Raceway body

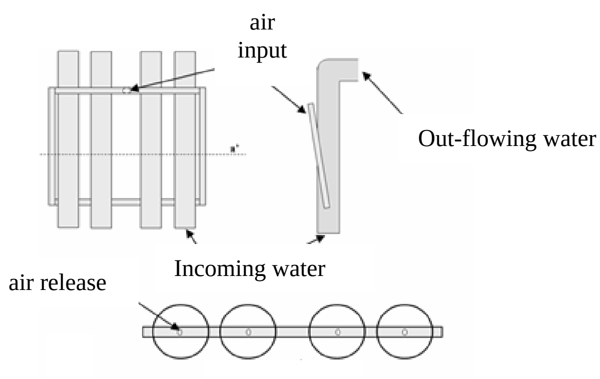

Figure 3: Design of the airlift system

SMART-1 is not self-floating. Therefore, a simple pontoon made of wood and 200-L HDPE drums is needed to support the raceways. Side walkway is 60 cm wide, enough for workers to move around and work. The raceways are hung on the pontoon by Ø14 mm bolts (450 mm long), 5 – 10 cm from water surface. Alternatively, to reduce capital cost a solid frame is built from the pond bottom, emerging about 20 cm above the water surface.

SMART-1 raceways are then attached on this frame. Pond water depth should be kept stable at a right level to facilitate operation of the airlift system.

2.2.2 SMART-2 raceway

Although the nursing results were very good with SMART-1, its design showed a number of technical limitations in operation. Therefore, SMART-2 was developed to address these limitations and increase the production scale (Hoang & Huynh 2008). First, the working volume of SMART-2 is 6 m^3, double that of SMART-1 allowing farmers to nurse more fingerlings. Second, the supporting pontoon for SMART-1 was too heavy and difficult to clean or move around. Further, capital cost was relatively high. Thus, SMART-2 is made as a self-floating unit. The raceway body is attached to a fiberglass chamber running along its surface and stuffed with Styrofoam. SMART-2 weights only 400 kg and can be moved around easily. This makes the raceway more mobile and can be operated instantly when placed in a reservoir pond (Fig.4).

Figure 4: SMART-2 raceway

Third, for SMART-1 the airlift system was fixed on the raceway body. Thus, when more weight (e.g. more workers) was applied on the supporting pontoon, the whole system was pushed down to the pond bottom, changing the depth from water surface to the air-releasing holes. As a result, higher pressure of the water column reduced water flow rate through the airlifts or even blocked some of them. For SMART-2 the airlift system has eight Ø90 airlifts and is allowed to slip up and down along a simple groove made of Ø60 PVC pipe. Water exchange rate is 100% for every 10 minutes. Further, it was found that when the water depth is low, the airlift system of SMART-1 tended to suck sediment from the pond bottom and pumped it into the raceway. To avoid this problem an intake compartment was then created for SMART-2. Pond water will overflow from the surface into the compartment before lifted up by the airlifts. This design allows SMART-2 to operate in shallow ponds as long as the pond water depth is equal to its height. The outlet of SMART-2 is also different from that of SMART-1. A sheet of fiberglass is created 10 cm in parallel with the raceway body, which runs 30^o from its bottom to surface. This creates a sucking power which removes fish waste and uneaten feed from the raceway bottom more efficiently.

2.3 Supporting facilities

In-pond floating raceways are operated by an aeration system. Air blower/compressor with high volume of compressed air and low pressure should be selected. The capacity of the air blower/compressor depends on the production scale. For a set of six SMART-1 or three SMART-2 raceways a 3-HP air compressor with 65 – 70 m^3 of compressed air per hour (e.g. ANLET BSR-40, Made in Japan) should be ample. It is always safe to operate two compressors in roster, i.e. 12 hours each to avoid any technical failure that may occur.

Due to high volume of compressed air the air piping system should start with a large chamber right at the outlet of the air compressor. If not, the air compressor and the pipe will get hot and may be damaged. Soft air pipe (Ø60 and Ø42) is used to construct the air piping system, direct the compressed air to the airlift system of each raceway. Continuous attention should be paid to ensure the air compressors work properly and there is no leak along the pipe. If possible, an alarm system should be installed because no or not enough air supply could result in mass mortality of the nursed fish in minutes. Furthermore, where electricity supply is not reliable, generators should be made available immediately in emergency cases.

3. NURSING PROTOCOLS

3.1 Setting up nursing system

Standard preparation protocol for production aquaculture ponds should be deployed to prepare the reservoir pond. This may include the removal of pond sediment, sundrying, liming and disinfection of water after filling up the pond. Install the raceway system and operate the paddle wheel to circulate water around the reservoir pond.

Fertilizers (organic or inorganic) are then applied to promote a slight bloom of healthy algae. Next, 30-g tilapia are stocked at 0.5 – 1 fish/m^2 in the reservoir pond. It has been demonstrated that the fish can utilized the waste from the raceway system and help maintain a stable algal bloom, which is important for water quality maintenance. Key water parameters such as temperature, salinity, pH and dissolved oxygen (DO) should be checked before stocking.

If the raceways are used for the first time they should be soaked in a pond for at least one week and cleaned thoroughly with freshwater and commercial detergent several times. For raceways which had been used for a while they should be sun dried for a few days, cleaned of fouling materials such as barnacles and macro-algae by high-pressured water jet and finally by freshwater with commercial detergent.

3.2 Stocking and fingerling quality

The SMART raceway system can be used for advanced nursing of species like barramundi, groupers, cobia, mangrove jack, red drum and tilapia. In all cases the quality of fingerlings is of prime importance. They should be disease-free, swimming actively with no sign of abnormal behaviour. For carnivorous species size variation should be minimal to minimize cannibalism. Stocking size and initial density for barramundi, Malaba grouper and cobia are recommended in Table 1. Maximum density at harvest should be kept between 50 and 75 kg/m^3.

Table 1: Recommended stocking size and density for marine fish nursed in SMART floating raceways

Species	Stocking size (total length, mm)	Stocking density (fish/m^3)
Barramundi	15 – 25	3,000 – 6,000
Malaba grouper	30 – 50	2,000 – 3,000
Cobia	50 – 80	1,000 – 2,000

3.3 Feeding

Although minced or chopped trash fish results in fast growth rate in many nursing farms, commercial pellets should be used for ease in management including disease prevention. The CARD VIE062/04 has developed an effective feeding protocol that ensures both fast growth of the nursed fish and competitive production cost.

INVE pellet (granular shape, 800÷1200 μm in size; 56% crude protein content) is used during the first two week of advanced nursing. From week 2 onwards a small proportion of shrimp pellets (e.g. Grobest or UniPresident size 1 or 2) is added to wean the fish. This helps significantly reduce the production cost as INVE pellets for marine fish is six time more expensive than Grobest or UniPresident pellets for *Penaeus* shrimps. High level of lipid has been considered important for development of marine fish at early stages and can be supplemented effectively by coating the shrimp pellets with commercial squid oil (5 – 10 mL/kg) half an hour before feeding. The weaning period takes normally one week. From week 3 onwards feeding can be done merely with shrimp pellets coated with squid oil.

Feeding is conducted six times a day from 06:00 to 18:00. Daily feeding rate is 10 – 18% of total biomass. If automated feeding machines are used, technicians should spend enough time to observe fish during feeding time. The feeding point is after the baffle. While cobia fingerlings actively feed on the water surface, barramundi and Malaba grouper fingerlings feed 20 – 30 cm below water surface. Larger fingerlings of barramundi are often distributed close to airlifts. Thus, feeding should be spread evenly over the raceway surface so that smaller fingerlings can access feed. Also, barramundi will not feed after sunset.

3.4 Raceway and pond management

Raceways should be cleaned daily, using a soft brush. Frequent cleaning also helps train the nursed fish so that they are not too sensitive to handling. With SMART-1 raceways fish wastes and uneaten feed are accumulated at the end of the raceway and should be siphoned out once a day, around 16:00 - 17:00 before the last feeding of the day. Siphoning is not necessary with SMART-2 as the latter version is more effective in removing fish wastes and uneaten feed. Once a week the airlift systems should be cleaned or changed. When water temperature is down to 20 – 22^{o}C, technicians should reduce the feeding rate as the fish normally stop feeding.

The paddle wheel should be operated during night time to supply more oxygen and a few hours during day time, particularly between 13:00 and 15:00 to eliminate thermal stratification. A healthy bloom of pond water should be maintained. Normally, fertilizers are not needed as the wastes of fish from the raceway system provide ample nutrients. Limited feeding for the tilapia in pond is necessary, but should not be conducted too often. Probiotics that help maintain good water quality can be used.

3.5 Prevention of diseases

Observation of the nursed fish's behaviour should be made whenever possible, particularly during feeding time. Once a week the nursed fish are bathed with hydrogen peroxide (H_2O_2) 5 – 10 ppm for 15 minutes. To do this the airlift system is turned off. The raceways will then become static tanks. Additional airstones are placed into the raceways to supply enough DO to the fish. The chemical is then added into the raceway. After 15 minutes turn on the airlift system to pump in new water and flush out the treated water. Freshwater bath was found effective with cobia and Malaba grouper. Cobia is, however, highly sensitive to handling while the hard dorsal spine of Malaba grouper could damage fish eyes.

3.5 Grading and harvesting

Grading helps reduced cannibalism in carnivorous fish and can be done easily with SMART raceways. A scoop net with its width almost equal to the raceway width is highly effective in catching the nursed fish. The net should be soft and have a small mesh size to avoid possible damage to the fish. Grading can then be done quickly through a set of grading trays. Fish at the same size should be restocked in a new raceway for further nursing. At harvesting fish biomass in the raceway is very high. Great attention should be paid to ensure that the airlift system performs well. Cobia can reach 200 – 300 mm in total length and may be too big for transportation in tanks. If possible, the whole raceway should be towed by boat to the grow-out cage for stocking.

4. EXPECTED PERFORMANCE

If the aforementioned nursing protocol is successfully applied, the likely survival after 40 – 45 days of advanced nursing is higher than 85% for barramundi, 90 – 95% for groupers and around 60% for cobia. (Hoang *et al.* 2008). Production cost is much lower than that if nursing is conducted in the other conventional systems such as tank, cages or earthen ponds.

Table 2: Size and production cost of fingerlings nursed in SMART raceways (calculated for 2008, Hoang et al. 2008)

	Barramundi	Malaba grouper	Cobia
Size at harvest (mm total length)	100	120	200
Production cost (VND)	1,551	7,391	9,596
Market price (VND)	7,000	16,000	20,000
Profit margin	2.82	1.16	1.08

5. FURTHER DEVELOPMENT AND APPLICATION

The developed SMART floating raceways and nursing protocol have been adopted successfully by several commercial enterprises in Vietnam, Australia and Malaysia. Further improvement on technical design to increase system stability and productivity is still needed. Currently, our research effort focuses on

(i) The application of floating raceway's working principles to developing a semi-recirculated farming system for the Tra catfish *(Pangasius hypophthalmus)* in the Mekong River Delta of Vietnam.

(ii) Modification of the airlift system of SMART-2 so that the raceway can sustain a biomass of 120 kg/m^3.

(iii) The design of a production system for discus (ornamental fish)

ACKNOWLEDGEMENT

This research was financed by the CARD Program (Collaboration for Agriculture Research & Development) through the Ministry of Agriculture and Rural Development of Vietnam. Special thank is given to GROBEST Vietnam for sponsoring fish feed for our research and other team members including Dr. Nguyen Dinh Mao, Mr. Luu The Phuong, Ms. Banh Thi Quyen Quyen, Mr. Ngo Van Manh at Nha Trang University; Dr. Adrian Collins, Mr. Ben Russel and Mr. Dan Willet at Bribie Island Aquaculture Research Centre (QDPI&F, Australia) for their valuable contribution. We appreciate the support of Nha Trang University, Khanh Hoa Fisheries Extension Center and Queensland Department of Primary Industries & Fisheries, Australia in making this research possible.

REFERENCES

Burke M., Russel B., Collins A. & Hoang T. (2007) Intensive in-pond floating raceway production of marine finfish. *In*: Book of Abstracts, World Aquaculture Society Annual Meeting, 26 February – 2 March 2007, San Antonio, Texas, USA.

Gottschalk T., Füllner G. & Pfeifer M. (2005) Möglichkeiten der Einführung neuer Fischarten als Objekte der Aquakultur in Sachsen. Aufzucht von Hybrid-Streifenbarschen in einer 'In-Teich-Kreislaufanlage', Schriftenreihe der Sächsischen Landesanstalt für Landwirtschaft Heft 14 – 10. Jahrgang 2005.

Hoang T., Burke M. (2007) Floating raceways provide option for marine fish fingerling production. The Advocate Jul

Hoang T., Collins A., Burke M. (2007) Milestone Report No. 2&4 of CARD VIE062/04 Project. CARD Program, MARD, Hanoi.

Hoang T., Burke M., Willet D. (2008) Milestone Report No. 8 of CARD VIE062/04 Project. CARD Program, MARD, Hanoi.

Hoang T., Huynh K.K. (2008) Advanced nursing of seabass using SMART-2 raceway. ViFINET International Aquaculture Workshop, Can Tho Dec 2008.

Luu T. Phuong (2006) Application float raceways to nurse barramundi (*Lates calcarifer* Bloch, 1790) from 2 – 8 cm total length. MSc thesis, University of Agriculture No. 1, Ha Noi (in Vietnamese).

Masser M.P. & Lazur A. (1997) In – pond raceways. Southern Regional Aquaculture Center, SRAC Punblication No. 170.