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Cobia *Rachycentron canadum* aquaculture in Vietnam: Recent developments and prospects

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ABSTRACT

The paper presents a review of the recent developments in research and production of cobia in Vietnam in hatching and cage farming, which have made Vietnam the 3rd largest producer of farmed cobia in the world. Conservative estimations for the 2007 production for the Asian-Pacific region exceed 35,000 t, with remaining global production adding an additional 2000 t, while official farm production registered by FAO is considerably lower. Estimated 2008 production in Vietnam was 1500 t, following the major production of PR China and Taiwan Province of China. This review reports on the various aspects of hatchery technology such as broodstock management, intensive and semi-intensive larval rearing, fry transportation as well as small-scale grow-out in wooden raft cages and large-scale in Norwegian style circular HDPE cages. Some of the prospects for accelerating future development of this species in aquaculture and challenges to be solved are also identified.

1. Introduction and background

Cobia has gained popularity as a good candidate for mariculture due to its rapid growth and white meat of versatile use (Shiau, 2007). Research on natural cobia populations commenced in the 1960s in the United States (Franks et al., 1999; Joseph et al., 1964) and the potential of cobia aquaculture was first proposed by Hassler and Rainville (1975). However, already during the 1970s cobia farming had started on a small-scale in Taiwan. During 1993–1995 annual aquaculture production was stagnant around 200 tons based on wild-captured fingerlings (Svennevig, *Pers. Comm.*). The first cobia reproduction took place in Taiwan in 1994 (Liao et al., 2001) and mass reproduction was achieved since 1997 (Liao et al., 2004).

Due to the rapid growth of cobia and its suitability for commercial production, cobia aquaculture has become more and more popular. To date, research and development of cobia aquaculture has been initiated in over 23 countries and territories, half of them in the Asian-Pacific region. Statistics of FAO (2009) show that the global aquaculture production of cobia has been increasing rapidly from only 9 tn in 1997 to nearly 30,000 tn in 2007. Meanwhile, the volume from capture fisheries has remained stable, around 10,000 tn annually (Fig. 1). While cobia was produced in a number of countries in 2007, only figures from 3 countries/territories including PR China, Taiwan Province of China and Reunion/Mayotte were specified in the 2007 statistics (Table 1). It is estimated by the authors that in 2008, Vietnam has produced 1500 tn thus, being the third largest cobia producer in the world.

History of cobia aquaculture in Vietnam dates back to 1997 when research on cobia reproduction started, leading to the first successful production of about 12,000 fingerlings in 1999 at a marine hatchery located in Cat-ba Island, Hai-phong province. In 2002, the first commercial batches of more than 20,000 cobia fingerlings were produced under a project co-funded by the Government of Vietnam and the Government of Norway. Since then, research on improvement of larviculture technology of cobia has resulted in better growth, survival and production. During 2008, more than 400,000 fingerlings were produced at a hatchery of the Research Institute for Aquaculture No1 (RIA-1) at Cat-ba Island in addition to a smaller number produced at a private hatchery at Khanh-hoa province.

Earlier farming of cobia – mainly in the southern Vung-tau region depended on imported fingerlings, but the more stable fingerling availability has now led to several larger fish farms to grow cobia – the Norwegian financed Marine Farms Vietnam being the largest. The production during 2009 from the latter company could reach 1000 tn.

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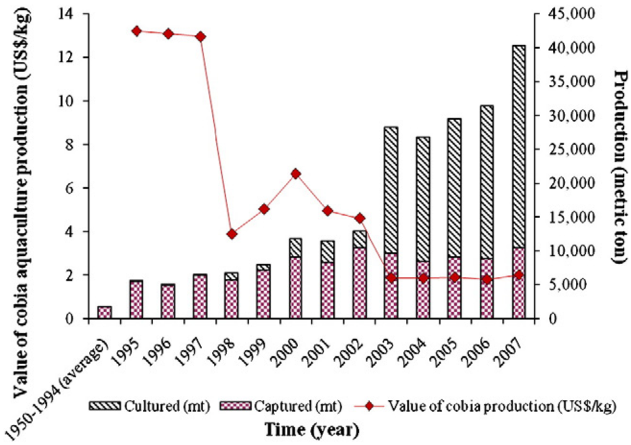

Fig. 1. Global production and value of cobia (FAO, 2009).

2. Hatchery technology

Hatchery technology of cobia generally involves broodstock conditioning and management, induced breeding, egg collection and incubation, larval rearing and nursing until fingerling stage.

2.1. Broodstock management

Details of cobia reproduction at marine hatchery scale in Vietnam were firstly described by Nhu (2005). Cobia used for broodstock are produced from hatchery juveniles and reared in sea cages. The breeders are PIT tags (internal passive integrated transponder) for better management i.e. to keep breeding history and to eliminate inbreeding problems.

Cobia broodstock are fed raw fish (RF) at a daily feeding rate of 3–5% of body weight. About 3 months prior to onset of spawning, a supplement of squid liver oil, vitamin and mineral-premix are given daily till the end of the spawning season. The first research on formulated diets for cobia broodstock was conducted by Nguyen et al. (2010) by studying the effect of dietary essential fatty acid (EFA) levels on spawning performance and egg fatty acid composition. This study showed that the cobia broodstock fed formulated diets with a similar composition, but different (n-3) highly unsaturated fatty acid (HUFA) levels, (0.94–1.72%, in dry weight (DW)) matured, spawned and had comparable eggs sizes, batch fecundity and batch larval production to those of broodstock fed RF with n-3 HUFA level of 1.86% DW. The fatty acid composition in broodstock diets influenced directly the fatty acid composition of the eggs (Nguyen et al., 2010).

Under captive conditions in sea cages in the North of Vietnam, cobia spawn naturally from late April to July with a peak in May. However, in south central Vietnam, where the water temperature is high all year around, the spawning can be induced except during the monsoon (November–January). The short breeding season of cobia in cages in the North of Vietnam created difficulties in the production of fingerlings during the first development stage (1998–2005). Exceptionally, some matured breeders have been detected during the autumn (October–November) in 2004 and some spawns occurred in late 2006 resulting in a production of around 15 million larvae at the marine hatchery in Hai-phong (RIA-1). This investigation opened the possibility to expand the availability of cobia fingerlings.

Table 1
The countries involved in cobia production in 2007 (FAO, 2009).

Countries/territories	Captured production	Aquaculture production	Total production per country
Bahrain	4		4
Brazil	635		635
China		25,855	25,855
Eritrea	19		19
Iran (Islamic Rep. of)	1528		1528
Kuwait	38		38
Malaysia	1719		1719
Reunion/Mayotte		6	6
Mexico	150		150
Oman	109		109
Pakistan	2253		2253
Philippines	2236		2236
Qatar	224		224
Saudi Arabia	280		280
Senegal	163		163
Taiwan Province of China	546	3998	4544
United Arab Emirates	500		500
United States	80		80
Global total	10,484	29,859	40,343

2.2. Induced breeding and larvae production

In Vietnam, spawning of cobia can be obtained either naturally or by hormonal injection of matured breeders. The body weight of breeders may vary from 15 to 25 kg. For the natural spawning, the matured breeders ready for spawning are selected and transferred immediately from sea cages to the breeding tanks in a hatchery nearby for spawning. For the hormonal induction, the breeders need to be inspected periodically for gonad development by cannulation. Females with oocytes larger than 700 μm in diameter and males with condensed milt are selected and transferred to the hatchery for spawning. The selected broodstock are injected with LH–RH_a at a dose of 20 μg kg^{-1} female and 10 μg kg^{-1} male (Nhu, 2005). Generally, 2 females are paired with 3 males in a spawning tank of 72 m^3 for one spawning batch. The fish normally spawn within 12–36 h after hormone injection.

A comparison of the two spawning methods was conducted based on the results of 10 spawns (6 spawns from hormonal induction and 4 natural spawns) in 2005. The natural and hormonal induction methods were implemented in normal conditions i.e. water temperature of 28.8 ± 1.4 °C and 29.0 ± 1.1 °C and salinity of 34.0 ± 0.0 g L^{-1} and 34.8 ± 0.5 gL^{-1}, respectively. Average weight (mean ± SD, kg) of male and female for natural induction were 18.5 ± 3.3 and 21.4 ± 4.8, respectively and for hormonal induction were 16.0 ± 2.9 and 22.3 ± 2.9, respectively. The results indicated that although the hormonal induction method had a lower spawning success (determined by ratio of spawned breeders per total injected breeders), it resulted in similar fecundity and better spawning quality in terms of fertilization rate and hatching rate (Fig. 2). The breeders were relatively big, making difficulty for handling. As a result, the lower fertilization rate and hatching rate of the natural spawning was probably caused by handling stress (when catching and transferring) especially during the ovulation. Thus, the hormonal induction method is more advantageous for hatchery planning and is at present widely applied.

After spawning, the breeders are transferred back to the sea cages, while their eggs are collected on a 500 μm mesh net, manually or automatically using airlift-collectors. Incubation is conducted in 500 L cylindro–conical tanks at a density of 1000–2000 egg L^{-1}, using filtered sea water with fine aeration. The bad eggs accumulating at the bottom are discharged every 5–7 h in order to maintain good water quality. The incubation time depends on water temperature, i.e. it takes 23–27 h to incubate at water temperature of 27–24 °C. The newly-hatched larvae should be collected and transferred to the larval rearing tanks as soon as they have hatched.

2.3. Larviculture and fingerling production of cobia

In Vietnam, there are two rearing technologies for cobia larviculture: intensive and semi-intensive. The intensive culture is conducted in recirculating aquaculture systems using produced live

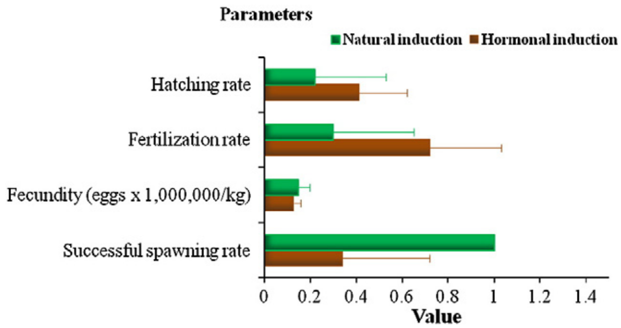

Fig. 2. Comparison of the spawning quality (mean ± SD) of the natural spawning ($n = 4$) and the hormonal induction ($n = 6$). Hatching rate = ratio of newly hatched larvae per total fertilized eggs; fertilization rate = ratio of fertilized eggs per total spawned eggs; fecundity = number of eggs spawned per kg of female; successful spawning rate = ratio of spawned breeders per total injected breeders.

food. This technology is mainly performed in a marine hatchery located in Nghe-an province (RIA-1 facility), which however has limited production capacity. The semi-intensive technology is implemented in outdoor ponds using partially natural zooplankton and is mainly performed in the larger facilities of RIA-1 located in Hai-phong province and in the private hatcheries located in Khanh-hoa province.

The protocol for intensive larviculture technology of cobia was established in 2002 and is mainly based on larviculture techniques of other marine finfish species i.e. using microalgae as green water technique (2–28 days post hatching (dph)) and use of enriched rotifers (3–11 dph) for the first feeding followed by freshly hatched *Artemia franciscana* (8–13 dph) and enriched *Artemia* nauplii (11–28 dph) (Fig. 3). The newly hatched larvae are stocked at an initial density of 30–50 larvae L^{-1} in order to maximize the live food use. The larval density will be reduced in the second week, when they are actively catching live preys. From 18 dph, formulated micro diets such as NRD®, Proton® (INVE Aquaculture NV, Belgium), Bio-Optima® (Denmark), or Otohime® (Marubeni Nisshin Feed, Japan) are introduced. The micro diets can be solely used after co-feeding along with *A.* nauplii for more than 10 days. When the larvae reach more than 3 cm, they need to be graded every 5 or 7 days to avoid cannibalism. After 45–50 days of rearing, the juveniles reach more than 10 cm and should be transferred to the bigger tanks or hapas in sea cages for further nursing. Survival of cobia juveniles (8–10 cm) reared using this protocol varies from 5.0 to 17.5% though some batches may even reach 30% survival, compared to the semi-intensive rearing method, which have a survival of less than 3.0% for the same size.

The semi-intensive rearing method in outdoor ponds has been developed since 2005 due to the high demand of cobia fingerlings and the limited facilities for the intensive production. The main steps of this rearing method are described in Fig. 4 including a combined use of indoor tanks and outdoor ponds to rear the larvae before they are being weaned to formulated diets. Firstly, cobia larvae are pre-nursed in the indoor tanks, fed on rotifers for the first feeding stage. The next rearing phase in outdoor ponds with abundant natural zooplankton, mainly copepods, allows reducing live food production cost. Before introducing the larvae, the outdoor ponds, typically 500 m^3 in rectangular or hexagonal shape with sandy bottom, are filled up with filtered sea water and fertilized for natural zooplankton production. When most of the live foods in the ponds have been consumed by the larvae, zooplankton collected from other ponds, using automatic collectors or *A.* nauplii will be supplemented. As soon as the larvae reach more than 3 cm, they are transferred to tanks again for weaning and frequent grading to avoid cannibalism. When the juveniles reach 10–12 cm, they can be transferred to the bigger tanks or hapas in sea cages for further nursing for grow-out. Although the semi-intensive rearing method resulted in much lower survival rate as described above, higher growth rate of cobia larvae rearing in tanks using enriched live foods (for the same age) was experienced. The appropriate nutritional composition of natural zooplankton in outdoor ponds i.e. copepod for cobia larvae therefore, need to be addressed in future research.

The critical periods of cobia larviculture are mainly the first feeding and the weaning stage. Research on improvement of the first feeding, co-feeding and weaning period was considered as the priority to improve larval growth, survival and quality.

As for the first feeding stage, shortening and replacement of the rotifer feeding period was targeted to simplify the rearing protocol. Although cobia larvae cannot be fed *A.* nauplii as a starter feed (Faulk and Holt, 2003), they were able to ingest and digest umbrella-stage of *A. franciscana* (UAF) as their first feeding (Nhu et al., 2009a). Use of UAF resulted in lower growth and quality by 8 dph, but no significant differences were detected by 18 dph compared to cobia larvae fed enriched rotifers (Nhu et al., 2009a). This finding is important for intensive larviculture of cobia as *Artemia* cysts are readily available and easy to store, making the use of UAF more convenient and more cost-effective than using enriched rotifers.

Early co-feeding of Proton® (INVE Technologies NV) from 8 dph revealed a little improvement of larval growth, but did not improve their survival (Nhu et al., 2009b). Success of the trials on use of UAF and early co-feeding of Proton® opens a possibility to improve knowledge on cobia larvae nutrition, shortens the live prey feeding period and simplifies the rearing protocol. However, micro-diet digestibility and/or nutritional requirements of cobia are age dependent: the same experimental diet (formulated by INVE technologies NV) with higher levels of dietary protein (62% DW), n-3 HUFA (35 mg g^{-1} DW) and docosahexaenoic acid/eicosapentaenoic acid (DHA/EPA) ratio (2.5), but lower lipid content (10% DW), did not result in any significant effect for the period of 8–23 dph; on the other hand, it effectively improved growth, survival and quality of the

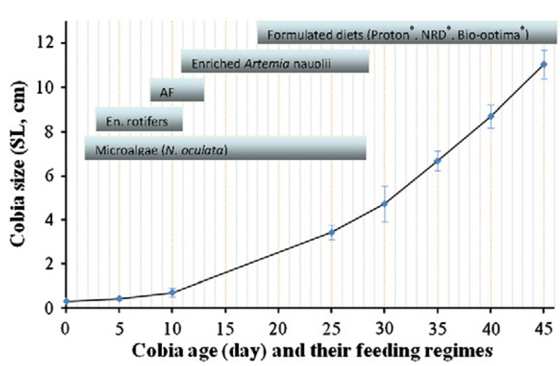

Fig. 3. Growth pattern (mean ± SD, $n = 30$) and feeding regime of cobia larvae cultured in the intensive system.

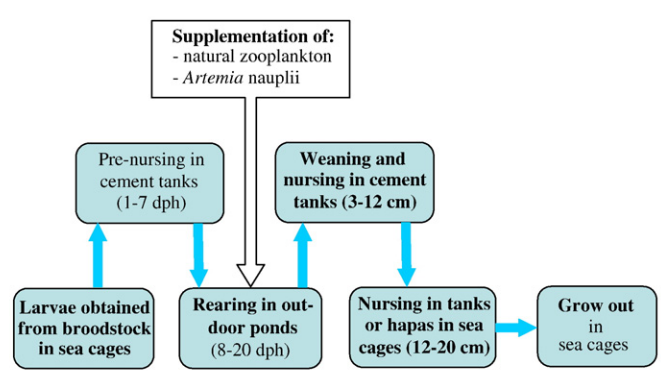

Fig. 4. Flowchart of semi-intensive fingerling production of cobia.

juveniles during period of 20–38 dph compared to the use of Proton® (Nhu et al., 2009b). Therefore, development of the appropriate diets for early co-feeding and weaning needs further investigations.

In Vietnam, minced trash fish followed by home-made moist diet (prepared from a mixture of minced trash fish, fish meal, rice meal, wheat flour, squid liver oil, mineral and vitamin premix) were earlier used as weaning diets. In 2005, a comparison of those diets and the commercial formulated diet (NRD®, INVE Aquaculture SA) clearly indicated the advantages of the commercial diet in terms of use, daily husbandry management, larval growth and survival improvement (Nhu et al., 2007). Then, the commercial micro-diets then were used instead of the local-made diets.

Cobia juveniles require high levels of dietary DHA and DHA/EPA ratio during weaning. The DHA content in larval tissues decreases from 41.29 to 10.33 mg g^{-1} DW with their age from 0 to 12 dph, but the DHA/EPA ratio increases from 4.6 to 6.6, respectively (Nhu et al., *unpubl. data*). These changes of DHA content reflected the low content of DHA in the live foods used that were not easy to enrich to obtain the same level as in yolk-sac larvae. The result indicated a necessity to improve the dietary DHA for cobia larvae using formulated diet for the later stage. High dietary DHA contents (ranging from 21.12 to 53.31 mg g^{-1} DW) and DHA/EPA ratios (ranging from 3.6 to 6.0) for the juveniles (12–30 dph) resulted in a better specific growth rate (22.60 to 23.77% day^{-1}), higher survival rate (53.11 to 69.22%) and higher survival (66.7–100.0%) in the transportation test for 36 h (Nhu et al., *unpubl. data*). The results indicated that improvement of growth, survival and production through nutritional manipulation was feasible.

Besides the nutritional aspect, rearing density and feeding frequency during weaning were also considered as important factors for hatchery-scale production. The experiments on different rearing densities (1, 2 or 4 weanling L^{-1} at initial standard length (mean ± SD) of 13.0 ± 0.9 mm) and different feeding frequencies (continuous or every 2 h or 4 h for cobia at initial standard length (mean ± SD) of 15.2 ± 2.4 mm) revealed that growth and survival of cobia juveniles are affected by the rearing density, but not by the tested feeding frequencies; the lower density of 1 or 2 weanling L^{-1} resulted in better growth and lower cannibalism rate compared to the ones reared at 4 weanling L^{-1} (Nhu et al., 2007). A medium density of around 2 weanling L^{-1} is suggested for the present practice.

Comparing the two rearing methods, the semi-intensive rearing method is simpler, low-cost and easy-copied and can lead to fast expansion of the production. Most cobia fingerlings have been produced in the semi-intensive systems in the period 2005–2008 (Table 2). However, as the rearing conditions are not fully controlled, pathogens can cause high mortality and up to 80% has been experienced at Quy-kim station in 2005 (Le and Svennevig, 2005). Attempts to reduce this risk: pre-treatment of rearing water or collected zooplankton or pre-treatment of juveniles before re-stocking in concrete tanks using formalin, had limited success. Therefore, sooner or later, the intensive production should replace the semi-intensive production to improve and sustain the juvenile quality and production.

Development of transportation techniques for cobia fingerlings was one of the priority researches during the period 2005–2008. At that time, the operation of large-scale cobia farms in the Central-south required large amounts of fingerlings, while the hatchery technology in that area was limited and haunted by parasite and disease. In the closed-transportation system using 50 L nylon bags containing 20 L seawater, 30 L oxygen and maintaining temperature at 25 °C, the densities of 20, 40 and 60 juveniles (5 cm) L^{-1} had survivals of 100, 80 and 60%, respectively after 12 h (Le and Svennevig, 2006). Meanwhile, the open system using 1000 L tanks equipped with aeration to transport the juveniles (6–7 cm) at a density of 3 and 5 juveniles L^{-1} for duration of 35 h at temperature of 23–24 °C resulted in survivals of 95 and 71%, respectively (Le and Svennevig, 2006). The latter method, which in fact exists on trucks for live transport of spiny lobsters to China, has since then been used commercially, at a lower density (2–3 juveniles L^{-1}), and has successfully transferred 300,000 juveniles in 2007 and 460,000 juveniles in 2008 from the North to the Central-south.

3. Grow-out of cobia in sea cages

Cobia farming in Vietnam was initially conducted in simple, small-scale wooden raft cages installed in closed bays, using wild-captured fingerlings as seed and trash fish as feed. The hatchery-fingerlings were imported from Taiwan or China before 2002 when the locally produced fingerlings were available. In the North of Vietnam the wooden cages, with typical dimension of 3 × 3 × 3 m, are assembled in a raft of 4 cages or more and each family normally operates 1 to 4 rafts. Production yield from each raft may vary from 1 to 1.5 tn per rearing cycle. The medium-scale farms (50–100 tn per cycle) are predominant in Vung-tau and Kien-giang provinces and also use wooden cages, which therefore has to be installed in closed bays or the lee side of islands. In a 2005 survey, there was a total of 16,319 marine cages producing approximately 3510 tn of marine aquaculture products (Ministry of Fisheries and The World Bank, 2006). It is estimated that the annual production of cobia from family-scale farms is around 300–400 tn, which mainly is sold for local consumption. Meanwhile, the medium-scale farms contributed between 300 and 450 tn $year^{-1}$ a large part of which was exported, making the total estimated production from wooden cages of around 900 tn in 2008 (Table 3).

Success of the introduction of HDPE circular cages in 1999 by the project SRV 0330, co-funded by the Government of Norway and the Government of Vietnam opened the possibility to expand cage volumes and move culture areas to more exposed areas. In Phu-yen and Khanh-hoa provinces in the Central-south, Nha Trang Pearl (Taiwanese) started industrial level cobia production in 2003 followed by An-hai Ltd. (Russian) in 2005 and Marine Farms Vietnam (Norwegian) in 2006. In 2008, cobia production by those companies was about 550 tn (Table 3). Prediction of cobia production by Marine Farms Vietnam in 2009 is 700–900 tn of their full designed capacity of 4000 tn. Thus, the production from HDPE cages may reach 1600 tn in 2009.

Cobia grown in 300 m^3 HDPE cages and fed trash fish can reach more than 5 kg in a year although growth ceases when water temperature is below 22 °C during winter (Fig. 5). However cobia fed

Table 2
Fingerling production of cobia produced at RIA-1 facilities in Vietnam during 2003–2008.

Year	Semi-intensive production	Intensive production[(1)]	Total
2003	0	22,500	22,500
2004	0	21,000	21,000
2005	120,000	25,400	145,400
2006	62,000	4000	64,000
2007	365,000	35,000	400,000
2008	900,000	0	900,000

[(1)]Production obtained from the marine hatchery located in Nghe-an province (RIA-1).

Table 3
Production (in metric ton) of cobia produced in Vietnam during the recent years.

	2007	2008	2009[(3)]
Production in wooden cages[(1)]	750	900	1000
Production in HDPE cages[(2)]	250	550	1600
Total	1000	1500	2600

[(1)]Calculated from small-scale and medium-scale (wooden cages) in Hai-phong, Quang-ninh, Thanh-hoa, Vung-tau and Kien-giang provinces.
[(2)]Calculated from Marine Farm Vietnam and An-hai Ltd. Company.
[(3)]Prediction based on fingerling production.

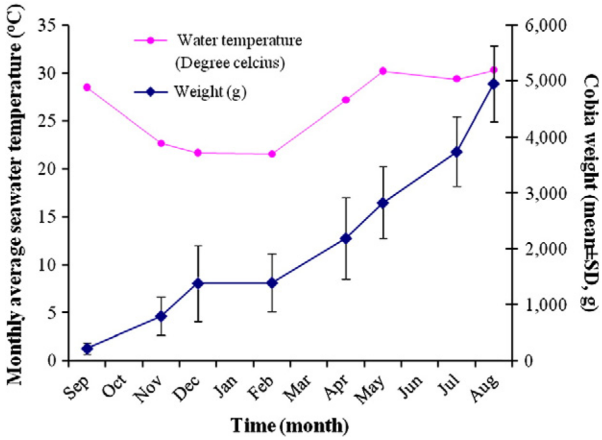

Fig. 5. Grow pattern (mean ± SD, $n = 30$) of cobia cultured in sea cages, in relation with seawater temperature.

extruded pellet feed (EWOS Ltd, Canada) gained double size (6.84 kg) compared to those fed trash fish which only reached 3.5 kg for a similar culture period of 13 months and culture conditions (Nguyen et al., 2008). The feed conversion ratio (FCR) of the extruded feed was increased from 1.2 to 1.8 and to 2.0, respectively for the cobia sizes of 0.16–1.2 kg; 1.2–3.7 kg and 3.7–6.8 kg; however, for the same size-stage (1.2–3.5 kg), the extruded feed still had a lower FCR (2.0) compared to that of trash fish (2.4) on dry weight basis (Nguyen et al., 2008). Extruded feed is currently used as sole feed in industrial-scale production of cobia in Vietnam.

4. Prospects, major challenges and solutions for cobia aquaculture in Vietnam

Cobia becomes increasingly popular for marine aquaculture due to its rapid growth and suitability for industrial-scale farming. Vietnam has a potential for cobia farming and has had a very good start. The coastal line of more than 3000 km and 4000 islands creates huge potential areas for marine aquaculture (Ministry of Fisheries, 1994). The establishment of cobia larviculture and grow-out technologies is an essential foundation for the marine fish farming development. Cobia is one of the important aquaculture candidates in the recent priority for mariculture that the Government of Vietnam has issued in the overall strategy for coastal-economic development. However, there are some challenges that need to be solved for the sustainable cobia aquaculture development.

The main constraint of cobia farming in Vietnam is market development. In addition, insecurity in supply of high quality juveniles and then some geographical or climatic constraints such as low temperature during winter in the North, and tropical typhoons occurring especially in autumn in central Vietnam. The main grow-out constraints would be parasites, bacteria and virus and feed quality and management to keep the FCR low.

Quality and quantity of cobia fingerlings affect the profit of cobia farming (Miao et al., 2009). At present, cobia fingerlings in Vietnam are produced mainly in the semi-intensive systems. Although this rearing method is relatively simple, low-cost and easy-copied, there are some uncontrolled factors and it has been experienced to result in relatively low survivals (Benetti et al., 2007; Liao et al., 2004; Weirich et al., 2004) and the cobia fingerlings obtained from these systems have been reported to be of unstable quality i.e. potential of size variation and parasite infection. Thus, the intensive production needs to be developed at appropriate proportion to reduce risk and to ensure sustainable development. However, the present intensive rearing method is relatively expensive and sophisticated and there is a need to simplify the protocol to reduce the production costs. In this regards, to shorten the live prey feeding period, improve nutritional condition and hatchery zoo-techniques will be elements to improve growth, survival and quality of cobia fingerlings.

Low temperature during winter is one difficulty facing cobia farming in the North of Vietnam. Cobia ceases eating at water temperatures below 18 °C. During the abnormal weather experienced in January–February 2008, the low water temperature of 15 °C lasts for more than 5 weeks causing mass mortality of cobia in sea cages, including broodstock. Low temperature is normally associated with rough sea conditions, which influence feeding and farm management. In case these conditions last more than two weeks, fungal and bacterial infections can be detected with occurrence of ulcerated spots and haemorrhages on the skin. It is suggested that maintaining high biomass in sea cages during winter in the North of Vietnam should be avoided.

Disease outbreak is another challenge for sustainable development of cobia aquaculture in Vietnam. During larval rearing, infections of protozoa such as *Vorticella sp.*, *Epistylis sp.*, *Pseudorhabdosynochus epinepheli*, *Benedenia* and *Trichodina* have been detected (Le and Svennevig, 2005). Samples collected from sudden crashes of cobia larviculture in RIA-1's hatcheries revealed Viral Nervous Necrosis (VNN) infection of 20–30% (Le and Svennevig, 2005). The vertical transmission of VNN has been confirmed. The use of iodine and peroxide did not effectively eliminate VNN from fertilized eggs (Le and Svennevig, 2006). Therefore, quarantine and screening of the broodstock before the reproduction cycle is essential to prevent the VNN vertical transmission. In addition, high mortality caused by *Amyloodinium ocellatum* attaching to gills and skin of cobia juveniles has been detected in RIA-1's hatcheries in 2005 and 2006. A high density of *A. ocellatum* in gills of cobia juveniles might inhibit breathing, leading to slow movement and finally cause high mortality. Formalin treatment at a concentration of 0.03–0.1 mL L^{-1} for 1 h with strong aeration or fresh water treatment can be effective in case the first symptom is detected in time.

Another constraint in cobia aquaculture in Vietnam is the lack of locally extruded feeds. At the moment, the large-scale farms still rely on imported extruded feeds, while the small-scale farms mainly use trash fish diets. The use of trash fish in the small-scale farms located in closed bays may result in reduced water quality. Evaluations of the environmental impacts including fouling around the farms are being conducted. High FCR and the dependency of imported feed supply are obstacles for cobia aquaculture development.

It is also important to mention the challenge of tropical typhoons in the areas. Vietnam is located in south-east Asia, situated in the western Pacific Rim exposed to the tropical typhoons from the Pacific Ocean during autumn. Large-scale farms need to be situated in fairly open sea areas to maximize the production, but can also be exposed to harsh weather conditions. The failure of some cobia farms in the Northern central region during a typhoon in 2005 showed to be caused by insufficient dimensioning of the mooring system. At the moment, the Government of Vietnam are supporting development of new semi-submersible cages (National project KC07/03-06/10), which can be controlled to sink temporarily to avoid surface damages during stormy conditions. This cage type can be installed in semi-open or open sea areas where a larger exposure resulting in high of water exchange will contribute to the maintenance of good water quality. Alternative grow-out systems such as land-based recirculation systems should also be considered to provide more options for the industry in regions haunted by typhoons.

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