THE GROWTH OF PATIN *Pangasiodon hypophthalmus* IN A CLOSE SYSTEM TANK

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ABSTRACT

This experiment aimed to evaluate the possibility of using integrated recirculation production system for patin grow-out. Each of twelve concrete 2.5x4.0x1.0 m^3 tanks filled to 0.73 m depth was stocked with 100 juvenile *patin*, 9-10g body weight. Six tanks were equipped with sand and palm (*Arenga pinata*) fibre filters planted with vegetables, lettuce and *kangkoong*. A submersible pump was installed in each tank to assure continuous water recirculation at the rate of 0.4 L sec^{-1}. The filtered water flowed into the tank at the surface (SC treatment), or at the bottom (BC treatment). In the other 6 tanks, the water flowed continuously from a concrete canal in an open culture system at a similar rate and with similar water entrance positions (SO and BO treatments). The experiment was arranged in a completely randomized design with three replicates. The fish were fed dry pelleted feed to satiation and sampled every other week for growth observation. After 90 days, the average individual weight of the fish attained the range of 80-100 g. The fish grew significantly faster ($P<0.05$) in SC tanks compared to those in the rest of the tanks, except in BC tanks. Denser growth of plankton and more suitable water quality was considered to encourage faster growth of the fish in close system tanks. The survival of the fish was not significantly different ($P>0.05$) among treatment, ranging from 99 to 100%. In terms of water usage, the closed system tanks produced fish weighing 202.38–220.05 g m^{-3}, much more efficiently than did the open system tanks, 1.87–1.89 g/m^3. The vegetables, either lettuce or water spinach, grew well on the filter. These results suggest that the integrated recirculation tank system is suitable for patin culture.

KEYWORDS: integrated recirculation, *Pangasius* grow-out

INTRODUCTION

Hardjamulia and Prihadi (1994) reported that research on *patin* (Thai catfish), *Pangasius hypophthalmus*, fry mass production was initiated in 1981, and since then large quantities of fry of *patin* have been produced in Indonesia. However, this success in fry production has not been followed by the development of a grow-out industry. Farmers culture the species in a very simple way using improperly designed ponds and floating net cages and neglecting the hygiene of the product (Nurdawati and Muflikhah, 2001; Djajasewaka *et al*., 1992). What most farmers know is patin survives even in waste water and water that is commonly considered to have no value for fish production. Patin is able to tolerate poor water quality conditions because it is equipped with an air breathing organ.

Nowadays, water is regarded as a valuable commodity that should be reserved for sustainable use. The Government of Indonesia predicts that the improper use of water will lead to a water crisis in the country in near future. Fish culture farmers, therefore, should wisely and efficiently use available water in producing fish meat. Yang Yi *et al*. (2002) reported that tilapia grew well in a closed system pond where the addition of water was only carried out to compensate water losses due to evaporation and seepage. Many countries have cultured fish in integrated aquaponic systems that efficiently use water to produce fish meat and vegetables (Anonymous, 2005a:

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2005b). The experiment reported here investigated the possibility of growing out patin in an integrated closed system to efficiently use water in producing healthy fish meat.

MATERIAL AND METHODS

The experiment was conducted for two months at the Toxicology and Aquaculture Environment Research Station, Research Institute for Freshwater Fisheries, Bogor, Indonesia. Initial average weight of the test fish was 8.60 g at standard length of 8.39 cm. All of the 1200 test fish originated from one batch of fry. One hundred fish were distributed evenly into each of 12 concrete tanks measuring 2.5×4.0×1.0 m^3, each. Water depth in each tank was maintained at 70–90 cm. The fish were fed commercial pelleted feed three times daily to meet 3–4 % biomass weight per day.

The experiment was arranged in a completely randomised factorial design with three replicates each. The first factors were culture type, i.e. closed or open system. The second factor was water inlet position, i.e. on water surface or tank bottom. Notations for the combination of treatment were SC (surface water inlet in closed system), BC (bottom water inlet in closed system), SO (surface water inlet in open system), and BO (bottom water inlet in open system). Water losses due to evaporation and seepage in the closed system were compensated for by the addition of water from the same source. Water debit and flow in all experimental units were maintained at 8–10 L $minute^{-1}$.

The filters in the closed system were positioned above the tanks, one filter for each tank. Filter substrate, i.e. gravel, palm fibre, and coarse sand, was made to suit vegetables, *kangkoong* (*Ipomea aquatica*), lettuce (*Lactuca sativa*), and *pakchoi* (*Brassica chinensis*) culture with about 30 % of tank total area. To maintain water quality and recirculation in the closed system tanks, water from fish tank was pumped out using a submersible pump into filter bed on which the vegetables growing.

Water quality variables such as DO and temperature were monitored every day and the daily fluctuation was monitored at 4 hour intervals in the beginning and the end of experiment for both close (C-i and C-f) and open (O-i and O-f) systems. Total ammonia, BOD, CO_2, pH, and transparency were monitored every second week. Fish were sampled for body weight and length every 14 days. Daily growth rate was calculated using the equation of Zonneveld *et al*. (1991): $Wt = Wo (1 + 0.01 \alpha)^t$. The differences between treatments in survival weight and growth, in term of daily growth rate and average individual final weight, were tested using one-way ANOVA and Tuckey's test with Minitab v.13.

RESULTS AND DISCUSSION

Water quality values in all tanks (Table 1) generally remained within the optimal requirements for *patin* culture. The lowest DO concentration was below optimal level for fish growth but this occurred for only 1–2 hours before dawn. Because *patin* has an air breathing organ, such a low DO concentration does not adversely affect their growth rate (Lagendre *et al*., 2000). Total ammonia (TAN) was higher and BOD was lower in the opened system than that in the closed system, but both

Table 1. Water quality in patin culture system tanks used in this experiment

Variable	**Treatment***			
	SC	**BC**	**SO**	**BO**
DO (mg L^{-1})	2.4 – 10.8	2.8 – 11.2	0.8 – 6.4	0.8 – 6.4
CO_2 (mg L^{-1})	3.6 – 12.0	1.2 – 8.0	10.0 – 20.7	4.8 – 20.4
pH	7.0 – 7.5	7.0 – 7.5	7.0 – 7.5	7.0 – 7.5
Temperature (^{0}C)	26.0 – 29.0	26.0 –29.0	24.5 – 28.0	24.5 – 28.0
TAN (mg L^{-1})	0.01 – 0.1	0.05 – 0.1	0.2 – 0.4	0.1 – 0.3
BOD (mg L^{-1})	2.8 – 3.2	2.4 – 6.4	0.4 – 3.2	0.4 – 2.0
Tranparency (cm)	14.0 – 25.0	20.0 – 30.0	70.0	70.0

* SC and BC = surface and bottom inlet in close system;
SO and BO = surface and bottom inlet in open system

were not reaching lethal concentration. BOD was higher and transparency was lower in the closed system than in the open system. This is likely because most of the nutrients originating from uneaten feed and fish faeces were trapped in the tanks and part was transported into the filter to become a source of fertilizer for the vegetables. Water temperature was slightly higher and CO_2 was much lower in the closed system due to the denser growth of phytoplankton, as indicated by lower transparency.

The survival rate of *patin* was not different ($P>0.05$) among treatment and ranged from 97-100 %. Mortality occurred only in the adaptation phase during the first week of the experiment. No mortality caused by either bacterial or viral disease was observed. Optimum water quality was suspected to positively support the survival of the test fish.

Analysis of variance at 95% confidence interval showed that the growth rate of the fish was significantly different between treatments (Table 2). In general, the fish grew significantly ($P<0.05$) faster in the closed than that in the open system. Water inlet position did not result in any effect on growth in either closed or open system. The daily growth rate ranged from 2.32% (opened system) to 2.70% (closed system). The denser growth and more species of plankton (Appendix), beside relatively higher dissolved oxygen concentration and temperature, may have provided a better environment for patin to grow faster in the closed than that in the open system. Transparency ranging from 14 to 30 cm seemed not harm the growth of patin in the closed culture system.

The average individual weight gain (range 25.83-33.89 g) was higher in the closed than that in the open system ($P<0.05$). More specifically, the fish raised in the closed system tanks equipped with surface water inlets gained weight more ($P<0.05$) than those in the other treatments (Table 2). The lowest weight gained was obtained from the opened system tank equipped with bottom water inlet (Table 2). At the end of the experiment, the heaviest fish (average individual weight of 45.53 g) were obtained in the closed system tank equipped with surface water inlet.

The fish in the closed system tanks grew to be significantly ($P<0.05$) longer than in the open system tanks (Table 2). The position of the water inlet did not significantly affect fish length. The standard length at the end of the experiment ranged from 4.42 to 5.34 cm and the longest fish, 14.40 cm, came from the closed system tank equipped with surface water inlet. Visually, the fish in the closed system tanks were distinctly larger than the fish in the open system tanks. Higher IWG and not different survival rate (Table 2) lead to the fact that total fish biomass at the end of the experiment was significantly higher in closed than in open system tanks.

Based on the water inlet measurements, 30.86 m^3 day^{-1}, to produce 3,475 g fish in the open system tanks requires 1,851.60 m^3 water over 2 months; in other words every cubic meter of water in produces 1.88 g of fish (Table 3). In the closed system tanks, the water used was 7.4 m^3 (water volume in the tank) plus 0.3-0.5 m^3 daily water addition to replace the losses due to seepage and evaporation; or 19.30 m^3 over 2 months to produce 4076.5 g fish. This closed system can produce 211 g of fish using only 1 m^3 water.

The vegetables successfully grown on the filter substrate were *kangkoong* (*Ipomea aquatica*), lettuce (*Lactuca sativa*), and *pakchoi*

Table 2. Survival rate (SR), daily growth rate (DGR), individual weight gain (IWG), and individual length gain (ILG) of *patin* raised in different culture system

Variable	**Culture system**			
	SC	**BC**	**SO**	**BO**
SR (%)	100.0^a	99.7^a	100.0^a	99.0^a
DGR (%)	2.70^a	2.52^{ab}	2.44^b	2.32^b
IWG (g)	33.89^a	30.29^{ab}	26.57^b	25.83^b
ILG (cm)	5.34^a	5.15^a	4.46^b	4.42^b

* The values in the same column followed by similar superscript are not significantly different ($P>0.05$)

Table 3. The water used in different tank culture systems to produce fish in 2 months

Item	**Tank culture system**			
	SC	**BC**	**SO**	**BO**
Volume of water used (m^3)	19.30	19.30	1851.60	1851.60
Yield (g)	4247.00	3906.00	3492.00	3458.00
Yield over water volume (g/m^3)	220.05	202.38	1.89	1.87

(*Brassica chinensis*). The yield of *kangkoong*, lettuce, and *pakchoi* every 20 days was 15, 6, and 6 kg, respectively. The size of filter particles and water intake is suspected to affect the productivity of the filter to produce those vegetables.

This experiment demonstrated that the close system is more suitable for patin culture than the open system. The capability of the closed system to trap most of the nutrients leads to dense phytoplankton growth (Appendix). In its turn, the dense phytoplankton growth encourages the development of zooplankton as supplemental food for the fish, and also maintains the concentration of dissolved oxygen at optimum levels: 2.4-11.2 mg L^{-1} for fish growth (Figure 1). In the open system tanks, the dissolved oxygen concentration fluctuated at lower levels: 1.6–6.4 mg L^{-1}. According to Pescod (1973) dissolved oxygen at 2.0 mg L^{-1} is sufficient for supporting fish life. Boyd (1979) reported fish survive for a short period at dissolved oxygen concentration 0.0-0.3 mg L^{-1}, died after some times at 0.3–1.0 mg L^{-1}, while at 1.0–5.0 mg L^{-1} fish survive but grow slowly. Further, Boyd (1982) found that fish grows normally at dissolved oxygen concentration above 5 mg L^{-1}. Specifically for *patin*, Komarudin (2000) and Lagendre *et al*. (2000) reported that the optimum dissolved oxygen concentration is 3 mg L^{-1} or higher, even though *patin* can survive at dissolved oxygen concentration as low as 0.6 mg L^{-1}.

The dense phytoplankton growth also suppresses the concentration of CO_2 and maintains water temperature fluctuating at around 1^0 C higher, 26-29^0 C, than in the open system tank, 24-28^0 C (Figure 2). According to Komarudin (2000) and Lagendre *et al*. (1999) the optimal water temperature for patin culture is 27- 31^0 C. The concentration of TAN was slightly lower in the close system tanks, 0.01-0.10 mg L^{-1}, than the open system tanks, 0.10-0.40 mg L^{-1}, presumably as a result of phytoplankton ability to use TAN as a source of nitrogen. The safe unionized ammonia (NH_3-N) concentration according to Pescod (1973) is below 1.0 mg L^{-1} at water pH around 7.0. This

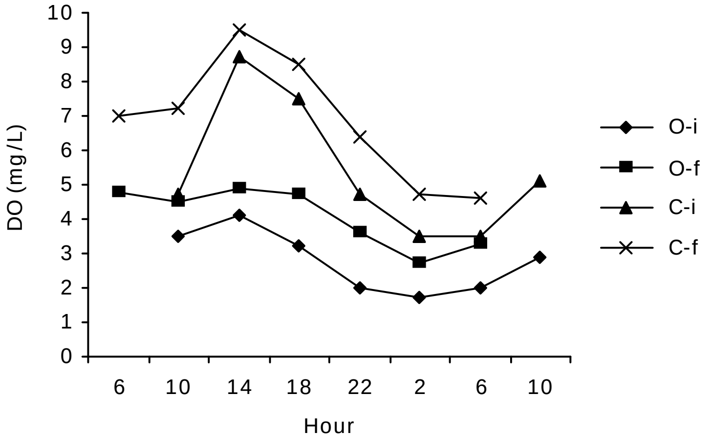

Figure 1. Daily DO fluctuation in open (O-i and O-f) and close (C-i and C-f) system tanks

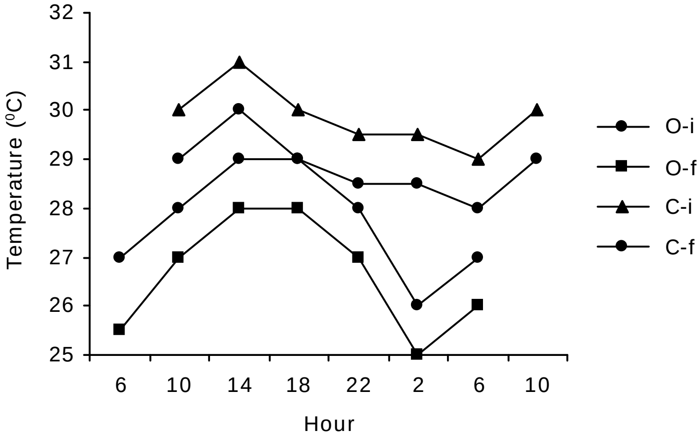

Figure 2. Daily water temperature fluctuation in open (O-i and O-f) and close (C-i and C-f) system tanks

indicates that the TAN concentration, just like the CO_2 concentration in this experiment was harmless to the test fish. Khairuman and Sudenda (2002) and Krismono (1987) suggested maintaining CO_2 concentration below 12.0 mg L^{-1} to assure high yield in a patin culture. Even though patin is very tolerant to pH fluctuation (Khairuman and Sudenda, 2002), Bardach *et al*. (1972) recommend pH 6.3-7.5 for *patin* culture.

Higher BOD_5 and denser plankton populations in the close system tanks indicate that much of the nutrient inputs are trapped in the tank and then assimilated into plankton growth. The BOD_5 in the closed system tanks, 2.4-6.4 mg L^{-1}, was lower than in the intensively managed fish pond, 0.12-0.70 mg L^{-1} $hour^{-1}$ (Boyd, 1979), but much higher than in the open system tank, 0.4-3.2 mg L^{-1} (Figure 3). As a result of having the capability to trap the nutrient inputs, the closed system provides sufficient nutrients, including CO_2 (Figure 3), for plankton growth. Consequently, the transparency in the closed system tanks, 14-30 cm, is more suitable for patin growth than in the open system tanks where transparency reached 70 cm. Based on Boyd's (1982) criteria, the optimum water transparency for fish culture is 30-40 cm and the water may need fertilizer addition when transparency exceeds 40 cm.

More efficient water use reduced environmental pollution from waste nutrients, and higher productivity is among the factors indicating that the closed system is more suitable for patin culture than the open system. The use of filter substrate for cultivating vegetables generates additional income for the farmer (Heerin, 2003). In the near future, fish

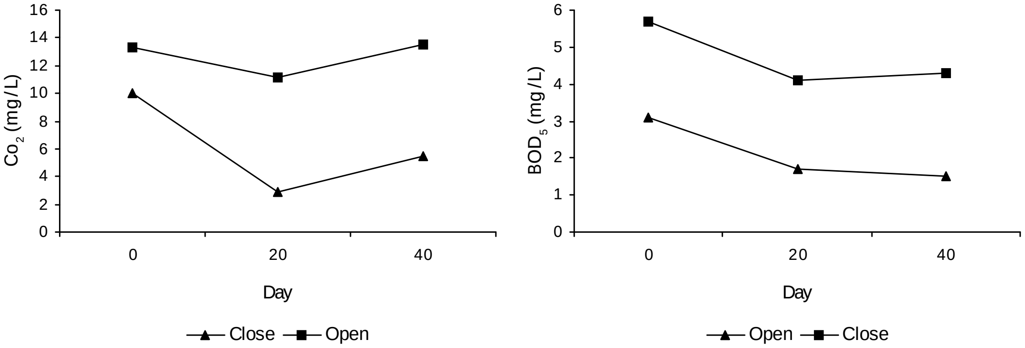

Figure 3. Fluctuation of CO_2 concentration and BOD_5 in open and closed system *patin* tanks

culture in closed system tanks might be more profitable than the open system, especially when people are more aware of the hazards of water pollution and increasing scarcity. Fish culture facilities must become more environmentally responsible. Based on the results of this experiment, the close system has been demonstrated to be more productive, economically attractive, technically accepted, and environmentally sound than the open culture system.

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Appendix: The abundance of plankton in different patin culture system tanks

Genus	**Culture system**				
	SC	**BC**	**SO**	**BO**	**Inlet**
Microcystis	466	124	1	1	0
Melosira	41	286	1	1	0
Coelastrum	24	74	1	0	3
Oscillatoria	51	74	7	0	1
Pediastrum	51	1	0	0	0
Vorticella	0	3	0	0	0
Synedra	8	0	1	0	0
Chromogaster	2	0	5	8	4
Keratella	1	0	1	0	0
Navicula	1	0	1	0	0
Scenedesmus	0	3	0	0	0
Synchaeta	0	1	0	0	0
Total	646	566	18	10	8
Cells mL^{-1}	1.45	1.25	43	24	20
Cyclops (pcs L^{-1})	2.245	2.245	2.245	2.245	0
Daphnia (pcs L^{-1})	4.49	13.468	4.49	4.49	2.245