Current practices of rice field eel *Monopterus albus* (Zuiew, 1793) culture in Viet Nam

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Rice field eel *Monopterus albus* is native to sub-tropical and tropical Asia, and is widely distributed in many countries from India to China, Japan, Malaysia, Indonesia, Bangladesh (Froese & Pauly, 2008; Guan et al., 1996), Thailand (Thongrod et al., 2004) and Vietnam. The fish, which is considered a nutritious and tasty species, is also a valued remedy in oriental medicine (Nguyen Van Thong, 2008). Raising eels is presumed a low-cost enterprise to farmers. Raising this species is easy to do and achieves more profit than some other small size fish-culture activities (Lu et al., 2005; IIRR et al., 2001). In recent years, the marketable rice field eel culture has increased strongly in some areas of Vietnam with the farm gate price of 85,000-100,000 VND per kg eel at 200g per individuals and over, seasonally. They are consumed mainly by domestic market and some by export.

Because of the high eel seed demand, many government and private sector people have studied it. On our June 2009 visit to An Giang Fishery Hatchery Center, a project on reproduction of rice field eel was being undertaken there. About 500 fingerlings produced initially but the rearing of them was not effective. An earlier study of Can Tho University on biological, feeding habitat and natural reproduction characteristics of rice field eel conducted. The ambition of this was to find out spawning season and other targets of eel's reproduction (Nguyen Anh Tuan et al., 2007; Ly Van Khanh et al, 2008). Besides, they also examined to induce spawning of the rice field eel (*Monopterus albus*) by injection of HCG (1,000; 1,500 and 2,000 UI kg^{-1} fish) and LH-RHa (50, 100 and 150 µg kg^{-1} fish). Results were that eels in all treatments spawned but in different ratios. The eels injected with 150 µg LH-RHa kg^{-1} fish had the highest spawning rate, 75%. The highest fertilisation rate was 86% for the eel injected with HCG of 2,000 UI kg^{-1} fish (Do Thi Thanh Huong et al. 2008). However, the commercial seed production of *M. albus* has been unsuccessful.

During 2008-2009, we also carried out a study on small-scale seed production of *M. albus*, which was financed by the Sustainable Development of Aquaculture Component (SUDA). Because it can breed in captivity without using any chemical stimuli, natural-reproduction (eel are reproduced naturally in raising tank) is considered the most optimum solution (IIRR et al., 2001).

Reproductive biological characteristics

We have studied the reproductive biology of the rice field eel for establishing technology for seed production. We found that showed that:

Rice field eel nest.

- The gonadal development of the fish includes six stages and is not uniform. There are eggs at the different stages in the same ovary.
- The spawning season of rice field eel mainly occurs in March and September with two spawnings every year.
- The average absolute fecundity of *M. albus* was 589 eggs per female (range from 236 to 1,328 eggs female) and relative fecundity was 9.9 eggs/g per female (range from 3.9 to 18.5 eggs/g per female).
- The real fecundity ranged from 38 to 625 eggs female, average 295 eggs per female.

Eggs after 3-3.5 day of incubation.

- Ripe eggs are non-adhesive and spherical with a diameter of 3 - 4 mm. They swell in water. At a a temperature of 28-31°C, the fertilised eggs hatch after 140 hours of incubation with average hatching rate of 92.8%.

- Eggs began to hatch after 5-6 days of incubation and yolk-sac was completely absorbed by the larva 7-9 days after that. The hatching rate varied from 84% to 97.5%.

Maturation culture

All broodstock *M. albus* used in our experiments were obtained from healthy cultured eel. Mean body weight of males was above 250g per animal or above 50 cm in total length (TL). Mean body weight of female range 40-100g per animal or 30-40 cm TL (to make sure that these eels haven't reversed sex yet). We found that the most suitable density for mature culture was 10 animals m^{-2} with male to female ratio of 1:2. For sexual re-maturation the most suitable ration was 4 animals m^{-2} at a male to female ratio of 1:1. Culture of eel broodstock for maturation included two steps, fattening period and maturation culture:

- **Period 1** (the fattening period): the fishes was fed adequately at about 3-5% of body weight once in the late afternoon daily. This period lasted about 1.5 months.

- **Period 2** (maturation culture): when testing the eels found that they had stage 3 ovaries, maturation culture started. The quantity of food needs to be decreased to about 60-70% of period 1. Before transferring the fishes to breeding tanks, feeding should be stopped five days in advance.

Natural propagation

After two months of maturation culture, broodstock were transferred to breeding tanks. We have carried out many experiments with different densities that were 2, 4, 8, 10, 20 and 30 animals m^{-2} with three-replicates per treatment. The experimental unit was two 7 m^2 nylon tanks. Male and female ratio was 1:1 and 1:2. During this period, they were fed once in the late afternoon every two days by home-made feed (including trash-fish- 70% combined with commercial feed,

Floating feeding tray.

Freshly hatched eel.

Cargill 30% P- 30%), at about 2-3% of body weight. Water exchange regime was 2-3 times per month in the morning, with 100% exchange of fresh water.

Result of these studies suggested that the most effective density for natural propagation was 4 animals m^{-2} at the male and female ratio of 1:1. The average spawning rate was 61.9% with 752 seeds kg per female.

Fry rearing

Fingerlings were collected and moved from breeding tank to rearing tank by net racket. The process of fry rearing included two periods:

- Period 1 (from newly collected fingerlings to 2 g body weight): The suitable stocking density was 100 individuals m^{-2}. The average survival rate was 92%. Over 3 months of rearing, seed eels obtained 157.6 mm in length and 2.04 g individuals in weight.

- Period 2 (from 2 g to 20 g per individual): The suitable stocking density was 50 individual m^{-2}. The average survival rate was 71%. The daily weight gain of *M. albus* was 0.15 g per day.

After seven to eight months of rearing, the eels obtained a size of 50 individuals per kg. They can be fully harvested (drain water and and remove materials as hiding place from the tank) or partially harvested depending on demand. The seeds must be collected quietly, avoiding scratches for good seed quality.

Grow-out practices of farmers

We had two trips to six provinces of the Mekong Delta in each year of 2008 and 2009 financed by SUDA for surveying eel-farming practices. We found that the total number of households raising eel in An Giang, Can Tho, Dong Thap and Hau Giang province was above 1,600 with an area of 10 ha and a production of about 600 tonnes per year. Among them, Chau Thanh district of An Giang province and Vinh Thanh

Grow-out tank.

district of Can Tho city had 1,000 households with an average production of 348 tonnes per year and 400 households had an average production of 192 tonnes per year, respectively.

Rice field eels can be raised all year round, with main stocking duration from July to February of the following year in the lunar calendar. In the Mekong Delta, the stocking crop is relative to the time of occurrence of natural seed of *M. albus* in the flood season. After harvesting cultured eels they are sorted into three categories: fishes at 200g and over which fetch high price, fishes from 100 g to below 200g which fetch lower price, and fishes below 100g that are restocked about three or four months to gain marketable size (the secondary crop). The rice field eel is stocked at many different densities by various farmers. In general, the most popular density is from 1-2 kg eels m^{-2} with 54% of farmers. And the production achieved is from 5-8 kg m^{-2}.

The eel is fed home-made feed with various materials depended on the season and locality. In An Giang province, golden snail combined with commercial feed for fish was used to feed them. First, the golden snail is boiled to take the snail meat out of the shell. The commercial feed is softened by a little water. After that, the ingredients are fixed together with an addition of digestive enzyme, vitamin C and some adhesive. This mixture is finely ground and rolled into balls before putting on feeding trays. The ratio of golden nail meat and commercial feed was 8-10:1. In Can Tho province, the way of making M. albus feed is similar to An Giang farmers. However, golden snail meat was replaced by mussel. Meat of mussel and commercial feed ratio ranged from 4-6:1. The average feed conversion ratio (FCR) was 6.1, with min of 4.5 and maximum of 11 among farmers surveyed (n=35). Disease often occurs in cultured *M. albus*. In the early time of stocking, the mortality of the fish is rather high ranging from 20-100% depending on seed quality and the farmer's technique. After 5-6 months of culture, the eels attain about 200g per animal weight and harvesting starts. The main method is to drain off water and remove materials as hiding place from the tank, then catch the fish. They are transported to the market live. The mean production cost and profit for each household were 14 million VND and 8.7 million VND, respectively. 86.3% of the surveyed farmers showed that they had profit and 52.8% of the total got a profit of more than 5 million VND per household. Thus, rice field eel is an aquaculture species that can bring good income to farmers with low risk.

Grow-out trial results

From 2008 to 2009, we conducted some experiments raising rice field eel at different densities (0.5, 1, 2 and 3 kg m^{-2}) and feeds (fresh feed, home-made feed and pellet feed).

The results showed that stocking density affected growth performance and survival rate of *M. albus* raised in nylon tanks with layers.

The daily weight gain of M. albus at densities of 0.5 kg m^{-2} (1.00 g day^{-1}) and 1 kg m^{-2} (0.99 g day^{-1}) were significantly higher than that of the other two treatments (0.86 and 0.68 g day^{-1} for 2 and 3 kg m^{-2} density, respectively) ($P<0.05$).

The average survival rate was 92.1, 91.5, 73.1% and 73.5% for the fishes stocked at densities of 0.5, 1, 2 and 3 kg m^{-2}, respectively.

The daily weight gain of the eels fed with pellet feed was significantly lower than the ones fed with home-made and fresh feed (0.78, 1.06 and 1.08 g day^{-1}, respectively). No significant survival rate differences were found among the feed treatments.

This study recommended that stocking densities ≤ 1 kg m^{-2} and using fresh or home-made feed are suitable for cultured *M. albus* in nylon tanks.

Discussion

Although rice field eel isn't a new farming species and is popularly being raised in Mekong River Delta now, there are very few documents published for it.

In captivity, competition for feed and hiding places between eels is strong because they are carnivorous. It is recommended to use a density of 1 kg m^{-2} for commercial practices in nylon tank. As for feed, the eels are able to eat fresh feed, home-made feed or pelleted feed. In the treatment using pelleted feed, food conversation ratio of 3.68 obtained was worse than the food conversation ratio of 1.29 reported by Qin et al (2001) for rice field eel cultured by commercial feed. Accordingly, if the FCR value decreases similar to that of Qin, farming eel will result high economic efficiency. High FCR for pellet feed might be due to inadequate nutritional value of the diet or bad feed management. According to Liu et al (2000), the best diet for eel growth contained 35.7% protein, 3-4% lipid, 23-24% glucose and the ratio of dietary protein to energy (E/P) of 31.6 to 38.9. On the other hand, using pelleted feed in mixing with home-made feed isn't an optimal method, although it is really convenient and being applied widely by farmers. Therefore, study of feed formulas to mix feed from locally available and crude materials (rice bran, coconut cake, golden snail, trash fish, mussels) is necessary for reducing the cost of production. Furthermore, pelleted feed for rice field eel needs to be produced for development of farming the species on a large scale.

Rice field eel after the harvest.

Beside the seed production of rice field eel, we should utilise properly abundant natural seed sources. Also, there is a need to assess the status of natural eel resources and improve fishing equipment to improve the quality of the seed.

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Table 1. Growth performances of *Monopterus albus* cultured at different stocking densities in experimental nylon tanks for 6 months. Data are mean values. Values with different superscripts in the same row are significantly different ($P<0.05$).

Parameter	0.5 kg/m^2	1 kg/m^2	2 kg/m^2	3 kg/m^2
Initial body weight (g)	25.1a	25.3a	25.1a	25.1a
Final body weight (g)	197.5a	195.8a	172.8b	143.2c
Daily weight gain (g day^{-1})	1.00a	0.99a	0.86b	0.68c
Specific growth rate (% day^{-1})	1.19a	1.18a	1.12a	1.01b
Survival rate (%)	92.1a	91.5a	73.1b	73.5b
Food conversion ratio	5.1a	5.2a	7.2b	6.2ab
Average yield (kg m^{-2} $crop^{-1}$)	3.8a	7.9b	9.9c	11.1c