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Original Article

Effects of water salinity on hatching of egg, growth and survival of larvae and fingerlings of snake head fish, *Channa striatus*

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Abstract

A study on the effect of water salinity ranging from 0-30 ppt on hatching success of snake head fish, *Channa striatus* was conducted in a 15-liter glass aquarium (water volume 10 liters) containing 500 eggs for various levels of water salinity. Fertilization rates at 0, 5, 10, 11, 12, 13 and 14 ppt were 69.33, 72.67, 71.33, 72.67, 82.00, 73.33 and 10.67%, respectively. The fertilization rate at 12-13 ppt salinity was significantly ($P<0.05$) higher than that at 0, 5, 10 and 11 ppt salinity. Hatching rate at 0, 5, 10, 11, 12, 13 and 14 ppt salinity were 60.00, 60.67, 66.67, 72.00, 77.33, 68.00 and 2.67%, respectively. Hatching rate at 12 ppt salinity was significantly ($P<0.05$) higher than that at 0, 5, 10, 11 and 13 ppt salinity. For the snake head fish, the water salinity of 12 ppt was shown to give the highest fertilization and hatching rates. The times of hatching out at water salinity of 0-14 ppt were between 1,192-1,442 minutes.

After hatching, the survival tolerance of snake head fish larvae in different salinity (0-30 ppt) within 24 hour were then studied using a 50-liter glass aquarium (water volume 30 liters) containing 50 larvae at each level of salinity. All treatments were done in triplicate. The survival rate of fish larvae in the 0, 5, 10, 15, 16, 17, 18, 19, 20, 25 and 30 ppt salinity were 100, 100, 100, 100, 0, 0, 0, 0, 0, 0 and 0 %, respectively. However, fish larvae that had survived at 15 ppt died after 8 days of rearing. The gain rate of total body length, body weight gain rate and survival rate (%) at 10 weeks at water salinity ranging from 0, 5 and 10 ppt were significantly ($P<0.05$) higher than that at 11, 12, 13 and 14 ppt salinity. However, there were no significance differences ($P>0.05$) among 0, 5 and 10 ppt.

Keywords: fertilization rate, hatching rate, hatching out, water salinity tolerance, snake head fish, *Channa striatus*

1. Introduction

Snake head fish, *Channa striatus*, is an economically important freshwater fish in Southeast Asian countries such as Thailand, Vietnam and Philippines (Wee, 1982). According to the Food and Agriculture Organization of the United Nations (2012), the production of snake head fish in 2011 was approximately 0.5 million tons and its production was obtained from both cultured and wild populations. The snake head fish is species that can naturally grow in various habitats such as rice-field, irrigated canals and ditches. Traditionally, the largest natural source of snake head fish production is from catching in the rice-fields. However, the productivity of this fish had declined because of some problems in rice production areas and pesticide usage (Ali, 1990; Mohsin & Ambak, 1983; Tan *et al*., 1973).

To avoid the risk of over-harvesting, aquaculture is a better approach to increase production of snake head fish.

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Generally, factors affecting its culture operation are water temperature and pH. Optimum temperature and pH for this fish to grow in nature are 20-35°C and 4.25-9.40, respectively (Varma, 1979; Vivekanandan, 1977). Since the snake head fish is a carnivorous fish, trash fish can be used as feed (Huong & Trinh, 2013).

In Southeast Asia, aquaculture plays an important role in the production of economically important aquatic organisms. However, suitable areas for the culturing of aquatic organism are limited. Consequently, coastal zone may be a potential alternative area for fish culture. Moreover, some shrimp ponds in the coastal zone have been abandoned owing to the outbreak of shrimp disease (Chotipuntu & Avakul, 2010). The possibility of using some abandoned shrimp ponds for culture of freshwater fish such as the snake head fish should be studied. However, these ponds in the coastal zone may be in high salinity water areas, which may affect the freshwater fish culture productivity.

Water salinity is one of the critical factors affects the survival rate, distribution and metabolism of fish. Many researches on the snake head fish have focused on physiology, biology, nutrition, artificial breeding and others, but there are few studies on the effect of environmental parameters on survival of this species (Huong & Trinh, 2013). Little published research on the effect of water salinity on this fish was found. Therefore, there is a need to study the effect of water salinity on the snake head fish. The objectives of this therefore were to evaluate effect of salinity on the hatching rate, the snake head water salinity tolerance, by culturing snake head fish in various water salinities.

2. Materials and Methods

Fertilized eggs of snake head fish were produced by induced spawning using chemical injection with Suprefact (30 µg/kg) and Motilium (5 mg/kg). The sexually mature fish were cultured in a fiber-glass tank (water volume 300 liters) with the ratio of male to female brooders of 1:1.

2.1 Study on fertilization rate, hatching out and hatching rate in different water salinity

The fertilization rate and hatching rate experiments were carried out using 15-liter aquaria (water volume 10 liters) each containing 500 eggs in different water salinities which were 0, 5, 10, 15, 20, 25 and 30 ppt. The number of fertilized eggs at 5 hr after incubation were then observed. In each aquarium, the fertilization rate was calculated by (number of fertilized eggs/number of eggs) x 100. The time required for the appearance of the first newly-hatched larvae, which would signal hatching out, was recorded. All newly-hatched larvae were collected using a dropper. The hatching rate was calculated by (number of newly-hatched/number of eggs) x 100 (Tarnchalanukit, 1978). The procedure was carried out with three replications.

2.2 Study on water salinity tolerance of larvae

The experiments were carried out using 50-liter aquaria (water volume 30 liters) each containing 50 fish (2.5 cm, total length) in different water salinities, which were 0, 5, 10, 15, 20, 25 and 30 ppt. The mortality of the fish in each water salinity was recorded at 10 minute intervals for 24 hours. The procedure was carried out with three replications.

2.3 Study on cultured in different water salinity

The experiments were carried out using 50-liter aquaria (water volume 30 liters) each containing 20 fish (2.5 cm, total length) in different water salinity (which in earlier experiments had shown a 100% survival rate). Throughout the rearing period with aeration, the larvae were fed twice a day with normal commercial pellet. The water exchange rate was 10% of the tank volume every day. The total length and body weight of 20 specimens were measured every 1 week, until completion of the experiment at in 10 weeks. The procedure was carried out with three replications.

3. Results

3.1 Fertilization rate, hatching out and hatching rate in different water salinity

The fertilization rates of 0, 5, 10, 11, 12, 13 and 14 ppt salinity were 69.33, 72.67, 71.33, 72.67, 82.00, 73.33 and 10.67%, respectively. However, no egg survived in the water salinity higher than 15 ppt. Fertilization rate at 14 ppt was significantly ($P<0.05$) lower than that at 0, 5, 10, 11, 12 and 13 ppt. Fertilization rate at water salinity of 12 and 13 ppt was significantly ($P<0.05$) higher than that at 0, 5, 10, 11 ppt (Table 1). In addition, the hatching rates at 0, 5, 10, 11, 12, 13 and 14 ppt salinity were 60.00, 60.67, 66.67, 72.00, 77.33, 68.00 and 2.67%, respectively. Hatching rate at 14 ppt salinity was significantly ($P<0.05$) lower than that at 0, 5, 10, 11, 12 and 13 ppt salinity. Hatching rate at 12 ppt salinity was significantly ($P<0.05$) higher than 0, 5, 10, 11 and 13 ppt salinity (Table 1).

In order to further understand the effect of salinity on the snake head fish, the time of hatching out was also recorded, and the times at 0, 5, 10, 11, 12, 13 and 14 ppt salinity were 1,382, 1,192, 1,384, 1,400, 1,416, 1,421 and 1,442 minutes, respectively. There were no significant differences ($P>0.05$) among the treatments 0 and 10 ppt. However, the hatching time at 5 ppt was significant lower than in water of salinity 0, 10, 11, 12, 13 and 14 ppt ($P<0.05$) (Table 1).

3.2 Water salinity tolerance of larvae

The study on the tolerance of snake head fish larvae in different salinity within 24 hour were done in 50-liter glass aquarium (water volume 30 liters) containing 50 larvae with fish 2.5 cm total length. The survival rate of fish larvae at 0, 5,

Table 1. Fertilization rate (%), hatching rate (%) and hatching time (min) of snake head eggs incubated in different water salinities (n=300)

Water salinity (ppt)	Fertilization rate (%) Mean±SD	Hatching rate (%) Mean±SD	Hatching out (min) Mean±SD
0	69.33±7.02[a]	60.00±10.39[a]	1,382±5.23[a]
5	72.67±10.06[a]	60.67±9.45[a]	1,192±7.81[b]
10	71.33±9.86[a]	66.67±7.02[a]	1,384±8.70[a]
11	72.67±4.00[a]	72.00±5.29[a]	1,400±6.11[c]
12	82.00±4.00[b]	77.33±2.31[b]	1,416±4.04[c]
13	73.33±3.05[b]	68.00±3.60[a]	1,421±5.00[c]
14	10.67±7.57[c]	2.67±2.51[c]	1,442±7.00[c]
15	0	0	0
20	0	0	0
25	0	0	0
30	0	0	0

Different superscript indicates significant different (P<0.05))

10, 15, 20, 25 and 30 ppt were 100, 100, 100, 100, 0, 0 and 0%, respectively. The water salinity tolerance was not significantly different (P>0.05) among 0, 5, 10 and 15 ppt salinities.

3.3 Cultured in different water salinities

The study on snake head fish larvae culture in different water salinity (in which the fish had survived 100%) and the experiments were completed in 10 weeks. Unfortunately at water salinity of 15 ppt, all fish died after rearing for 8 days. The result showed total length gains at 0, 5, 10, 11, 12, 13 and 14 ppt salinity were 7.07, 7.32, 6.87, 3.25, 2.89, 2.40 and 2.26 cm, respectively. The total length gain at water salinity ranging from 0, 5 and 10 ppt were significantly (P<0.05) higher than those at 11, 12, 13 and 14 ppt. The body weight gain at 0, 5, 10, 11, 12, 13 and 14 ppt were 8.13, 8.33, 7.73, 2.00, 1.67, 1.05 and 0.89 g, respectively. The body weight at water of salinity ranging from 0, 5 and 10 ppt were significantly (P<0.05) higher than those at 11, 12, 13 and 14 ppt. Finally, survival rate at 0, 5, 10, 11, 12, 13 and 14 ppt were 76.67, 75.00, 81.67, 63.33, 58.33, 56.67 and 16.67%, respectively. The survival rate at water salinity ranging from 0, 5 and 10 ppt were significantly (P<0.05) higher than those at 11, 12, 13 and 14 ppt. However, total length gain, body weight gain and survival rate were no significantly different (P>0.05) among 0, 5 and 10 ppt salinities (Table 2).

4. Discussion

4.1 Fertilization rate, hatching rate and hatching out

The result showed that water salinity (0-14 ppt) affected the snake head fish fertilization rate, and the highest fertilization rate was found at 12 ppt. In the present study, fertilized eggs were observed at water salinity equal to or below 14 ppt. In contrast, climbing perch, *A. testudineus* were successfully fertilized in water of salinity below 5 ppt and it was slower than in the present study. The fertilization rate of fish was related with activation of spermatozoids (Sampaio *et al.*, 2007). The effect of water salinity on fertilization rate

Table 2. Survival rate and growth of snake head fish reared in different water salinity

Water salinity (ppt)	Survival rate (%) (n=3) Mean±SD	Total length gain (cm) (n=20) Mean±SD	Body weight gain (g) (n=20) Mean±SD
0	76.67±2.89[a]	7.07±0.22[a]	8.13±0.04[a]
5	75.00±5.00[a]	7.32±0.38[a]	8.33±0.22[a]
10	81.67±7.64[a]	6.87±0.31[a]	7.73±0.16[a]
11	63.33±2.89[b]	3.25±0.28[b]	2.00±0.20[b]
12	58.33±7.64[b]	2.89±0.32[b]	1.67±0.13[b]
13	56.67±7.64[b]	2.40±0.24[b]	1.05±0.06[b]
14	16.67±7.64[c]	2.26±0.28[b]	0.89±0.05[b]

Different superscript indicates significant different (P<0.05)) was also found in black bream, *Acanthopagrus butcheri,* in which the fertilization rate was reduced at 5 ppt (Haddy & Pankhurst, 2000). Some researchers considered that fish sperm were mostly activated in water of salinity below 10 ppt (Bush & Weis, 1983; Pissetti *et al*., 2002). Furthermore, the fertilization rate and hatching rate were produced by chemical injection. In this study, snake head fish was injected with Suprefact (30µg/kg) and Motilium (5mg/kg). In addition, the chemical injection was the same as that use by Amornsakun *et al.* (2011), who reported that snake head fish injected with Suprefact (30µg/kg) and Motilium (5mg/kg) had a fertilization rate of 76.5%. Kiran *et al*. (2013) mentioned that the fertilization rate of *C. striatus* injected by LHRHa + pimozide (40-60 µg + 5 mg) was 75-85%. Haniffa *et al*. (2000) reported that snake head fish showed the highest fertilization rate when injected with ovaprim (95.3-98.0% of hatching rate).

The number of hatched eggs can be related to the hatchery technique, and it can increase the number of larvae to support further culturing. Experiments in the present study found that hatching rate was also affected by water salinity below 15 ppt with the highest hatching rate at 12 ppt. Yang and Chen (2006) mentioned that puffer, *Takifugu obscures,* hatched in water of salinity ranging from 0 to 20 ppt. Some freshwater fish such as silver carp, *Hypophthalmichthys molitrix* (Gao, 1965), catfish, *Heterobranchus longifilis* (Bombata & Busari, 2003), could only hatch in low salinity water. In addition, the result of hatching out was 1,192-1,442 minutes showing that eggs quickly hatched in water of salinity 5 ppt and the hatched more slowly in water of salinity above 5 ppt. Moreover, snake head fish could hatch after 1,720 minutes with water temperature ranging of 26.5-29°C in freshwater (Amornsakun *et al*., 2011). It was also reported that hatching time of green cat fish, climbing perch and Siamese gourami were 1080 minutes, 1420 min and 1330 min, respectively (Amornsakun, 1999a, 1999b; Amornsakun *et al*., 2004a, 2004b). Hatching out time was strongly related with water salinity in some fish such as puffer, *T. obscurus* (Yang & Chen, 2006) and whitefish, *Coregonus lavaretus* (Cingi *et al*., 2010).

4.2 Effect of water salinity tolerance of fish

Although many studies have examined the water salinity tolerance of freshwater fish (Brett, 1979), some studies could be applied to culturing those fish in the coastal zone (Gavin & Greg, 2002). Data in the present study show that snake head fish can survive in water of salinity below 15 ppt, and these can be applied to culture in brackish water as well. Nowadays, fish production for human consumption is necessary. However, freshwater fish culture is not enough to cater for the increasing demands. Some fish are starting to be cultured in brackish water to provide the food. The common carp, *Cyrpinus carpio,* could survive in 15 ppt (Paye, 1983). Grass carp, *Ctenopharyngodon idella,* showed a water salinity tolerance up to 14 ppt (Kilambi & Zdinak, 1980; Maceina & Shireman, 1979). Growth and surviva l rate of common carp larvae were actually better in water salinity up to at least 3 ppt than in freshwater (Lam & Sharma, 1985). Chotipuntu and Avakul (2010) mentioned that the maximum water salinity for climbing perch, *A. testudineus* to survive in brackish water was 12 ppt and the optimum water salinity for culture climbing perch was 4-8 ppt. It is important to identify a salinity threshold for freshwater fish species. Nile tilapia, *O. niloticus* showed the potential of freshwater fish to be cultured in the coastal zone (Lemarine *et al.*, 2004). Chanel catfish, *Ictalurus punctatus,* and blue catfish, *Ictalurus furcatus,* has been captured in water of salinity 11 ppt (Perry, 1968).

Investigation on water salinity tolerance of freshwater fish has been predominantly motivated by ecological concerns (Dhaneesh *et al.,* 2012). Flathead catfish, *Pylodictics olivaris* was studied by Bringolf *et al.* (2005), were showed that the fish survived at water salinity in the range of 0-11 ppt after 48 hours of experiment and the study was also included gold fish, *Carassius auratus* (Schofield *et al.,* 2006). These studies showed that freshwater fish could-survive, and showed a high potential of being cultured, in brackish water. African catfish, *H. longifilis* yolk-sac larvae survive 100% at water salinity ranging 0-7.5 ppt. (Bombata & Busari, 2003).

Although snake head fish can strongly survive in poor living condition such as low pH and low DO **(**Vivekanandan, 1977**)**, water salinity adaptation of snake head fish is limited. There was many studies on the effect of water salinity on growth and survival rate of fish but few on acclimation of freshwater species to sea water (Dhaeesh *et al.,* 2011). Breet (1979) mentioned that most freshwater fish showed high survival rate in approximately 10±2 ppt. However, snake head fish can survive at 0-14 ppt water salinity. So, this species can survive in brackish water as better than other freshwater fish. Boeuf and Payan (2001) concluded that freshwater fish showed high growth rate and survival rate in high water salinity, and marine species could grow with high growth rate and survival rate in low water salinity.

4.3 Effect of water salinity on cultured fish

Snake head fish showed the best growth rate in 0-10 ppt water salinity but the growth of fish was slowly changed when water salinity went up to 11 ppt. Jomori *et al*. (2012) reported that pacu, *Piaractus mesopotamicus*, showed fast growth at 2-4 ppt. In some studies, these authors mentioned that suitable saline water could reduce physiological stress (Jomori *et al*., 2012), the reduction of ionic and osmotic differences between external and internal fluids (Lam & Sharma, 1985; Riley *et al*., 2003; Wurts, 1995). Osmoregulation was also one of the important factors affecting growth rate of fish. Boeuf and Payan (2001) reported that freshwater fish transferred to high water salinity needed more energy for breathing and osmoregulation. In addition, Wang *et al*. (1997) mentioned that water salinity also affected the digestive system, FCR and growth rate of common carp and showed that the suitable water salinity for this species was 2.5 ppt.

Britz and Hecht (1989) mentioned that growth rate and survival rate can be affected by water salinity. Study of growth rate and survival rate of catfish, *Clarias gariepinus*, in different water salinity including 0, 2.5, 5, 7.5 and 10 ppt showed that high mortality and low growth rate of fish occurred in the water of salinity 7.5 ppt, but that the fish fry would die after 48 hours at 10 ppt, and that a water salinity of 0-2 ppt was the best for fry of this fish to grow. The effect of water salinity on survival rate of fish was probably related with water salinity (Jomori *et al*., 2012). The relationship between water salinity and survival rate was studied in some freshwater species such as common carp, *Cyprinus carpio* (Wang *et al*., 1997), nile tilapia, *O. niloticus* (Bart *et al.,* 2013), pacu, *P. mesopotamicus* (Jomori *et al*., 2012), climbing perch, *A. testudineus* (Chotipuntu & Avakul, 201).

It was concluded that fertilization rates, hatching rates and hatching out time of snake head fish were high at water salinity range of 0-14 ppt. However, the suitable water salinity for snake head fish fertilization and hatching was 12 ppt, and hatching out time was in the range of 1,192-1,442 minutes. When snake head fish were directly transferred to water of salinity ranging from 0 to 30 ppt. The fish can grow at water salinity of 0-14 ppt, but unfortunately the growth rate was slowly decreased after water salinity was increased to the range of 11-14 ppt. Water salinity in the range of 0-10 ppt was shown to provide the highest survival rate and growth. Further research should focus on the physiological adaptability to changing water salinity of this fish species.

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