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Biological performance of Asian catfish (*Clarias batrachus*) (Teleostei, Clariidae) cultured in recirculating aquaculture system

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Abstract. The study was conducted to assess the biological performance of Asian catfish in RAS by using 4 tanks (3 culture tanks and 1 sedimentation tank) measuring 2 m x 1 m x 0.60 m with a volume of 900 liters and bio-filter as water purification unit. The numbers of catfish cultured in each tank were as many as 300 fish i each tank, with a size of 5-8 cm (Tank 1), 8-12 cm (Tank 2) and 12-15 cm (Tank 3), respectively. This study was conducted for 30 days (August-September 2010) by considering the water quality during experiment, indicates that the RAS are able to provide proper conditions for growth and survival of catfish with a survival rate more than 92% on all tank experiments with specific growth rate from 0.64 to 0.89% per day and feed conversion rate of about 0.18-0.27. The existence of the impurities from the fish waste directly influences water quality, but the decline of water quality still at a decent level for the culture of catfish. The ANOVA test to the biological performance and water quality showed that the difference in the size of fish in each tank has no significant influence between each other.
Key Words: Recirculating aquaculture system (RAS), Asian catfish, water quality, growth parameters.

Abstrak. Penelitian ini dilakukan untuk mengkaji performansi biologi ikan lele yang dibudidaya dalam sistem akuakultur resirkulasi (RAS) dengan menggunakan 3 tangki budidaya dan 1 tangki sedimentasi berukuran 2.00 m x 1.00 m x 0.60 m dengan volume air 900 liter dan biofilter sebagai unit pembersihan air. Jumlah ikan lele yang dibudidaya dalam setiap tangki adalah sebanyak 300 ekor dengan ukuran 5-8 cm (Tangki 1), 8-12 cm (Tangki 2) dan 12-15 cm (Tangki 3). Pada penelitian yang dilakukan selama 30 hari dengan memperhatikan kualitas air selama percobaan menunjukkan bahwa RAS mampu menyediakan kondisi yang layak bagi pertumbuhan dan kelangsungan hidup ikan lele dengan tingkat kelangsungan hidup lebih besar dari 92 % pada semua tangki percobaan dengan laju pertumbuhan spesifik sebesar 0.64–0.89% per hari dan tingkat konversi pakan sekitar 0.18–0.27. Adanya limbah hasil kotoran dari ikan secara langsung mempengaruhi kualitas air, namun penurunan kualitas air masih tetap pada kondisi yang layak untuk pemeliharaan ikan lele. Pada uji ANOVA terhadap performansi biologi dan kualitas air menunjukkan bahwa perbedaan ukuran ikan pada setiap tangki tidak memiliki pengaruh signifikan antara satu dengan yang lainnya.
Kata Kunci: Sistem akuakultur resirkulasi (RAS), Ikan lele, kualitas air, parameter pertumbuhan.

Abstrak. Kajian nyo geupeulaku keneukjak kalon kinerja biologi eungkoet seungkoe yang geupeulihara lam saboeh sistem akuakultur resirkulasi (RAS) ngon geu ngui 3 tangki peulihara ngon 1 tangki sedimentasi ngon luah 2.00 m x 1.00 x 0.60 m, asoe ie 900 lite, ngon bio-penyareng sebagoe teumpat peugleh ie. Eungkoet seungkoe yang geu peulihara lam tiep-tiep tangki nakeuh 300 neuk ngon ukoran 5-8 cm (Tangki 1), 8-12 cm (Tangki 2), 12-15 cm (Tangki 3). Bak kajian nyoe abeh masa 30 uroe ngon geu kalon kualitaih ie meurempoek hase nakeuh RAS sep jroeh keu udep ngon meutamah rayeuk eungkoet seungkoe bak tingkat seulamat udep leubeh nibak 92 % bak mandum tangki yang teu ujoe, tingkat meutamah rayeuk spesifik nakeuh 0.64-0.89% tiep uroe, ngon tingkat konversi eumpeun 0.18–0.27. Na abeuk hase ek eungkoet that meukeunong ke kualitaih ie, bah pieh meunan ditroen kualitaih ie mantoeng bak lam keadaan cukop jroeh keu ta peulihara engkoet sungkoe. Bak ujoe ANOVA keu kinerja biologi ngon kualitaih ie merempoek hase nakeuh meubeda-beda ukoran eungkoet yang teu peulihara bak tiep-tiep tangki hana that meupeungaroeh bak ban mandum tangki.
Haba kunci: Sistem akuakultur resirkulasi (RAS), eungkoet seungkoe, kualitaih ie, paramete meutamah rayeuk.

Introduction. Aquaculture in the tropical climates usually experiences problems that may cause fish to die on the arrival of winter or rain season. With studies that have been developed, the use of Recirculating Aquaculture System (RAS) was believed effective to solve this problem. This system was made in a closed system which can produce fish and shrimp throughout the year. By using this RAS technology, farmed fish are healthier and food circulation rate is lower (Bura & Szelei 2009) than in conventional fisheries as in other ponds.

RAS is a relatively new and unique farming techniques in the fishing industry (Suantika 2001). Recirculation system is a system of intensive cultured which is an attractive alternative option to replace the extensive system, and it is suitable to be applied in areas with limited land and water (Suresh & Lin 1992). The use of this system has several advantages such as efficient water use, flexibility of culture location, more hygienic, the need for space or land is relatively small, the ease in controlling and maintaining, environmentally friendly, safe at contamination that occurs in aquatic environments, minimize the impact of a disease outbreak from outside environment, and its water quality parameters are more stable (Bovendeur et al 1987, Greiner & Timmons 1998, Hutchinson et al 2004, Lekang 2008, Losordo & Westerman 1994, Malone & Beecher 2000, Martins et al 2010).

Researches on the concept of recirculating aquaculture production systems are important, especially those related to growth rate, survival rate and water quality control. The investment in the aquaculture farming model is not a problem if it is implemented on a large scale. Considering the needs and benefits of this system in the future, the experiment under small-scale design is significant to be studied.

Materials and Method. The culture of Asian catfish *Clarias batrachus* (Linnaeus, 1758) and water samplings were performed in two periods, and they were taken once every three days, for 30 days (August–September 2010) at 9:00 am and 3.00 pm. Water quality parameters were studied on the temperature, pH, dissolved oxygen, and total ammonia nitrogen. The equipments used for RAS were 3 units: a blue culture tank with a size of 2 m x 1 m x 0.60 m, a 1-hp water pump, a Fiberglass Reinforced Plastic (FRP) filtration unit with dimensions of 10 x 44 inches, a sedimentation tank (particulate) in increments of 1 unit of similar size with culture tank, and polyvinyl chloride (PVC) pipe to connect between the tanks, filters and pump. The measurement of water parameters was carried out with a thermometer (HACH Session 2), pH meter (HACH Session 2), DO meter (YSI 55 DO) and Ammonia meter (HANNA HI 93715).

Experimental design. The numbers of catfish cultured in each tank were as many as 300 fish with a size of 5-8 cm in tank 1, 8-12 cm in tank 2 and 12-15 cm in tank 3, respectively (Table 1). All three tanks were connected to filters as a supplier of water to each tank through a PVC pipe. Each culture tank of produces waste from fish excrement and leftover of feed, then the waste is discharged into the sedimentation tank, pumped into the filter and eventually returned to the culture tank. This goes on continuously in the recirculation (Figure 1).

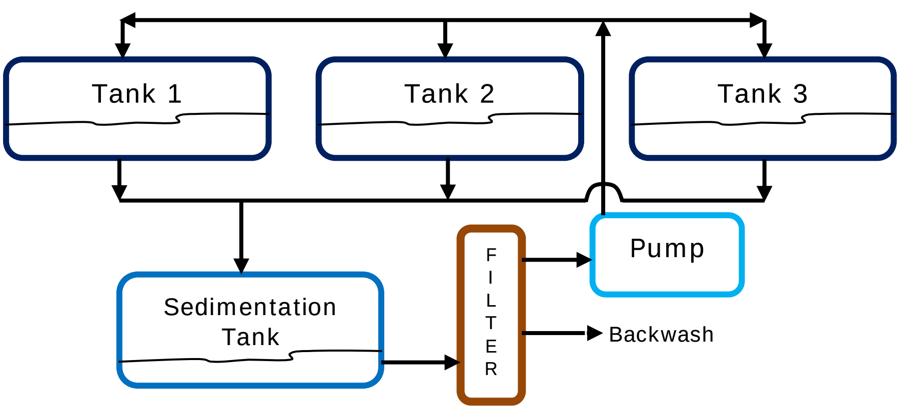

Figure 1. Schematic diagram of RAS.

Prior to used, filter unit should be prepared by filling a variety of media that serves as a filter and also for development of the nitrifying bacteria. In this research, the filter used was a multi-medium, consisting of gravel, coarse silica sand, silica sand medium, fine silica sand and activated carbon (Table 1).

Table 1

System summary of the Asian catfish culture in RAS facilities

Facility acronims	*Tank 1*	*Tank 2*	*Tank 3*
Initial fish size (cm)	5–8(6.5±1.5)	8–12(10±2.0)	12-15(13.5±1.5)
Final fish size (cm)	10–14(12±2.0)	14–18(16±2.0)	16–21(18.5±2.5)
Number of fish (fish)	300	300	300
Experimental period (days)	30	30	30
Feeding rate (% body weight)	3	3	3
Rearing tank material	Fiberglass	Fiberglass	Fiberglass
Tank size (m)	2 x 1 x 0.60	2 x 1 x 0.60	2 x 1 x 0.60
Water in-out (l/minute)	3.24	3.24	3.24
Total time of water recirculation (hours)	5.03	5.03	5.03
Water volume (liter)	900	900	900
Size of bio-filter unit (inch)	10.00 x 44.00		
Material of bio-filter	Fiberglass Reinforced Plastic (FRP)		
Media of bio-filter	Gravel, Coarse silica sand, Medium silica sand, Fine silica sand, Activated carbon		

Feed given to fish of 2 times per day in the morning and afternoon as much as 3% of the total weight of the fish per tank (Kumari et al 2003, Zonneveld et al 1988). Data analysis used Completely Randomized Design (CRD) with 3 treatments and 2 replicates, as well as using software of SAS version 9.1.3 (SAS Institute Incorporated 2004). If the F-test is significant then further analyzed with the Least Significant Different (LSD) at the level of 5% (Gomez & Gomez 1984, Steel & Torie 1980).

Growth parameters. Numerical description most often used to measure the growth of fish is the Specific Growth Rate (SGR): $SGR\ (\%/days) = 100 \times (\ln W_t - \ln W_o)/t$, where W_o and Wt is initial weight and weight at the end and t is time (day) (De Silva & Anderson 1995, Talbot 1993).

Survival Rate (SR) of catfish was in the daily monitor data in the accumulated total at the end of the experiment period. The formula used to calculate the Survival Rate is as follows: $SR(\%) = (N2/N1) \times 100$, where *SR* is survival rate, *N2* is final total number of fish alive and *N1* is the initial total number of fish (Akinwole & Faturoti 2007).

Data collection of total length of the fish was done by measuring the length increase from 10 fish samples in each experiment tank. All measurements were taken from the mouth at the tip of the snout to the end of the upper lobe of the tail (Abbas 2000, FFWCC 2010). The growth rate of catfish in each tank was made based on the measurement range of the fish samples were taken randomly.

Fish weight gain during the cultured period was obtained by subtracting the final weight of the fish with the initial weight of the fish. The formula used is: $WG = W_t - W_o$, where *WG* is the weight gain (g/fish) (Akinwole & Faturoti 2007, Weatherly 1972). Daily growth rate was calculated by using the formula below: $DGR = WG/t$, where *DGR* is Daily Growth Rate (g/fish/days) (Akinwole & Faturoti 2007). The formula to calculate FCR was: $FCR = F/(W_t+D)-W_o$, where *FCR* is feed conversion ratio, *F* is total feed fed (g), *D* is total weight of dead fish (g) (National Research Council 1977). Net production at the end of the experiment period was calculated using the formula: $NP = WG - D$, where *NP* is net production (gram) (Weatherly 1972).

Results and Discussion

Growth performance. Based on the daily growth rate through numerical analysis of specific growth rate, the survival rate, feed conversion ratio, production of fish, total length, feed efficiency, the results showed that there was no significant difference in growth rates of fish in all the tanks. It has been shown in the ANOVA test ($p>0.05$) having the same superscripts between one tank to another (Table 2). This means that the difference in size of fish in each tank culture, have no significant effect on the growth of the fish.

Percentage of daily growth in specific growth rate analysis indicates that smaller fish have higher growth rates than larger fish. This phenomenon is in accordance with the statement of Stickney (1979), which states that one of the determinants of growth and development of the fish are the age and maturity level of farmed fish, usually smaller fish have higher growth rates than larger fish.

Survival rate of catfish in the total at the end of the experiment period was above 92% (Table 2). This suggests that catfish culture in the three tanks was well performed and it can be applied commercially. FCR at 0.18 (Tank 1), 0.19 (Tank 2) and 0.27 (Tank 3) is very ideal for the culture of catfish, while the value of the above conditions are ever reported on the culture of African catfish (*C. gariepinus*) in the Netherlands with a FCR value of 0.85 (Eding & Kamstra 2001) and in Nigeria with a value of 1.1 to 1.7 (Akinwole & Faturoti 2007). By calculating the FCR for the fish will greatly assist us in that we will make efficient use of feed. FCR calculation results with small numbers mean that the feed given the better.

Table 2

Production performance figures of Asian catfish cultures (mean ± SD for growth performance parameters)

Parameter	*Production*			*References*
	Tank 1	*Tank 2*	*Tank 3*	
Duration of culture, DOC (days)	30	30	30	
Initial weight, IW (g/fish)	0.80 ± 0.20^{a}	1.75 ± 0.35^{a}	4.50 ± 1.20^{a}	
Final weight, FW (g/fish)	11.20 ± 1.80^{a}	24.10 ± 0.30^{b}	29.50 ± 2.80^{b}	
Specific growth rate, SGR (%/day)	0.89 ± 0.14^{a}	0.88 ± 0.07^{a}	0.64 ± 0.06^{a}	De Silva & Anderson 1995
Survival rate, SR (%)	94.33 ± 3.67^{a}	97.00 ± 0.33^{a}	92.67 ± 2.34^{a}	Akinwole & Faturoti 2007
Feed conversion ratio, FCR	0.18 ± 0.017^{a}	0.19 ± 0.015^{a}	0.27 ± 0.022^{a}	NRC 1977
Production of Fish, PF (fish)	283 ± 11^{a}	291 ± 1^{a}	278 ± 7^{a}	
Total length ratio, TLR (cm)	5.25 ± 0.25^{a}	5.25 ± 0.25^{a}	4.75 ± 0.75^{a}	Abbas 2000, FFWCC 2010
Weight gain, WG (g)	10.40 ± 2.00^{a}	22.35 ± 0.65^{b}	25.00 ± 1.60^{b}	Weatherly 1972
Net production, NP (kg)	$27.95+7.73^{a}$	62.88 ± 2.33^{b}	$62.70+0.02^{b}$	Weatherly 1972
Daily growth rate, DGR (g/fish/day)	0.35 ± 0.07^{a}	0.75 ± 0.02^{b}	0.83 ± 0.05^{b}	Akinwole & Faturoti, 2007
Total feed fed, TFF (g)	$554.77 + 152.21^{a}$	$1206.20 + 140.22^{ab}$	$1893.99 + 217.60^{b}$	

Note: The same letters in a row showed that there were no significant differences ($p>0.05$).

In the analysis of weight gain, net production, daily growth rate and total feed fed, there are significant differences between one tanks to another (Table 2). This is normal, considering the larger fish have a weight and a large amount of food as well, but in terms of percentage growth rate, as described above is relatively the same.

Water quality. All tank culture in these experiments has the same temperature range by a margin of fluctuation of the difference in the morning with afternoon around 1.95–2.35°C (Table 3). This is in accordance with the opinion of Asmawi (1983) which states that the temperature difference between morning and afternoon sessions does not exceed 5°C. Thus, the temperature range in these experiments was in a normal level and suitable for the growth and fish life (Kordi 2004, Satar 1984, Sutisna & Sutarmanto 1995, Zweig et al 1999).

Table 3

Water quality standard for Asian catfish and observed ranges under RAS method

Parameter	*Standard*	*Observed ranges*		
		Tank 1	*Tank 2*	*Tank 3*
Temperature (°C)	21-30 (Zweig et al 1999)	24.05 ± 2.35^a	24.50 ± 2.00^a	24.45 ± 1.95^a
pH	6.0-8.5 (Buttner et al 1993)	6.885 ± 0.17^a	6.845 ± 0.31^a	6.850 ± 0.22^a
DO (ppm)	> 3	1.098 ± 0.019^a	1.097 ± 0.031^a	$1.041+0.044^a$
Ammonia (ppm)	0.5-1.5 (Chervinsky 1982)	$1.654+0.54^a$	1.618 ± 0.45^a	1.988 ± 0.76^a

Note: The same letters in a row showed that there were no significant differences ($p>0.05$).

Dissolved oxygen, pH and ammonia value in the RAS have already met the standards of freshwater aquaculture. Although the dissolved oxygen is at a value below the standard but given the catfish can take oxygen directly from air, because this species has a special breathing device called the air-breathing organ (arborescent or labyrinth) (Bruton 1979, Clay 1979, Singh & Hughes 1971). It is not so influential on the survival of the catfish. In order to further study, the use of aerators may be able to resolve this problem. It may therefore be said that in general this system can be used for commercial catfish culture.

Conclusions. The growth rate of fish was optimum which can be seen from the length of the fish from day to day. SGR catfish was 0.89+0.14%/day (Tank 1), 0.88+0.07%/day (Tank 2), 0.64+0.06%/day (Tank 3) while the length of the catfish in Tank 1 was from 5-8 cm to 10-14 cm, Tank 2 was from 8-12 cm to 14-18 cm and Tank 3 was from 12-15 cm to 16-21 cm. This system can be used for aquaculture land and is expected to increase there fishery production and fulfill the needs of the society consumption.

The difference in size of fish in each tank indicates no significant effect on the growth and survival of cultured catfish. The difference between one tank to another was very small. For example, the survival rate of catfish in Tank 3 ranged from 92.67±2.34 to 97.00±0.33%. Similarly, the water quality and the difference between one tank to another tank was relatively the same.

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