International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 5, ISSN No. 2455-2143, Pages 6-12
Published Online September 2019 in IJEAST (http://www.ijeast.com)

PERFORMANCE OF RECIRCULATION SYSTEM IN THE DOMESTICATION AND REARING OF JUARO FISH FINGERLINGS (*Pangasius polyuranodon*)

Niken Ayu Pamukas
Department of Aquaculture
Faculty of Fisheries and Marine Science, Riau University
Pekanbaru, Riau, Indonesia

Mulyadi, Adelina, Santhy Wisuda Sidauruk
Department of Aquaculture
Faculty of Fisheries and Marine Science, Riau University
Pekanbaru, Riau, Indonesia

Abstract-- The study on the implementation of water resirculation system to domesticate and to grow out juaro fish fingerlings (*Pangasius polyuranodon*) has been carried out. Several filter materials were used into four kinds of treatment, namely aquarium using aerators (control), aquarium using spons, aquarium using carcoal and palm fiber as well as aquarium using zeolite. Results of the study showed that different filter materials were significantly affecting in the juaro fish fingerling culture media. As long as adaptation period (one week), juaro fish fingerling (*Pangasius polyuranodon*) could be weaning to consume fish meal by involving other fish species in the same culture media. It was found that treatment of water resirculation system combining with zeolite increased water quality parameters such as DO (3.9-4.56 mg/L), CO_2 (8.6-9.15 mg/L), NH_3 (0.02-0.10 mg/L), NO_2 (0.01-0.08 mg/L), NO_3 (0.01-0.09 mg/L) respectively, however, pH and temperature did not differ significantly. The best results were achieved at the same treatment especially absolute weight (9.24 g), absolute length (5.14 cm), specific growth rates (1.76 %), biomass (62.23 g), food efficiency (28.07%), FCR (3.45%) and survival rate (86.67 %).

Keywords-- ***Pangasius polyuranodon*, domestication, recirculation, growth**

I. INTRODUCTION

Juaro fish (*Pangasius polyuranodon*) belongs to family Pangasidae [1] does not have scales, and the fish has hard and sharp dorsal fin [2]. The fish has soft and delicious meat and the price is quite expensive, so it is prospective to fish farming. To fulfill the demand for juaro fish (*P. polyuranodon*) caught uncontrollably resulting disruption of fish habitat and are feared extinct. To prevent the extinction of the fish domestication and culture should be given priority in order to conserve this fish. For farming activities could be implemented continuously investigations on domestication of the fish is to be done successfully [3]. The food habits [4] and reproduction of juaro fish (*P. polyuranodon*) [3] have been reported from the Musi River.

Through the efforts of domestication, the fish are expected to adapt to the controlled environment and can accept artificial feed and survive at high density. In this context best technologies to be investigated to optimize resource utilization including artificial feed and natural feeds to rear the adults and youngones to produce quality fingerlings to ensure continuous supply to the aquaculture activities for marketing and consumption.

Intensive aquaculture techniques to accelerate the growth of juaro fish as well as to improve the water quality must be applied for the success of domestication, spawning, larval rearing, nursery and grow out phases. To improve the water quality in accordance with the conditions needed by fish screening, deposition and absorption techniques are followed. Materials such as sand, gravel, charcoal, palm fiber, pulp lime, alum, stone, zeolite and others [5] along with aeration and water recirculation.

Recirculation systems using a wide variety of filter material is an innovation technology expected to reduce waste and increase productivity. Principally, this technology is to conserve land and water use as well as to increase business efficiency through the utilization of nutrients from uneaten food and waste of fish metabolism, and environment friendly fish culture. The study aims to provide information to the fishermen about the techniques of domestication and rearing of juaro fish on limited land and water resources with a recirculation system. The study is expected to reveal the appropriate food to be given at the various domestication stages under a closed recirculation system by using various types of filters to improve water quality and also to find out the best recirculation technology in domestication and rearing of juaro fish.

II. MATERIALS AND METHODS

The research was conducted in the hatchery laboratory, Faculty of Fisheries and Marine Sciences of Universitas Riau. The size of the aquarium tanks used was 60x40x40 cm^3 having 48 liters volume are equipped with water pump with a power of 20 watts to drain water into fish containers. Filter tank was made from the gutter with a volume of 24 liters. Furthermore, the water from the filter tank will flow back through PVC pipe with a diameter of 2.5 cm to the growing aquarium of juaro fish fingerlings. Comparison between the filter tank to a aquaria was 1:2.

An experimental method using a completely randomized design having two factors, 3 level of treatments and 3 replications was followed. All the treatments were provided with five fingerlings. There were aquarium without substrate filter (P_0), sponge filter (P_1) filter fibers and activated charcoal (P_2) and zeolite stone filter substrate (P_3) as treatments.

Juaro fish fingerlings 3-5 cm in length from the Siak River, Tampan village were used stocked in the tanks and floating fish meal as well as natural live food were given as long as research period. The study was conducted after the juaro fish fingerlings were successfully adapted in the aquarium and able to accept pellet feed. The growth parameters such as absolute weight and length, specific growth rate, biomass gain, feed efficiency, feed conversion ratio (FCR) and survival rate (SR) were recorded. The water quality parameters such as temperature, pH, dissolved oxygen and carbon dioxide, ammonia (NH_3), nitrite (NO_2) and nitrate (NO_3) were measured. Data obtained were analyzed using variance analysis (ANOVA) and SNK test using SPSS.

III. RESULTS AND DISCUSSION

Juaro fish fingerlings were obtained from fishermen in the Tampan village on the Siak River, relatively acidic (pH 6) and temperature ranges between 27-30 °C and browned water color (Figure 1).

Figure 1. Location of fishing ground of juaro fish fingerling in Siak River.

Juaro fish fingerlings were caught using fish net and transportated using an open plastic drum having diameter 75 cm and 125 cm height. The drum was equipped with aerator batteries and ice to maintain the temperature of the water during the transportation. During the 1 hour transport 5 individuals died because of handling.

Acclimatization of fish fingerlings was done over two months in cement tanks, aquaria and fiber tanks aequipped with a recirculation system, almond leaves and water hyacinth plants to imitate their natural habitat. In cement tanks and aquaria all the fish died because of stress, whereas in the fiber tanks, the fish were alive (Figure 2). This was due to the condition of the fiber tanks resemble to their natural habitat, where water brown color caused by almond leaves. According to Akbar (2013) [6] almond leaves contain humic acids and tannins that inhibit the growth of various types of bacteria that endanger the health of the fish.

Figure 2. Adaptation of juaro fish fingerling in fiber tank.

The response of the fingerlings during adaptation was observed (Table 1). In the first week of adaptation period the juaro fish fingerlings can not accept artificial feed, and then *Tubifex* sp was as fish meal substitution. Then gradually the fish was given natural food and artificial feed, until finally the fish can receive 100% artificial food. In more detail, fish behavior as long as adaptation period can be seen in Table 1.

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 5, ISSN No. 2455-2143, Pages 6-12
Published Online September 2019 in IJEAST (http://www.ijeast.com)

Table 1. The behavior of juaro fish fingerling (*P. polyuranodon*) during adaptation period

Day-	Behavior
1 (One)	Fish have seen huddled under water plant near air stones and tend to remain silent. Fish were not given fish meal purposely assuming that when hungry they may be more receptive to the food.
2 (Two)	Mortality (2) and injuries were noticed in cement tanks and aquaria. The fish were alive in the fiber tanks when treated with Potassium Permanganate ($KMnO_4$) at a dose of 0.2 g/L.
3 (Three)	Fish fed with *Tubifex* sp, fish did not respond to the given feed.
4- 7 (Four-Seven)	Weaning fish was performed using tilapia as companion fish. Fish look begin to want to respond to a given feed of *Tubifex* sp. Then gradually the fish fed with pellets until the fish can receive a pellet of 100% (after 1 week of adaptation)

After the fish start receiving the feed, the fish look healthy and active swimming. During adaptation, the fish were fed with *Tubifex* sp and pellets at ad libitum, three times a day, namely morning, afternoon and evening. In the fiber tanks, syphoning was conducted every morning to keep the best water quality. During the adaptation period, water temperature in tanks was 27-30 °C, pH 5.5 and dissolved oxygen 4 to 4.5 mg/L (Table 2).

Table 2. The average of water quality parameters as long as research period

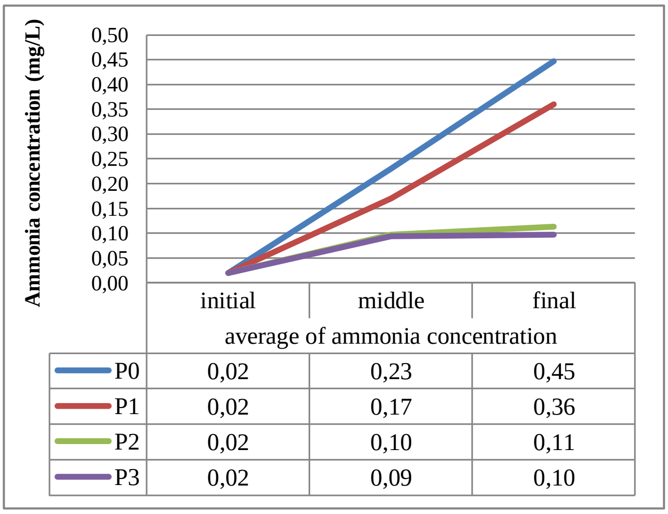
Parameter	Treatments				Standard value PP No 82; in 2001, Class II (Aquaculture)
	P_0	P_1	P_2	P_3	
Temperature °C	28.60-29.33	28.50-29.33	28.63-29.17	28.50-29.33	Deviation of 3
pH	5.5	5.5	5.5-6	5.5-6	6-9
DO mg/L	3.89-4.26	4.13-4.46	3.90-4.34	3.99-4.59	4 mg/L
CO_2 mg/L	9.57-11.07	9.27-10.35	8.59-9.71	8.59-9.18	10 mg/L
NH_3 mg/L	0.02-0.45	0.02-0.36	0.02-0.11	0.02-0.10	≤ 0,02 mg/L (for sensitive fish)
NO_2 mg/L	0.01-0.38	0.01-0.38	0.01-0.11	0.01-0.08	
NO_3 mg/L	0.01-0.38	0.01-0.32	0.01-0.09	0.01-0.09	10 mg/L

Table 2 shows that the average of temperature in all treatments during the study were relatively similar, ranging from 28.50 to 29.33 °C, the temperature in all the aquarium was still in a good range to support the growth of juaro fish fingerlings based on standard values for freshwater aquaculture activities based on [7]. According to Boyd (1982) [8] differences in temperature do not exceed 10 °C and it is still quite good for the organisms in the tropic region of 25-32 °C. Mina (2014) [9] stated that the ideal temperature for fish farming is a stable temperature in the range of 28-30 °C and differences of water temperature between day and night do not vary more than 5 °C. The fish will give positive responses in this condition such as the fish immune system will works optimally and metabolism system will run effectively.

pH in all treatments ranged from 5.5 to 6 and it was still within the range that can be tolerated for the growth and survival of the fingerlings. According Daelami (2001) [10] low and high pH affect the fish negatively. Syafriadiman et al. (2005) [11] stated that fish grow well with a neutral pH and the ideal for aquaculture is 5-9. The highest dissolved oxygen (DO) was found in treatment P_3 (3.99 to 4.59 mg/L), followed by treatment P_1 (4.13 to 4.46 mg/L), P_2 (3.90 to 4.34 mg/L) and P_0 (3.89 to 4.26 mg/L) respectively. Concentration of dissolved oxygen in all treatments was in the range good enough to support the growth of juaro fish fingerlings according to standards for aquaculture. According to Effendi (2003) [12] in the levels of dissolved oxygen of 1-5 mg/L the fish can survive however, 5 mg/L was appropriate to all aquatic organisms (reference).

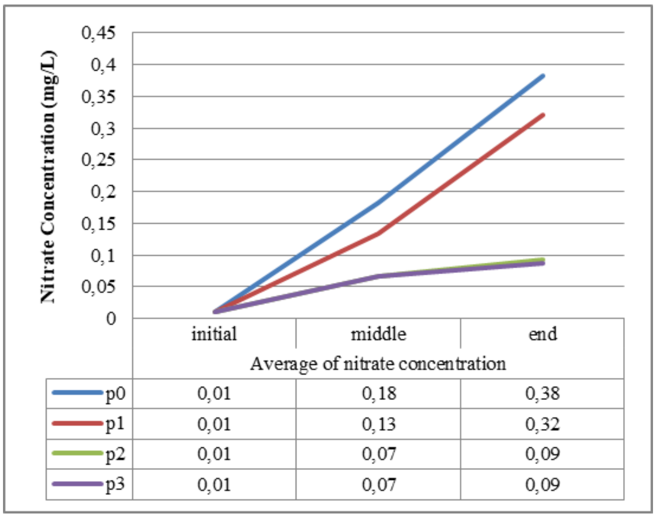
The highest concentration of CO_2 was found in P_0 treatment ranged from 9.57 to 11.07 mg/L, followed by P_1 from 9.27 to 10.35 mg/L, P_2 8.59 to 9.71 mg/L, and P_3 8.59 to 9.18 mg/L respectively. Based on the standard value of freshwater aquaculture activities according to Government Regulation Number 82 (2001), the CO_2 content on P_2 and P_3 was within the range that was good for fish growth, while at P_0 and P_1 was too high. The high concentration of CO_2 was in treatment P_0 without substrate filter and P_1 with sponge so that uneaten feed and the metabolism disposal were not filtered. The range of free CO_2 content in all treatments were within the range that can be tolerated by fish. According Kasry et al. (2002) [13] high concentration of CO_2 in the water resulting from the recycle process of organic matter by microbes. The best concentration of CO_2 for fish was not more than 12 mg/L and the lowest content was 2 mg/L.

The highest ammonia concentration at the end of the study was in treatment P_0 (0.45 mg/L) followed by treatment P_1 (0.36 mg/L), P_2 (0.11 mg/L) and P_3 (0.10 mg/L). Ammonia concentration tend to increase from the beginning in all treatments but it was not increase significant in P_2 and P_3 (Figure 3).



	initial	middle	final
P0	0,02	0,23	0,45
P1	0,02	0,17	0,36
P2	0,02	0,10	0,11
P3	0,02	0,09	0,10

Figure 3. Ammonia concentration (NH_3) in the treatment tanks.



	initial	middle	end
p0	0,01	0,18	0,38
p1	0,01	0,13	0,32
p2	0,01	0,07	0,09
p3	0,01	0,07	0,09

Figure 4. Fluctuation of nitrate concentration (NO_3) as long research period

High concentration of ammonia in the P_0 and P_1 is due to the inefficiency of the filters used. The use of fibers and charcoal (P_2) and zeolite (P_3) were found good to absorb the ammonia. According to Setyoningrum et al. (2018) [14] activated charcoal could absorb solution or vapor effectively. According to Sudrajat (1991) [15] coconut charcoal can filter organic compounds such as volatile organics as well as some heavy metals and widely used as an absorbent in the absorption of gas or liquid. Murtiati and Sri (1999) [16] stated that zeolite has great absorption power and be selective, and it can absorb ammonia, which is toxic to fish and maintain the water quality. The range of ammonia concentrations in all treatments were still within a safe range for the all living organisms which is less than 1 mg/L [8].

Based on analysis of variance (ANOVA), it can be concluded that different filter substrate in this study has different effect on the ammonia concentration in the culture media of juaro fish fingerlings. Furthermore, Student Newman Keuls test showed that between treatments P_2 and P_3 as well as P_0 and P_1 were not different. While between P_0 and P_1 was different from P_2 and P_3 indicating the filter fibers and charcoal (P_2) as well as zeolite (P_3) were most effective in absorbing ammonia.

The concentration of nitrate (NO_3) during the study increased from the beginning to the end of the study. The highest nitrate concentration at the end of the study was found in treatment P_0 of 0.38 mg/L, followed by P_1 of 0.32 mg/L, P_2 and P_3 of 0.09 mg/L respectively (Figure 4).

According to Effendi (2003) [12] nitrate is a form of nitrogen that acts as a major nutrient for plant growth and algae. Nitrates are highly soluble in water. Nitrates derived from ammonium nitrate (NH_4) that goes into the tanks through the domestic waste and its concentration will decrease when farther from the point of discharge due to the activity of microorganisms in the water, for example; Nitrozomonas bacteria. The microbes will oxidize ammonium into nitrate. The highest nitrate concentration in the study was found in P_0 (0.01 to 0.38 mg/L), followed by P_1 (0.01 to 0.32 mg/L) and P_2 and P_3 in the amount of 0.01 to 0.09 mg/L. The test results of analysis of variance (ANOVA) showed the P value (0.000) < 0.05, it means that a different filter substrate influenced nitrate concentration. Furthermore, Student-Newman-Keuls test showed that P_0 and P_1 was different from P_2 and P_3.

Concentration of nitrite (NO_2) in all treatments continues to rise from the beginning to the end of the study. The highest nitrite concentration at the end of the experiment was found in the treatment of P_0 and P_1 of 0.38 mg/L, followed by treatment P_2 0.11 mg/L and P_3 0.08 mg/L respectively (Figure 5).

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 5, ISSN No. 2455-2143, Pages 6-12
Published Online September 2019 in IJEAST (http://www.ijeast.com)

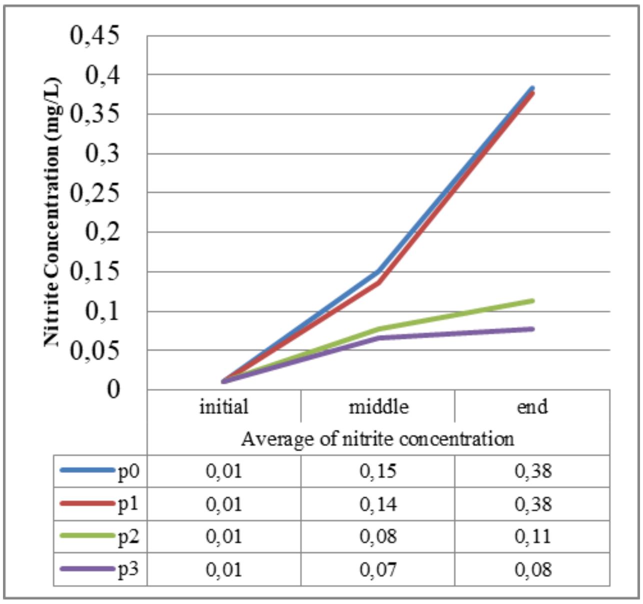


Figure 5. Nitrite concentration (NO_2) in the treatment tanks

Nitrite compound in water is the result of the reduction of nitrate compounds as well as the oxidation of ammonia by microorganisms. In addition nitrite compounds also comes from phytoplankton excretion. The high nitrite concentration disrupts the metabolic processes which can cause death of fish [12]. The highest range of nitrite concentration throughout the study was found the treatment of P_0 and P_1 ranging from 0.01 to 0.38 mg/L, followed by P_2 0.01 to 0.11 mg/L and P_3 0.01 to 0.08 mg/L. Nitrite concentration in all treatment were still within the limits that can be tolerated by juaro fish fingerlings, this was in accordance with the opinion of Siikavuopio and Saether (2006) [17] that the safe limit is less than 1 mg/L. According to Syafriadiman et al. (2005) [11] nitrite concentrations above 2 mg/L for long periods of time is deadly to fish.

The results of analysis of variance (ANOVA) showed P (0.001) < 0.05, it means that a different filter substrate was affecting concentration of nitrite in the water. Furthermore, Student-Newman-Keuls test showed that nitrite in the treatments P_0 and P_1 was different from P_2 and P_3. The results on the average absolute weight, absolute length, specific growth rate, the growth of biomass, feed efficiency, feed conversion and survival rate of juaro fish fingerlings are presented in Table 3 and Figure 6.

Table 3. The average of absolute weight, absolute length, specific growth rate, biomass gain, feed efficiency, feed conversion ratio and survival rates of juaro fish fingerlings during the period

Parameters	Unit	Treatments			
		P_0	P_1	P_2	P_3
Absolute weight	gm	3.81 ± 0.76^{a}	4.95 ± 1.27^{a}	5.39 ± 2.11^{a}	9.24 ± 0.35^{b}
Absolute length	cm	1.53 ± 0.76^{a}	1.26 ± 1.27^{a}	1.41 ± 2.11^{a}	5.14 ± 0.35^{b}
Specific growth rate	%	0.75 ± 0.02^{a}	1.08 ± 0.34^{a}	1.07 ± 0.37^{a}	1.76 ± 0.17^{b}
Biomass gain	gm	34.6 ± 5.69^{a}	37.86 ± 1.33^{a}	43.26 ± 5.60^{a}	62.23 ± 6.93^{b}
Feed efficiency	%	5.22 ± 0.78^{a}	11.07 ± 2.74^{a}	12.13 ± 5.02^{a}	28.07 ± 5.80^{b}
Feed conversion ratio	%	5.58 ± 1.93	4.83 ± 1.48	4.88 ± 0.48	3.45 ± 1.55
Survival rates	%	66.67 ± 11.55	73.33 ± 11.55	80 ± 0.00	86.67 ± 11.55

Note: superscript at the same colum indicates different significantly ($P < 0.05$).

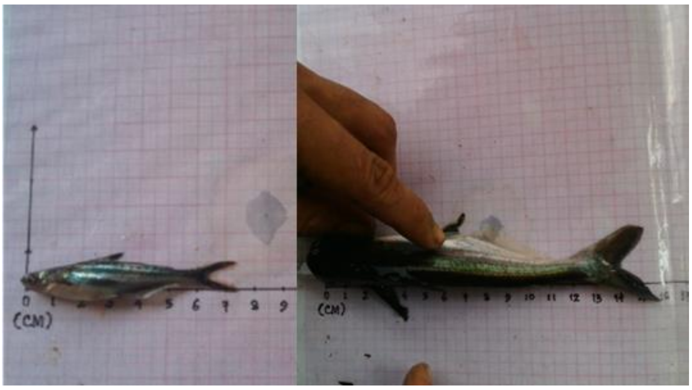


Figure 6. Juaro fish (*P. polyuranodon*) at the initial and the end of research period

Table 3 showed that the highest absolute weight of juaro fish fingerlings was found in treatment P_3 (9.24 gm), followed by treatment P_2 (5.39 gm), P_1 (4.95 gm) and P_0 (3.81 gm) respectively. The best result of treatment P_3 is because the fingerlings could effectively utilize complete commercial fish meal with protein content 35% for fish growth even though all the fish consumption the same fish meal, as it is also affected by the better water quality in that treatment P_3 rather than water quality in the other treatment, so the factors appetite of fish higher in the treatment P_3 than treatment P_0, P_1, and P_2. According to Huet (1986) [18] and Effendi (2003) [12] growth is influenced internal factors such as genetic, gender and age and external factors like water quality, food and stocking densities. The growth of the fingerlings in terms of length during the study was as follows: P_3 (5.14 cm), P_0 (1.53 cm), P_2 (1.41 cm) and P_1 (1.26 cm). The highest specific growth rate of juaro fish fingerlings was observed in P_3 treatment (1.76%), followed by P_1 (1.08%), P_2 (1.07%) and P_0 (0.75%). This result indicated that commercial fish meal given has been eaten by fingerlings very well.

The biomass growth of juaro fish fingerlings was highest in P_3 (62.63 gm), followed by P_2 (43.26 gm), P_1 (37.86 gm) and the lowest in P_0 (34.6 gm). This showed that the filter with zeolite substrates provided the largest biomass growth, because the water quality was the best at this treatment. Feed utilization can be indicated from total biomass and increase in the amount of feed given to fish culture. According to Putra and Pamukas (2011) [19] fish growth is influenced by the quality and quantity of fish meal, age and water quality. Average feed efficiency during the study ranged from 5.22 to 28.07%, the highest feed efficiency was found in treatment P_3 (28.07%), followed by P_2 (12.13%), P_1 (11.07%) and P_0 (5.22%) respectively. Feed efficiency in this study was still low, because the juaro fish juveniles were still adapting to a given commercial feed, so the ability of juaro fish juveniles to digest the fish meal was not optimal [20]. In addition, Ahmadi et al. (2012) [21] stated that feed efficiency of fish depends on feed delivery more than 50% or even close to 100%.

The average of feed conversion during the study ranged from 3.45 to 5.58%, the highest feed conversion was found in treatment P_0 (5.58%). This is due to the bad water quality especially CO_2 and ammonia level, and this condition will decrease of fish appetite. The lowest feed conversion in P_3 of 3.45% indicates that zeolite provided the most conducive environment for the growth of fingerlings. However, the feed conversion in this study was relatively high, because the fish was still adapting to the commercial fish meal diet as the consumption and ability to digest the feed were not optimal. Feed conversion if the value $\geq$ 2% is preferable while close to 1% is good.

The highest survival rates were found in P_3 (86.67%), whereas the lowest in P_0 (66.67%) (Table 3). Juaro fish fingerling death was mainly due to stress while adapting to the aquarium. In the treatment P_0 and P_1 fish death was caused by ammonia. According to Mulyadi et al. (2014) [22] various environmental factors affecting survival rates of the fish include competitor, density, population, age, and the organism's ability to adapt to the environment. Test analysis of variance (ANOVA) $P < 0.05$ indicates the type of filters and their efficiency have significantly affected the absolute weight and length, specific growth rate, biomass, feed efficiency and survival rates of juaro fish fingerlings. Furthermore, Student-Newman Keuls test showed that the best results were observed in P_3.

IV. CONCLUSIONS

Based on the research it can be concluded that juaro fish fingerling (*Pangasius polyuranodon*) could be reared in a controlled environment, such as in an aquarium with a recirculation system and feeding with artificial fish meal (pellets). The use of a recirculation system with different filter substrates can maintain water quality, especially temperature, pH, dissolved oxygen, the content of CO_2, ammonia (NH_3), nitrite (NO_2) and nitrate (NO_3) as well as all these environmental parameters appropriate for juaro fish growth. The treatment P_3 gave ideal environmental condition to the fingerlings and high average absolute weight and length and feed efficiency and survival rate in this study, stocking density was low and the value of the feed conversion and feed efficiency were not good. Hence it is suggested that further research with a different stocking density and fish meal with different protein content and rearing system in a plastic pools with a recirculation system using zeolite filter substrate or on a floating net cages is to be undertaken.

V. ACKNOWLEDGMENT

The authors wish to thank the LPPM Universities Riau and the Ministry of Research, Technology and Higher Education (Ristekdikti) for funding this research.

VI. REFERENCES

[1] Saanin, H. (1984). *Taxonomies and Keys to Fish Identification*. Jakarta, Indoensia: Bina Cipta, (508 pp.).

[2] Kottelat, M., Whitten, A. J., Kartika, S. N., & Wirjoatmodjo, S. (1993). *Indonesian Freshwater Fish in Western and Sulawesi*. Jakarta, Indonesia: Periplus Edition (HK), (461 pp.).

[3] Ernawati, Y., Prianto, E., & Ma'suf, A. (2009). Biology of reproduction of juaro fish (*Pangasius polyuranodon*) in the Musi River Basin, South Sumatra. *Periodical Biological Research*, vol. 15, No. 1, (pp. 45-52).

[4] Ramadan, P. P. (2008). *Study of Juaro (Pangasius polyuranodon) Food Habits in Musi River Waters, South Sumatra*. Bogor, Indonesia: IPB Repository, (43 pp.).

[5] Mulyadi, Hasibuan, N., & Romiantoyo. (2010, Unpublished). *Recirculation system by using different filters in maintenance media of carp* (*Cyprinus carpio* L). Pekanbaru, Indonesia: Research Report, (57 pp.).

[6] Akbar, H. (2013). Benefits of ketapang leaves for betta fish. Retrived January 28, 2019, from http://aquariumhias.blogspot.com .

[7] Governmental Regulation 82. (2001). Concerning Water Quality Management and Controlling Water Pollution. Retrived March 02, 2019, from https://peraturan.bpk.go.id/Home/Details/53103/pp-no-82-tahun-2001 .

[8] Boyd, C. E. (1982). *Water Quality in Ponds for Aquaculture. Alabama Agricultural Experiment Station*. Auburn, USA: Auburn University, (482 pp.).

[9] Mina, S. (2014). Water is too cold, low of fish appetite. Retrieved April 21, 2019, from http://www.bibitikan.net .

[10] Daelami, D. A. S. (2001). *To Create Healthy Fish*. Jakarta, Indonesia: Self-help Spreaders, (166 pp.).

[11] Syafriadiman, Pamukas, N. A., Hasibuan, S. (2005). *Fundamentals of Water Quality*. Pekanbaru, Indonesia: Mina Mandiri Press, (132 pp.).
[12] Effendi, H. (2003). *Water Quality Study*. Yogyakarta, Indonesia: Kanisius, (258 p.).
[13] Kasry, A., Sedana, I. P., Feliatra, Syahrul, Nugroho, F., & Sofyan, I. (2002). *Introduction of Fisheries and Marine Sciences*. Pekanbaru, Indonesia: UNRI Press, (168 p.).
[14] Setyoningrum, T. M., Setiawan, A., & Pamungkas, G. (2018). Production of activated carbon from waste rubber tyres pyrolysis. *Eksergi*, vol. 15, No. 2, (pp. 54-58).
[15] Sudradjat, E. S. B. (1991). Activation of coconut shell charcoal using zinc chloride. *Indonesian Technology Journal*, vol. 14, No. 1, (pp. 14-15).
[16] Murtiati, & Sri, E. A. (1999). *Effects of Various Zeolite Levels in the Filter Recirculation System on Growth and Survival Rates of Dumbo Catfish (Clarias gariepinus Buechell)*. Bandung, Indonesia: Diponegoro University. (28 pp.).
[17] Siikavuopio, S. I., & Saether, B. S. (2006). Effects of chronic nitrite exposure on growth in juvenile Atlantic cod *Gadus morhua*. *Aquaculture, 255*(1), 351-356.
[18] Huet, M. (1986). *Text Book of Fish Culture: Breeding and Cultivation of Fish*. Farnham, United Kingdom: Fishing News Books, (418 pp.)
[19] Putra, I., & Pamukas, N. A. (2011). Maintenance of fish selais (*Ompok* sp) by recirculation, aquaponic systems. *Journal of Fisheries and Maritime Affairs*, vol. 16, No. 1, (pp. 125-131).
[20] National Research Council. (1993). *Nutrition and Requirement of Warmwater Fishes*. Washington, USA: The National Academic Press, (102 pp.).
[21] Ahmadi, H., Iskandar, & Kurniawati, N. (2012). Probiotics in fish meal for growth of sangkuriang catfish (Clarias gariepinus) in nursery II. *Journal of Fisheries and Marine*, vol. 3, No. 4, (pp. 99-107).
[22] Mulyadi, Usman, T., Yani, E. S. (2014). Recirculation system using diffetent filters on growth of tilapia juvenile (*Oreochromis niloticus*). *JARI*, vol. 2, No. 2, (pp. 117-124).