SHORT COMMUNICATION

Stocking density-dependent growth and survival of Asian red-tailed catfish (*Hemibagrus wyckioides*) fries: early nursing in cages

Wirat Jiwyam · Nudtha Nithikulworawong

Abstract Asian red-tailed catfish (*Hemibagrus wyckioides*) were raised at five different stocking densities in cages (submerged and with a volume of 1 m^3) suspended in a fish pond from July to August 2012. *H. wyckioides* fries (mean weight 0.8 ± 0.1 g) were stocked at densities of 25, 50, 100, 200, and 400 fish/m^3. At the end of 56 days, the mean fish weights among the stocking densities of 25 and 50 fish/m^3 were significantly lower than those of the 100, 200, and 400 fish/m^3 density. The specific growth rates and final mean weights amongst fish reared in higher stocking densities of 100, 200, and 200 fish/m^3 were higher than those of the low stocking densities of 25 and 50 fish/m^3. Asian river catfish performed poorly at the lowest density. The results indicate an initial lower stocking threshold for Asian red-tailed catfish fries of above 100 fish/m^3. The Asian red-tailed catfish fries reared in small cages placed in a pond reached the size 5–6.6 g within a 56-day nursing period.

Keywords Asian red-tailed catfish · Stocking density · Fish fry nursing · Fish fingerling · Cage culture

Introduction

Asian red-tailed catfish *Hemibagrus wyckioides* is an omnivorous freshwater fish which is commonly found within the Mekong River Basin (Prasertwattana et al. 2005). The red-tailed catfish reared in several Asian countries are well accepted by consumers as food fish (Sahoo et al. 2010). This species is the largest bagrid catfish in Asia and can reach 80 kg in the wild (Ng and Rainboth 1999). The body length of *H. wyckioides* can increase from 0.85 to 3.25 cm in 6 weeks, and the specific growth rate may reach up to 10.23 %/day (Amornsakun 2000). In addition, *H. wyckioides* grows and develops well in waters which have different chemical compositions and temperature ranges. *H. wyckioides* eats a wide variety of prepared, frozen and live foods, which makes it an excellent species for intensive aquaculture (Ng and Rainboth 1999). Now that *H. wyckioides* is popular in cage culture in the Mekong River Basin (Prasertwattana et al. 2005), this has led to a high demand for *H. wyckioides* fingerlings for stocking in grow-out cages. Stocking density, quality of feed and water quality management are some of the important factors to be considered during intensive aquaculture. Stocking density plays a crucial role in determining the growth and survival, and ultimately the fish or seed production, in an intensive system (Sahoo et al. 2010). The negative impact of density on growth and survival has been widely reported when raising catfish (Dada et al. 2000; Sahoo et al. 2004). However, a

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higher density has been reported to have had beneficial effects on growth responses in *Clarias gariepinus* fingerling (Toko et al. 2007), whereas the growth rate was inversely related to stocking at the fry stages (Haylor 1991). Survival was not affected in higher density rearing of *Brycon cephalus* larvae (Gomes et al. 2000). Asian river catfish, *Pangasius bocourti* performed poorly at the lowest density, and an initial lower stocking threshold for this species was above 5.20 kg/m^3 (Jiwyam 2011).

Thus it is believed that fish show interesting differences, which vary with the species and life stage, of the fish. No literature is currently available on the density-dependent rearing performance of *H. wyckioides* fries. Therefore, the aim of this study is to determine the optimum stocking density for *H. wyckioides* during their early nursing phase.

Materials and methods

The study was carried out in a 400-m^2 earthen pond. The metal frame cages measured $1 \times 1 \times 1.5$ m and were made of polyethylene with 1-mm mesh netting. The submerged volume of each cage was 1 m^3. The cages were suspended from a bamboo structure fixed by cotton-nylon cords to a walkway from shore. Plastic bottles, attached along the four sides of each cage, were used as floats. There were 5 treatments using 5 different stocking densities, with three replicates in each treatment. A total of 2,325 red tail catfish fingerling with a mean weight of 0.8 g were stocked at 5 different stocking densities of 25, 50, 100, 200, and 400 fish/m^3, and reared for 8 weeks.

A commercial catfish feed pellet (Chareon Pokpand Ltd., Thailand) of known nutrient content (crude protein, 40 % by weight) was used. Fish were hand fed initially at 8 % of body weight 3 times/day (9:00 a.m., 12.00 and 16:00 p.m.). The total biomass of fish in each cage was used to readjust the food quantity downwards from 8 to 6, 4 and 3 % body weight for the 3 rd, 5th and the 7th week, respectively, according to the actual fish biomass. The uneaten feed was collected 30 min after feeding and then oven-dried at 70 °C. The weighting value was used to calculate the amount of the feed intake. Total fish biomass in each cage was measured and number of fish in each cage was counted at weekly intervals. Dissolved oxygen and temperature levels were measured weekly between 08.00 and 09.00 h, at the mid depth of each cage, using a YSI Model 52. On each sampling day, the pH was also measured with a portable pH meter (IQ Scientific Instruments).

At the end of the experiment the production parameters were evaluated. The final average weight (g) of the individual fish in each cage was calculated by dividing the total final biomass in the cage by the number of survivors. Total weight increments (net yield) were estimated by deducting the biomass stocked from the biomass harvested and was expressed as kg/m^3. The specific growth rate (%/day) was calculated as: $(\ln W2 - \ln W1)/t \times 100$, where W1 is the initial live body weight (g), W2 is the final live body weight (g), and t is the time in days. Survival rate (%) was calculated as: (no. of fish harvested/no. of fish stocked) $\times$ 100. Weight gain and daily weight gain were calculated based on mean weight increments during the rearing period of 56 days. The feed conversion ratio was calculated as: feed consumption/weight gain.

An analysis of variance (ANOVA) was applied to test the differences between stocking densities. The percentages of fish survival values were arcsine transformed. This analysis was then followed by a Tukey-HSD test where significant differences were observed. Differences were considered significant when $p < 0.05$. Data were presented as mean $\pm$ S.E. (standard error, $n = 3$).

Results and discussion

Water quality parameters, i.e. dissolved oxygen (4.52 ± 0.16 mg/l), pH (8.07 ± 0.04) and temperature (28.44 ± 0.13 °C) during the experimental period were not different among the treatments.

There were no significant differences amongst the initial mean weights of the fish at the start of the experiment (Table 1). The mean weight of the fish at all densities increased during the nursing period (Fig. 1). The survival rate was higher than 70 % at all stocking densities, and no significant differences were observed among the cages stocked at 25, 50, 100, 200, and 400 fish/m^3. Specific growth rates ranged from 3.02 ± 0.20 to 3.70 ± 0.02 %/day. The specific growth rate at densities of 25–50 fish/m^3 averaged 3.14 %/day and was significantly ($p < 0.05$) lower than those of 100, 200 and 400 fish/m^3. Specific growth rates increased with

Table 1 Harvesting data for Asian red-tailed catfish *Hemibagrus wyckioides* reared in cages for 56 days at five stocking densities

Growth parameters	Stocking density (fish/m³)				
	25	50	100	200	400
Initial mean weight (g)	0.90 ± 0.14	0.76 ± 0.00	0.77 ± 0.00	0.77 ± 0.00	0.78 ± 0.00
Final mean weight (g)	5.09 ± 0.4[a]	5.09 ± 0.1[a]	6.06 ± 0.3[b]	6.58 ± 0.1[b]	6.47 ± 0.1[b]
Specific growth rate (%/day)	3.02 ± 0.20[a]	3.27 ± 0.03[a]	3.55 ± 0.10[b]	3.70 ± 0.02[b]	3.66 ± 0.02[b]
Survival rate (%)	86.7 ± 4.8	70.0 ± 6.4	80.0 ± 6.7	76.8 ± 9.2	71.5 ± 18.6
Feed conversion ratio	2.4 ± 0.1	2.8 ± 0.3	2.3 ± 0.26	2.3 ± 0.2	3.4 ± 1.2
Harvest (kg)	0.11 ± 0.01[a]	0.18 ± 0.01[a]	0.49 ± 0.06[ab]	1.08 ± 0.11[b]	1.84 ± 0.48[c]
CV of weight (%)	17.3 ± 2.1	18.3 ± 2.1	18.5 ± 1.9	17.9 ± 0.3	18.1 ± 0.5
CV of total length (%)	6.2 ± 0.64	6.49 ± 0.33	7.30 ± 0.33	6.78 ± 0.19	7.09 ± 0.68

The values are means ± standard errors ($n = 3$) Mean values with different letters in the same row are significantly different ($p < 0.05$)
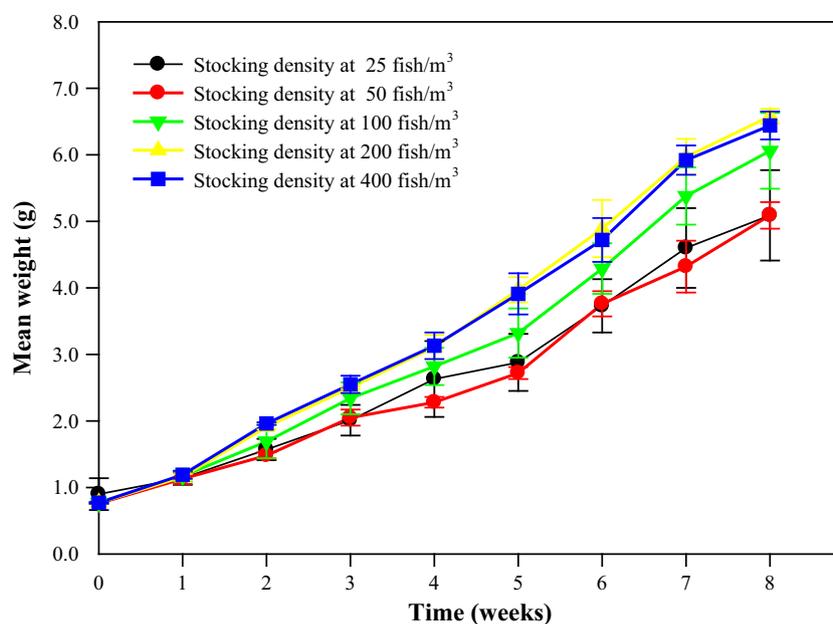
Fig. 1 Estimated mean weight gains between each sampling day for Asian red-tailed catfish, *Hemibagrus wyckioides*, reared in cages stocked with 25, 50, 100, 200 or 400 fish/m⁻³ over a 56-day period

increasing stocking densities but only from the densities of 25–100 fish/m³. Harvests from the cages ranged from 0.11 ± 0.01 to 1.84 ± 0.48 kg/m³ with an individual mean weight of 5.09 ± 0.4–6.58 ± 0.1 g. The highest specific growth and final mean weight were achieved at a density of 200 fish/m³. However, it was not significantly different from the highest stocking density (400 fish/m³). There were no significant differences in feed conversion ratios among the fish stocked at different densities ($p > 0.05$). However, the highest feed conversion ratio was at the highest stocking density (400 fish/m³). Final weight and total length variation coefficients were not significantly different ($p > 0.05$). The average final weight and total length variation coefficients were 18 and 6.8 % respectively.

Water characteristics (dissolved oxygen, pH and temperature) measured during the experimental period were within the range recommended for aquaculture (Boyd and Tucker, 1998). The present study gives, for the first time, survival and growth data of the Asian red-tailed catfish *H. wyckioides* fries reared in cages. The Asian red-tailed catfish fries reached a weight of 5.1–6.6 g within a 56-day nursing period. Survival rates of Asian red-tailed catfish were not related to the stocking density as might have been expected. Similarly, the survival rate of African catfish in cages was also not clearly influenced by stocking density (Hengsawat et al.

1997). But, Yi et al. (1996) found that stocking densities of caged tilapia had significant effects on the survival, growth, and food conversion ratio's of caged tilapia and on the growth of open pond tilapia. However, survival rates of *H. wyckioides*, 70.0–86.7 % were higher than that of *Heterobranchus longifilis*, 15.1–68.0 %. Even cannibalism was density dependent in *C. gariepinus* (Hecht and Appelbaum 1988) and *H. longifilis* (Coulibaly et al. 2007). The maximum specific growth rate of *H. wyckioides*, reared from initial weight 1.9 g to final weight 10.21 g in an 8 week-period, was 2.98 %/day (Deng et al. 2011). This was similar to the maximum specific growth rate of 3.7 %/day achieved from the present study. Specific growth rates are likely to increase with increasing stocking densities, but only from densities of 50–100 fish/m^3. In the present study, the growth rates were high even at the highest stocking density. These results agree with those reported for other catfish species as well as other species. Hengsawat et al. (1997) noted that the instantaneous growth rates of African catfish cultured in cages were unrelated to stocking density. At low stocking densities, it was observed in African catfish (*C. gariepinus*) and vundu catfish (*H. longifilis*) that growth rates increased with increasing densities; significantly so in the African catfish stocked at 8 fish/m^3 compared with the other densities of between 4 and 6 fish/m^3 (Toko et al. 2007). Similarly, specific growth of *P. bocourti* increased with increasing stocking densities of between 12 and 50 fish/m^3, but there was no difference from stocking densities of between 100 and 200 fish/m^3 (Jiwyam 2011). However, there was no effect of stocking density on the growth rate and weight gain of tambaqui *Colossoma macropomum* in cage culture (Gomes et al. 2006). The differences between the results were probably caused by differences in the biology and environmental requirements of each species. Coulibaly et al. (2007) noted that the main constraint of the culture of *H. longifilis* remains the high mortality rate due to cannibalism. In that experiment African catfish *H. longifilis* Valenciennes with initial mean weight of 0.8 g were stocked at densities 50, 100, 200, 500 and 1000 fish/m^3 in fine mesh cages (1 m^3). Final weight variation coefficient increased with stocking density, whereas the survival rate decreased. The final weight variation coefficient in that experiment ranged from 29 to 80 % at stocking densities of 50, and 1,000 fish/m^3, respectively. A low final weight and total length variation coefficients, 18 and 6.8 %, respectively indicate that there was no cannibalism in the cage rearing of this species. However, when fingerlings of this species were stocked in grass aquarium a very high rate of loss, due to cannibalism was observed (author's unpublished data). Scotoperiod improves survival and growth of tactile feeders with refuge seeking behaviors in light conditions such as African catfish *C. gariepinus* (Hossain et al. 1998; Applebaum and Kamler 2000), sutchi catfish *Pangasianodon hypophthalmus* (Mukai et al. 2010; Mukai 2011) and vundu catfish *H. longifilis* (Baras et al. 1998). Rearing fish in cages suspended in pond water where the water is more turbid as compared to clear water in grass aquarium may help to reduce cannibalism of this species because of the low light levels. The results in the present study were similar to those observed when cage rearing of *H. longifilis* which noted higher survival rates when compared to traditional rearing system.

Recently, Pirozzi et al. (2009) found that an appropriate initial lower stocking threshold for mulloway, *Argyrosomus japonicus* was above 4.08 kg/m^3. In addition, it was noted that the low feed efficiency value for the fish at low stocking densities does provide an indication of the overall inefficient feeding behavior of mulloway. Although feed conversion ratio among fish groups in the present study was not significantly different; but they seemed to be high at the low and the highest densities as compared to the medium densities. In the reported studies of Khan (1994) and Jiwyam (2011) thresholds in stocking densities are higher than in the present study (i.e. >5.9 to 7.8 kg/m^3 (Khan) and >10.6 to 42 kg/m^3 (Jiwyam). Maximum yield may not have been reached in the present study. In that study, feed conversion seems to be higher at lower stocking densities; therefore, it hypothesizes that, at a certain density, a social cohesiveness forms that encourages a reduction in corporate vigilance and a change to normal feeding and behavior. Below this threshold, Asian river catfish may become increasingly skittish and vigilant, which leads to increasing general activity and inefficient feeding behavior. However, growth and feeding studies combined with quantifiable behavioral data would test this hypothesis. So, the results of the present study indicate that a lower threshold of stocking density may also be applied to Asian red-tailed catfish. But, the highest feed conversion at the highest stocking density may indicate the carrying capacity of system. Due to the fact that increasing stocking density usually results in stress (Leatherland and Cho 1985), which leads to enhanced energy requirements causing reduced growth, feed utilization, and net yield (Grant 1997; Hengsawat et al. 1997).

Conclusion

The results indicated that the stocking density has an influence on growth and survival of *H. wyckioides* fingerling during nursery rearing. The growth and survival were not inversely related to density. A minimum threshold stocking density of *H. wyckioides* fingerlings during their nursing period was 100 fish/m^3. The high stocking densities of 200–400 fish/m^3 did not significantly influence growth and survival.

Conflict of interest The authors declare that they have no conflict of interest

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