Effects of Different Stocking Density on Growth Performance and Economic Returns of Mekong Giant Catfish (*Pangasianodon gigas*) Raised in Small-scale Cage Culture

Kritima Saowakoon[1], Samnao Saowakoon[1,*], Praneet Ngamsnae[2], Suthus Phaukgeen[3] and Talerngkiat Somnuek[1]

[1]Fisheries Department, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan, Surin Campus, Thailand 145 Moo 15 Nokmueng, Mueng Surin 32000 Thailand

[2]Faculty of Agriculture, Ubon Ratchathani University, Warin Chamrap Ubon Ratchathani 34190 Thailand

[3]Nong Khai Inland Fishery Development, 152 Moo 12 Phan Phrao, Si Chiang Mai, Nong Khai 43130 Thailand

Abstract : Study on effects of stocking density on growth performance and economic returns of Mekong Giant Catfish (*Pangasianodon gigas*) cultured in experimental floating cages was conducted, using four stocking densities (SD): 10, 20, 30 and 40 fish/m^2, respectively. Fish of initial average size of 16.32–16.92 cm in length and 160.03–162.09 g in body weight were stocked in 1.0x1.0x1.5 m^3 cages. The fish were fed with pellet diet containing 30% protein twice a day (*ad libitum*) for twelve months. Results showed that survival rates of fish were 86.67±5.77%, 85.00±5.00%, 84.44±6.94% and 79.17±6.29% respectively. Survival rates increased with decreasing stocking density and the fish stocked of 10 fish/m^2 was significantly highest among treatments (p<0.05). The results also revealed that the 10 fish/cage had significantly (P<0.05) greatest final weight with 1,062.98±4.15 g. No significant difference was observed for other treatments; 1,059.17±2.27 g, 1,058.18±2.56 g and 1,058.06±3.49 g for 20, 30 and 40 fish/cage, respectively. However, daily growth rate in terms of weight and length were not significantly different (P>0.05). The significantly highest SGR of fish stocked at 10 fish/m^2 (0.5189%/day) confirmed the optimum stocking density of this study. Research findings showed that returns of investments in the cage culture of Mekong Giant Catfish in the 30 fish/m^2 (99.77±21.64%) were economically higher in comparisons to those of 20, 10 and 40 fish/m^2 (98.61±12.81, 93.87±12.95 and 90.17±19.64 %, respectively).

Keywords : Mekong Giant Catfish, *Pangasianodon gigas*, stocking density, Growth Performance, Economic Returns

*Corresponding Author : saowakoon@gmail.com Tel. 089 8467202

1.Introduction

Stocking density is considered to be one of the important factors that affect fish growth, feed utilization and gross fish yield (Chakraborty and Banerjee, 2010). The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. Fish intensification by increasing stocking density is also found suitable to overcome the problem of land shortage (Khattab *et al*., 2004). But, fish culture on a small-scale basis has often failed due to inadequate knowledge regarding ideal stocking density of fish. In terms of the fish production in cages, stocking density, which is related to the volume of water or surface area per fish is an important factor. Increase in stocking density results in increasing stress, which leads to higher energy requirements, causing a reduction in growth rate and food utilization. Contrarily, in case of low stocking densities fish may not form shoals and feel comfortable. Consequently, identifying the optimum stocking density for a species is a critical factor not only for designing an efficient culture system (Leatherland and Cho, 1985), but also for optimum husbandry practices.

Mekong Giant Catfish (*Pangasianodon gigas*), is one of the largest freshwater fish in the world, native to Mekong River basin with the fact that the species is critically endangered. However, in recent decade, techniques of induced propagation have been successfully established (Pholprasith, 1983; Pholprasith and Tavarutmaneegul, 1997; Pholprasith *et al.,* 1992 and Leelapatra *et al*., 2000). Recently, the artificial insemination and pond cultivation of the Mekong Giant Catfish has been successfully established. Nowadays, the breeding programs of this species were set up in some Inland Fisheries Development Centers, Department of Fisheries (DOF), to supply the wildlife conservation activities. On the other hand, culture of Mekong Giant Catfish (*Pangasianodon gigas*) for domestic consumption and exporting abroad were also practiced by private sectors.

Many different culture systems, including suspended cages, reservoir and pond culture systems were developed and adapted for Mekong Giant Catfish production, in order to enhance production efficiency and decrease production cost. However, information regarding effect of stocking density on fish performance of Mekong Giant Catfish (*Pangasianodon gigas*) cultured in experimental floating cages is limited. This study was therefore design to investigate the effects of different stocking density on growth performance, food conversion and survival of *Pangasianodon gigas* juveniles, and to evaluate the economic returns of the *P. gigas*, reared in cages with a view of complimenting existing information to assist the farmers on better culture methods. It is hope that the results will contribute significantly to the knowledge of culture requirements of the species.

2. Materials and Methods

All experiments were conducted at Department of Fisheries, Faculty of Agriculture and Technology, Rajamangala University of Technology Isan (RMUTI), Surin campus since November 2010 to September 2011.

2.1 Experimental design

Mekong giant catfish juveniles were taken from the induced breeding project of Kalasin Inland Fisheries Station and acclimatized to pellet diet feeding 2 weeks prior to starting the experiment. At the start of feeding trial the acclimated fish were deprived of feed for 24 hrs, pooled, and 12 groups of fish with the initial mean weight of 160.03–162.09 g and length of 16.32–16.92 cm, were randomly stocked into floating net cages with 1.0 x 1.0 x 1.5 m^3 size. Group of fish in triplicate were randomly selected and four stocking densities of 10, 20, 30 and 40 fish/m^2 were assigned using Complete Randomized Design (CRD).

The fishes were fed twice per day *ad libitum* with floating pellet containing 30% protein at 08.00 and 15.00 hrs. Fish weight and length were measured at the beginning of the experiment and subsequently every two weeks for 12 months. After each measuring period, the amount of feed given was adjusted according to the biomass in each cage.

2.2 Growth performance

Weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) were calculated after the experiment as follows:

$$\text{SGR (\%)} = \frac{\ln \text{final wt} - \ln \text{initial wt}}{t \text{ (days)}} \times 100$$

$$\text{FCR} = \frac{\text{Food consumed in g (dry weight)}}{\text{Live weight gain in g}}$$

$$\text{Survival rate (\%)} = \frac{\text{final number of fish individuals}}{\text{initial number}} \times 100$$

2.3 Water Quality

Water quality analyses were conducted two times a week for temperature, transparency, dissolved oxygen, pH, alkalinity and hardness. Unionized ammonia was calculated based on total ammonia–nitrogen, water temperature, and pH according to Boyd (1982).

2.4 Economic analysis

The economic analysis was performed to estimate the cost required to raise fish in each treatment. The economic evaluations for total cost, depreciation cost, total income and return on investment were calculated based on the method of Chamchong (2003) as follows:

$$\text{R.O.I.} = [(\text{income} - \text{capital})/\text{capital}] \times 100$$

2.5 Statistical analysis

Data on survival rate, specific growth rate (SGR), weight, length, feed conversion ratio (FCR) and survival rate were subjected to one-way analysis of variance using Statistical program version 5.0. Differences in treatment means were compared by Duncan's new multiple range test ($p<0.05$).

3. Results and Discussion

3.1 Water Quality

During the study period, overall water quality values (Table 1), the range of dissolved oxygen 4.1–6.2 mg/L; temperature 28.5–33.9°C; pH 5.7–7.2; unionized ammonia 0.13–0.16 mg/L; alkalinity 60.3–70.2mg/L; transparency 20.0–23.6 cm and total hardness 158.4–173.3mg/L. Water quality parameters were within ranges suitable for health and growth of general freshwater fish (Duangsawat and Somsiri, 1985).

3.2 Mekong Giant Catfish Growth

Growth of Mekong Giant Catfish in each different stocking density was shown in Table 2. Survival rates of fish were 86.67±5.77%, 85.00±5.00%, 84.44±6.94% and 79.17±6.29 % respectively. Survival rates increased with decreasing stocking density and the fish stocked 10 fish/m^2 was significantly highest among treatments ($p< 0.05$). The results revealed that 10 fish/cage had the significantly ($p<0.05$) greatest final weight with 1,062.98±4.15 g. No significant differences were observed for the other treatments; 1,059.17±2.27 g, 1,058.18±2.56 g and 1,058.06±3.49 g for 20, 30 and 40 fish/cage, respectively. However, daily growth rate in terms of weight and length were not significant different ($p>0.05$). The significantly highest SGR of fish stocked 10 fish/m^2 (0.5189%/day) confirmed the optimum stocking density of this study.

Several studies have also demonstrated that increased stocking density has a negative effect on growth and survival (Rowland *et al,* 2004; Schram *et al*., 2006 and Irwin *et al*., 1999). This poor growth by stocking density may be attributed to reduced food consumption, lower food conversion rates or increased metabolic cost. Higher survival rates in low stocking density indicated that increasing stocking density results in increase activity such as air breathing, swimming and decrease aggression.

Contrarily, in some cultured fish species, growth is inversely related to stocking density and this is mainly attributed to social interactions (Holm *et al.*, 1990; Haylor, 1991 and Jiwyam, 2011). Social interactions through competition for food and/or space can negatively affect fish growth.

3.3 Production cost and economic returns

The highest fish harvest was found in 40 fish/m^2 at the level of 33.50±2.60 kg/cage, followed by 30 fish/m^2 (26.08±2.14), 20 fish/m^2 (18.01±1.04) and 10 fish/m^2 (9.21±0.58 kg/cage), respectively (Table 3). This results in the increased total incomes with increasing stocking density. However, in term of total cost, it was found that 40 fish/m^2 had the highest cost of 5,298.86±275.76 baht, while 4,033.95±128.18 baht, 2,721.23±76.09 baht, and 1,425.60±16.43 baht were observed at 30, 20 and 10 fish/m^2, respectively.

4. Conclusions

Stocking density had a significantly effect on growth of Mekong giant catfish raised in cages. An optimal stocking density for this fish in small-scale cage culture was 10 fish/m^2, by which an increasing weight per day was 2.476±0.000 g, the length per day 0.097±0.000 cm and survival rate at 86.67±5.77%. Followed by the stocking density of 30 fish/m^3, 20 fish/m^2 and 40 fish/m^2 respectively. No significant difference ($p>0.05$) observed between feed conversion ratio (FCR) and survival rate in each different stocking density. The 30 fish/m^2 stocking density had the highest economic return at the level of 99.77±21.64%, which was recommended for Makong Giant Catfish culture. This would help agriculturist gain more benefit.

5. Acknowledgement

Research and Development Institute, Rajamangala University of Technology Isan (RMUTI), Surin campus and Faculty of Agriculture and Technology is gratefully acknowledged for their support and funds.

6. References

Boyd., C.E.: Water quality management for pond fish culture. Elsvier Scientific Publishing Company Amsterdam, The Netherland. 1982.

Chakraborty, S.B.; Banerjee, S.: Effect of Stocking Density on Monosex Nile Tilapia Growth during Pond Culture in India. *World Acad. Sci. Eng. Technol*., 2010, Vol. 44, pp.1521-1525, P-ISSN: 2010-376X.

Chamchong, C.: Farm management. Wang buraba. Bangkok. 2003.

Duangsawat, M.; Somsiri, J.: *Water properties and method analysis for research in fisheries. Department of freshwater fisheries*. Inland Fisheries Institute, Department of Fisheries. Ministry of Agriculture and Cooperative. Bangkok. 1985.

Haylor, G.S.: Controlled hatchery production of *Clarias gariepinus* (Burchell 1922): growth and survival of fry at high stocking density. *Aquacult. Fish. Manag*., 1991, Vol.22, pp.405-422, ISSN (Print) 1230-6428.

Holm, J.C.; Refstie, T.; Bo, S.: The effect of fish density and feeding regimes on individual growth rate and mortain rainbow trout (*Oncorhynchus mykiss*). *Aquacult*., 1990, Vol.89, No. 3/4, pp.225-232, ISSN 0044-8486.

Irwin, S.; Halloran, J.O.; FitzGerald, R.O.: Stocking density, growth and growth variation in juvenile turbot (*Scophthalmus maximus*) Rafinesque. *Aquacult*., 1999, Vo.178, pp. 77-88, ISSN 00448486.

Jiwyam, W.: The effects of stocking density on yield, growth and survival rate of Asian river catfish (*Pangasius bocourti Sauvage*) cultured in cages. *Aquacult. Int*., 2011, Vo.19, pp. 987-997, ISSN 09676120.

Khattab, Y. A. R.; Abdel-Tawwab, M.; Ahmad, M.H.: Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry (*Oreochromis niloticus* L.), in Proceedings of the Sixth International Symposium on Tilapia in Aquaculture, R. Bolivar, G. Mair and K. Fitzsimmons, Eds. Manila, Philippines, BFAR, Philippines, 2004, pp. 264-276.

Leatherland, J.F.; Cho, C.Y.: Effect of rearing density on thyroid and interrenal gland activity and plasma and hepatic metabolite levels in rainbow trout, *Salmo gairdneri* Richardson. *J. Fish. Biol*., 1985, Vol.27, pp.583-592, ISSN 10958649.

Leelapatra, W.; Srisakultiew, P.; Sukumasavin, N.: Biology and breeding of Indigenous Mekong fish species in Thailand. *Management of reservoir fisheries in the Mekong Basin II. In: Component Report No.2*, Mekong River Commission, Phnom Penh, p. 83-86.

Pholprasith. S.: Induced spawning of the Mekong giant catfish. *Thai Fisheries Gazette*. 1983, Vol.36, No.4, pp.347-360, ISSN 0125-6297.

Pholprasith, S., Benjakarn, M.; Ritthaporn, R.: Development of commercial culture of the Mekong giant catfish. *Technical Paper No.14, Inland Fisheries Division. Department of Fisheries*, Ministry of Agriculture and Cooperatives, Bangkok. pp.51.

Pholprasith, S., Tavarutmaneegul, P.: Biology and culture of the Mekong giant catfish, *Pangasianodon gigas* (Chevey 1930). *Extension Paper No. 31*. *National Inland Fisheries Institute*, Bangkok. pp.79 (1997).

Rowland, S.J., Allan, G.; Hollis, M.; Ponifex, T.: Production of silver perch (*Bidyanus bidyanus*) fingerlings at three stocking densities in cages and tanks. *Aquacult*., 2004, Vol.229, pp.193-202, ISSN 0044-8486.

Schram, E, van der Heul, J.W.; Kamstra, A.; Verdegem, M.C.J.: Stocking density dependent growth of dover sole (*Solea solea*). *Aquacult*., 2006, Vol.252, pp.339-347, ISSN 0044-8486.

Table 1 Some major water quality parameters inside the cages

Quality Index	Cage area			Range
	Upper cage	Middle cage	Bottom cage	
pH	6.28±0.61	6.24±0.57	6.24±0.57	5.7-7.2
Temperature (°C)	3075±1.81	30.89±1.66	30.89±1.66	28.5-33.9
Dissolved oxygen (mg/L)	5.27±0.69	5.16±0.68	5.16±0.68	4.1-6.2
Alkalinity (mg/L)	64.51±2.72	64.19±2.85	64.19±2.85	60.3-70.2
Hardness (mg/L)	166.04±4.95	165.96±4.97	165.96±4.97	158.4-173.3
Transparency (cm)	20.85±1.40	20.85±1.40	20.85±1.40	20-23.6
Unionized ammonia, NH_3 (mg/L)	0.15±0.01	0.15±0.01	0.15±0.01	0.13-0.16

Table 2 Growth performance and feed utilizations of the Mekong River Giant Catfish (*Pangasianodon gigas*), raised in small-scale cage culture for 4 months (16 weeks) period (mean±SD)

Growth parameters	Stocking density (fish/m^2)			
	10	20	30	40
Initial weight (g)	161.12 ±0.94	160.03 ±0.78	162.09±0.76	160.09±0.82
Final weight (g)	1,062.98±4.15^a	1,059.17±2.27^b	1,058.18±2.56^b	1,058.06±3.49^b
Initial length (cm)	16. 76±1.14	16. 56±1.08	16. 92±1.02	16. 32±1.09
Final length (cm)	52.49±0.19^a	52.45±0.15 ^{a}	52.41±0.11^a	52.26±0.14^a
Average daily growth :				
- weight (g/day)	2.476±0.000^a	2.474±0.001^{ab}	2.474±0.002^{ab}	2.473±0.002^b
- length (cm/day)	0.097±0.001^a	0.097±0.001^a	0.097±0.001^a	0.098±0.001^a
Specific growth rate; SGR (%/day)	0.5189±0.0001^a	0.5187±0.0001^b	0.5187±0.0001^b	0.5186±0.0001^b
Feed conversion ratio (FCR)	1.67±0.15^a	1.63±0.23^a	1.66±0.35^a	1.70±0.46^a
Survival rate (%)	86.67±5.77^a	85.00±5.00^a	84.44±6.94^a	79.17±6.29^a

Table 3 Economic returns of the River Mekong Giant Catfish (*Pangasianodon gigas*) production, raised in all experimental treatments

Items/ Cage	**Stocking density (fish/m²)**			
	10	**20**	**30**	**40**
1. Cost (Thai ; Baht)				
Fish [1]	1,000	2,000	3,000	4,000
Fish feed [2]	325.6±16.43	621.23±76.09	933.95±128.18	1,198.86±275.76
Depreciation cost [3]	100	100	100	100
Total cost	1,425.60±16.43	2,721.23±76.09	4,033.95±128.18	5,298.86±275.76
2. Fish production (kg/cage)	9.21 ± 0.58	18.01±1.04	26.08±2.14	33.50±2.60
Production cost (Baht/kg)	155.22 ± 1.75	151.49±10.13	151.39±16.86	158.96±17.43
3. Income (Thai ; Baht)				
Total income from selling fish [4]	2,763.33±175.22	5,401.55±312.46	8,041.14±642.66	10,050.52±780.95
Profit/cage	1,337.74±179.38	2,680.31±324.66	4,007.20±756.04	4,751.66±899.46
Profit/kg	144.78±10.75	148.51±10.13	148.61±16.86	141.04±17.43
4. Return on investment (%)	93.87±12.95	98.61±12.81	99.77±21.64	90.17±19.64

Note: Fish [1] — Fish cost: 100 Baht/fish
Fish feed [2] — Feed cost: 25 Baht/kg
Depreciation cost [3] — Cage depreciation: 400 Baht/cage used four years
Total income from selling fish [4] — Market’s selling price 300 Baht/kg