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Growth performance and survival of snakehead *Channa striata* juvenile with different stocking density reared in recirculation system

Kinerja pertumbuhan dan sintasan benih ikan gabus *Channa striata* dengan padat tebar yang berbeda pada sistem resirkulasi

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ABSTRACT

Snakehead *Channa striata* is a local specific fish species and has high economic value. Until now the production of snakehead still relies on the catch of nature because cultivation of snakehead is still underdeveloped. The main constraint in snakehead fish farming is high mortality on snakehead juvenile rearing phase. This study was conducted to determine the best stocking density on snakehead juvenile rearing to achieve optimal production. The treatments used in this study were stocking density of 1 juvenile/L, 2 juveniles/L, and 3 juveniles/L. Snakehead juveniles with a body length of 3.41 ± 0.39 cm and weight 0.28 ± 0.07 g, were reared for 42 days in the aquarium sized 40×40×40 cm with a volume of 40 L. Fishes were fed by bloodworms in ad libitum method. The result showed that the treatments did not affect the survival, growth, and the ratio of RNA/DNA of snakehead juvenile. Survival of juvenile snakehead ranged from 92.5–94.58% ($P>0.05$). The result of water quality measurement showed that it was on optimum condition to support snakehead growth at 3 juveniles/L stocking density. Furthermore, recirculation can be used to maintain water quality for optimum condition. Thus, the rearing of snakehead fish juvenile in the recirculation system could use a stocking density of 3 juveniles/L and the recirculation system could maintain the water quality in good condition.

Keywords: growth, recirculation system, snakehead fish, stocking density, survival rate.

ABSTRAK

Ikan gabus *Channa striata* merupakan ikan spesifik lokal dan mempunyai nilai ekonomis tinggi. Sampai saat ini produksi ikan gabus masih mengandalkan tangkapan dari alam karena kegiatan budidaya ikan gabus masih belum banyak berkembang. Kendala utama dalam budidaya ikan gabus adalah tingginya mortalitas pada fase pemeliharaan benih. Penelitian ini dilakukan untuk menentukan padat tebar terbaik dalam upaya memperoleh pertumbuhan dan sintasan terbaik. Perlakuan yang digunakan dalam penelitian ini adalah padat tebar 1 ekor/L, 2 ekor/L, dan 3 ekor/L. Benih ikan gabus dengan panjang rata-rata 3,41± 0,39 cm dan bobot rata-rata 0,28 ± 0,07 g dipelihara selama 42 hari di dalam akuarium berukuran 40×40×40 cm dengan volume air 40 L. Benih ikan gabus diberikan pakan berupa cacing sutera secara *ad libitum*. Hasil penelitian menunjukkan bahwa penggunaan padat penebaran yang berbeda tidak memengaruhi sintasan dan pertumbuhan serta rasio RNA/DNA benih ikan gabus ($P>0,05$). Sintasan benih ikan gabus pada akhir pemeliharaan berkisar antara 92,5–94,58%. Hasil pengukuran terhadap kualitas air pada kepadatan 3 ekor/L masih dalam kondisi optimum untuk mendukung pertumbuhan benih ikan gabus sehingga sistem resirkulasi yang digunakan dapat mempertahankan kualitas air dengan baik. Hasil penelitian menunjukkan pemeliharaan benih ikan gabus pada sistem resirkulasi, sebaiknya menggunakan padat tebar 3 ekor/L dengan sistem resirkulasi sehingga dapat mempertahankan kualitas air dalam kondisi baik.

Kata kunci: ikan gabus, pertumbuhan, padat tebar, sintasan, sistem resirkulasi.

INTRODUCTION

Snakehead *Channa striata* is one of the economically high-value species, traditional food source from South Sumatera (Muthmainnah, 2013), and it potentially acts as a post-surgery wound healing property (Hannifa *et al*., 2014; Wahab *et al*., 2015; Romadhoni *et al*., 2016). The major market demand towards snakehead fish is still fulfilled by nature catch, though the aquaculture activity in snakehead rearing has been started, one of them is in South Sumatera (Muthmainnah, 2013). However, the extinct treat of snakehead has already predictable because of the decline of population due to the over-exploitation and environmental destruction.

The supply of snakehead juvenile for grow-out rearing and restock in their habitat through natural or semi-natural spawning showed a great result, but a massive juvenile production still constrained by low survival rate (War *et al*., 2011; Siriyappagouder *et al*., 2014). The low survival rate was caused by the unestablished nursery rearing system, lack of nutritional information, and high in cannibalism at the nursery phase (Qin & Fast, 1996). An optimal rearing system of snakehead is definitely required to increase juvenile production and survival rate.

An optimal stocking density resulted in a greater chance to increase the production. There were several studies about fish nursery phase; neon tetra *Paracheirodon innesi* (Budiardi *et al*., 2007), common carp (Karakatsouli *et al*., 2010), seabass (Lupatsch *et al*., 2010), *Senegalese sole* (Salas−Leiton *et al*., 2012), spotted sea trout (Manley *et al*., 2014), Siamese catfish *Pangasianodon hypophthalmus* (Darmawan *et al*., 2016), and rainbow trout (Timalsina *et al*., 2017). The optimal stocking density in snakehead larvae rearing has been known (50 juveniles/L) (War *et al.,* 2011), however, there wasn't any scientific information about snakehead juvenile rearing yet. Cannibalism was the problem when it comes to a controlled system of snakehead juvenile nursery due to its carnivorous nature instinct (Qin & Fast, 1996; War *et al.,* 2011; Amornsakun *et al*., 2011). It was indicated by a part and or a whole individual predation in a population (Folkvord, 1997), especially at larvae and juvenile phase which experienced a high growth rate (Baras *et al.,* 2010).

The cannibalism between the individual in a population potentially occurs when the overall size of each individual was differ greatly, uncontrolled feeding, and suboptimal stocking density. Larvae to juvenile phase is a development and grow phase when the optimal feeding is definetely needed. Live feed (*Tubifex* sp.) is used in larvae rearing due to the complete nutrition content. The snakehead juvenile from natural habitat sized in 0.03 g/ind was rearing in a 0.5×0.5×0.5 m net with stocking density 10 ind/container. Live feed was given (*Daphnia, Tubifex* sp., and mosquito larvae) at satiation, three times a day in two months of rearing. The study resulted in the survival rate of 30–100% and the juvenile grew to 0.13–0.3 g (Muslim & Syaefudin, 2012).

The sustainability of aquaculture is confronted to water supply, land, and labour problems (Siikavuopio *et al*., 2009; Bosma & Verdegem, 2011; Mungkung *et al*., 2013; Feucht & Zander, 2015). These problems will also be faced by freshwater aquaculture which is land-based aquaculture, include snakehead culture. Several studies showed that the recirculation system is a solution for water supply, land, and labour problems. Those studies were also proved that recirculation system was effective to be applied in aquaculture activity (Akunwole & Faturoti, 2007; Siikavuopio *et al*., 2009; Cancino−Madariaga *et al*., 2011; Davidson *et al*., 2016). There is no study about the application of recirculation system in snakehead culture using different stocking density so far, so that this study aimed to determine the optimal stocking density in order to achieve greater growth and survival rate in snakehead juvenile rearing using recirculation system.

MATERIALS AND METHODS

Experimental design

This study was conducted for 42 days at Wet Laboratory, Institute of Research and Development for Freshwater Aquaculture and Fisheries Extension, Bogor, West Java. The study used a complete randomized design with three different stocking density treatments and it was repeated three times for each treatment. The treatments were 1 juvenile/L, 2 juveniles/L, and 3 juveniles/L of stocking density.

The rearing of experimental fish and data collection

The rearing containers were nine aquariums size in 40××40×40 cm. The containers were disinfected and rinsed using water and dried. All the containers were equipped with an aeration system and filled with 40 L of water and then set aside for 24 hours. To adjust the natural environment of snakehead, three dried tropical almond *Terminalia catappa* leaves were used. The leaves were replaced every three days. The recirculation system (water debit 1.200 mL/ minute) and mechanical heater (capacity 100 L) were also set into the container. Zeolite, matala filter mat, chemical filter, and biological filter were applied in the recirculation system (Nurhidayat *et al*., 2012; Diansari *et al*., 2013).

The experimental fish was 20-day-old snakehead juvenile with the average body length of 3.41 ± 0.39 cm and weight of 0.28 ± 0.07 g. The snakehead juvenile was got from a middleman in Parung, Bogor, West Java. Before exposed by the treatment, all the snakehead juvenile were adapted to the environment for three days. Before the snakehead juvenile was put into the aquarium, they were sampled randomly and measured the weight and length, after that they were stocked in the aquarium with 40, 80, and 120 of stocking density.

The snakehead juveniles were reared for 42 days. The total mortality was calculated and weighed each day. The weight and length of the juveniles were sampled every seven days using 30 fries/aquarium randomly. The ruler with 0.1 cm of precision was used to measure the body length, while the digital balance with 0.01 g of precision was used to measure body weight. At the end of the study, four fishes per aquarium were sampled to measure the RNA/DNA ratio using Sambrook and Russell (2001) method.

The feeding kind for the snakehead juveniles was *Tubifex* sp. The *Tubifex* sp. was rinsed using clean water before feeding to the juvenile. The feeding method was ad libitum. Before and after feeding, the amount of feed was weighed using a digital balance.

Water quality management

The water quality management was done using siphon technique to clean the uneaten feed and metabolism waste on the bottom of the aquarium. The water quality consisted of water temperature (measured using a mercury-in-glass thermometer), pH (measured using pH meter with a precision of two decimal), dissolved oxygen (measured using Horiba DO meter with a precision of two decimal), and alkalinity measured using titration method. The nitrite parameter was measured referred to SNI 06−6989.9-2005, while the ammonia referred SNI 06−6989.30-2005 method. All the water quality sample were analyzed in Environment and Toxicology Laboratory, Institute of Research and Development for Freshwater Aquaculture and Fisheries Extension, Bogor, West Java.

Experimental parameter

Survival rate

The survival rate (SR) is a percentage of the final population alive at the end of the study. Survival rate was calculated using a formulation:

$$SR\ (\%) = \frac{Nt}{No} \times 100$$

Note :
Nt = Final population (individual)
No = Initial population (individual)

Absolute growth rate

Absolute length and weight growth rate (growth rate, GR) is an increase of body weight/ length during the period of study. GR was calculated using a formulation (Huisman, 1987):

$$GR\ (g/day) = \frac{Wt - Wo}{t}$$

Note :
Wt = Final length or weight (g)
Wo = Initial length or weight (g)
t = Period of study (day)

Feed conversion ratio

Feed conversion ratio (FCR) is the amount of feed to produce 1 kg of fish. The FCR was calculated using a formulation (Huisman, 1987) :

$$FCR = \frac{F}{Wt + D - Wo}$$

Note :
F = Amount of feed (g)
Wt = Final biomass (g)
D = Deceased fish biomass (g)
Bo = Initial biomass (g)

Data analysis

All of the data were tabulated and calculated for further analysis. Analysis of variance in 95% confidence level was used to determine the significant effect of the treatment towards the parameters. When there was a significant difference, further analysis was conducted using Tukey test. Descriptive analysis was applied to survival rate, total length/weight accretion, and water quality parameters. Data analysis was conducted using Microsoft Office Excel 2010 and SPSS 20.0.

RESULTS AND DISCUSSIONS

Result

The stocking density difference did not affect the survival rate and there was no cannibalism during the study (P>0.05), but the stocking density affected the feed conversion ratio. The growth performance of snakehead juveniles with different stocking density was shown in Table 1.

Survival and growth rates were not significantly different (P>0.05) (Table 1). Feed conversion ratio of 3 fish/L stocking density treatment showed a higher value (P<0.05), while two other treatment showed no significant difference (P>0.05).

The survival rate of snakehead juveniles during the study was presented in Figure 1. The survival rate of snakehead juveniles was decreased from the beginning of the study until at the end of the study. However, the survival rate was still considered as high 92.5−94.58%.

Different stocking density on snakead juveniles rearing in a recirculation system did not affect the RNA/DNA ratio (P>0.05). The RNA/DNA ratio was ranged from 2.15−2.26 (Figure 2).

Absolute length growth of the snakehead was shown in Figure 3. The absolute length of snakehead was increased at each treatment from the beginning until at the end of the study. The total length of snakehead ranged from 4.88−5.22 cm.

Total weight growth of snakehead during the study was shown in Figure 4. The weight body of snakehead juveniles was increased from the beginning of the study until the end of the study. The total weight of snakehead juveniles was ranged from 5.30−6.3 g.

Water quality parameter result was presented in Table 2. The water temperature was maintained around 29–30°C, and the pH parameter was maintained around 5.25–6.31. The dissolved oxygen was ranged from 2.94−6.14 mg/L. The alkalinity was quite high, ranged from 86.43–101.84 mg/L, while nitrite was considered low 0.017–0.12 mg/L. Hence, the water quality was still in the snakehead tolerance level to support its growth.

Discussion

Cannibalism is predation between individual in a certain population, either some parts of or the whole part of the body (Folkvord, 1997). Cannibalism in fish population is getting serious attention because it potentially affects aquaculture production. Cannibalism in snakehead juveniles rearing was affected by feeding kind, feed supply, and different size between individuals in the population (War *et al.,* 2014). A snakehead juvenile could prey the other smaller species even its own kind, when the size variance was 60–80% (Srivastava *et al.,* 2011). It means when the size

Table 1. Growth performance of snakehead juveniles *Channa striata* with different stocking density for 42 days using recirculation system.

Parameter	Stocking density (fish/liter water)		
	1	2	3
Survival rate (%)	94.17 ± 6.29[a]	94.58 ± 1.91[a]	92.5 ± 3.00[a]
Absolute length growth rate (cm/day)	0.12 ± 0.010[a]	0.12 ± 0. 004[a]	0.12 ± 0.005[a]
Absolute weight growth rate (g/day)	0.14 ± 0.001[a]	0.14 ± 0.001[a]	0.13 ± 0. 003[a]
Feed conversion ratio	3.90 ± 0.31[a]	3.94 ± 0.31[a]	4.77 ± 0.04[b]

Note : The same superscript letter in the same row indicated no significant difference on significant level 5% (Tukey test)

Table 2. Water quality of snakehead juveniles rearing in different stocking density for 42 days using a recirculation system.

Parameter	Treatment			Optimal level
	1 juvenile/L	2 juveniles/L	3 juveniles/L	
Temperature (°C)	29−30.9	29.6−30.6	29.6−30.1	27.8−32.5[a]
pH	5.36−5.57	5.25−5.78	5.4−6.31	4−6.3[a]
DO (mg/L)	3.62−6.14	3.13−5.23	2.94−4.89	0.5−7.4[a]
Alkalinity (mg/L)	94.86−96.97	92.75−94.86	86.43−101.84	30−100[b]
Nitrite (mg/L)	0.002−0.585	0.003−0.8	0.051−0.540	0.5−5[b]
Ammonia (mg/L)	0.021−0.081	0.017−0.1	0.017−0.120	<0.1[b]

Note : a: BPBAT Mandiangin (2014); b: Boyd (1982)

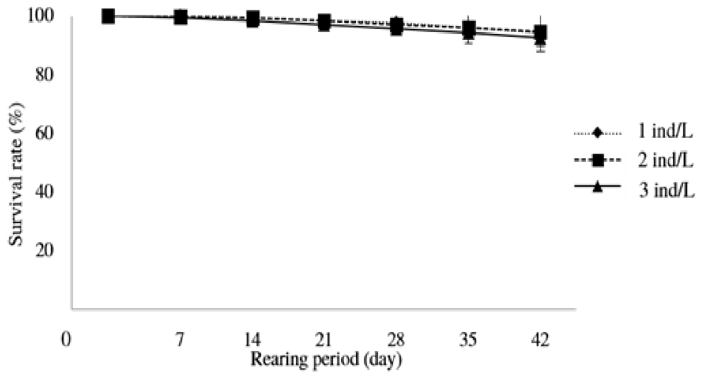

Figure 1. Survival rate of snakehead juveniles *Channa striata.*

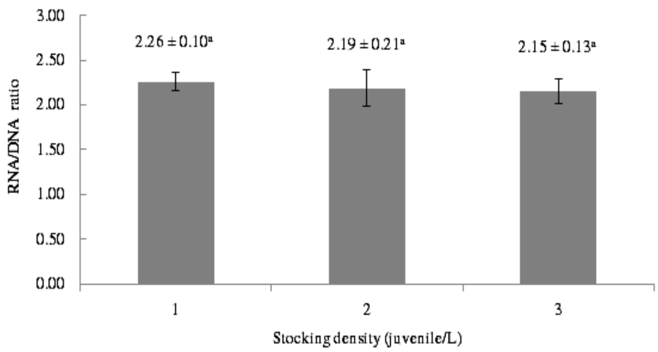

Figure 2. RNA/DNA ratio of snakehead in different stocking density.

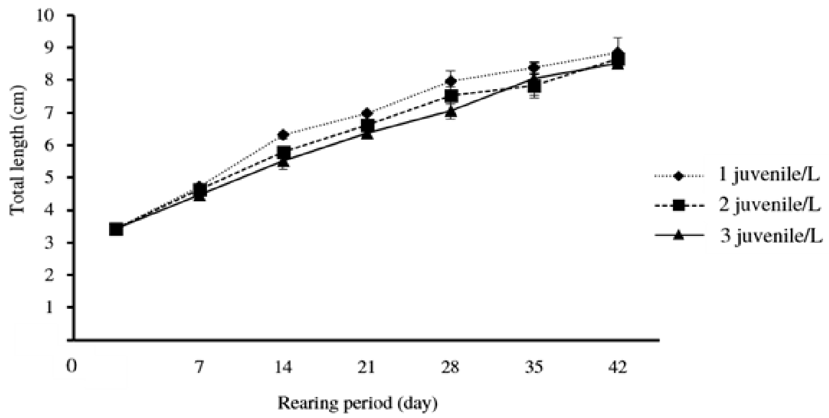

Figure 3. Total length growth of snakehead *Channa striata.*

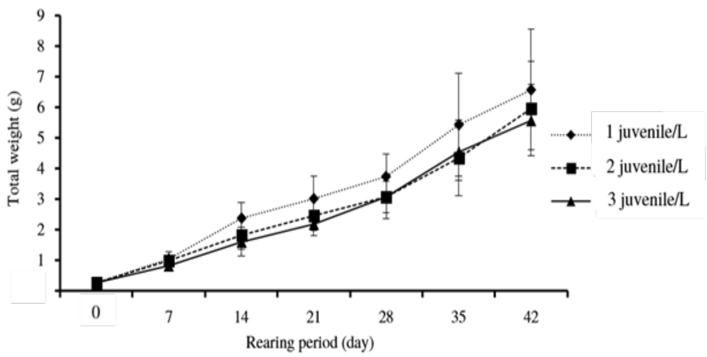

Figure 4. Total weight of snakehead juveniles *Channa striata.*

variance was higher than 20%, the cannibalism would be possible. The result of the study was in line with those previously reported by others. At the end of the study, the cannibalism was 0% which means no cannibalism because the size variance was below 20%. It also showed that the stocking density treatment was applicable and tolerable by the snakehead juvenile.

Survival rate is percentage of final population at the end of the study. The survival rate of snakehead juveniles decreased in each treatment, from the beginning until the end of the study. Sarah *et al*. (2009) stated that a higher stocking density would affect physiology process and fish behavior towards its moving spaces. At the end of the story, it potentially downturn fish healthiness, so that feed utilization, growth, and survival rate would be decline. However, the result of survival rate was classified as high (92.5–94.58%). It was predicted that the stocking density treatment was quite tolerable by the snakehead juveniles and the feed amount was still sufficient for the snakehead juveniles.

Growth is size (weight and length) added in a certain period of time. The length and weight of snakehead juveniles increased in each treatment from the beginning and the end of the study. However, the growth (weight and length) rate decrease in higher stocking density. It was predicted that the moving space of the population was getting narrower when the stocking density was higher, so that the population was fighting over the feed and it caused stress. A stressful condition caused hyperglycemia which interrupted the development process, or worst it potentially caused death (Yeh *et al*., 2010; Leland *et al*., 2013; Pederzoli & Mola, 2016). In a stressful condition, there was a reallocate metabolic energy (such as growth and reproduction) turned into homeostasis, such as respiration, movement, hydromineral regulation, and tissues recovery (Arifin *et al*., 2014).

DNA/RNA ratio is supporting parameter to predict the growth internally. DNA is more conservative, while RNA more fluctuative, so that RNA and DNA ratio can represent growth internally (Mukherjee & Jana, 2007). The result of this study showed that snakehead juvenile rearing in different stocking density using recirculation system did not affect DNA/RNA ratio. It was predicted that there was similar opportunity in achieving growth on each treatment. It was reflected that snakehead juvenile reared in 1 juvenile/L, 2 juveniles/L, and 3 juveniles/L have same growth rate possibility. It caused by raising of RNA value as fish muscle former (protein) and it described bigger growth potency in fish (Tanaka *et al*., 2008).

Feed is a main factor in aquaculture. Feed conversion is described as the ability to convert the feed into biomass. The lower feed conversion means fewer feed needed to gain 1 kg biomass. The result showed that FCR value was no significantly different between 1 juvenile/L and 2 juveniles/L ($P>0.05$) but those values were significantly different with 3 juveniles/L ($P<0.05$). The FCR value were 3.90, 3.94, and 4.77 respectively. It was predicted that the increasing of stocking density acted as stress impulse to the juvenile. Stress condition induced energy utilization which belongs to grow, so that feed efficiency was low. The feed conversion ratio of this study ranged from 3.9–4.77. A stress-resistant population would utilize the certain energy to deal with stress condition, but still have some sources of energy to maintain its daily need, such as antibody synthesis process. Stress condition caused an escalation the glucocorticoid which caused blood glucose increasing to deal with high energy demand during stress condition (Costas *et al.,* 2008).

Snakehead is a wild freshwater species lived in the swamp area with low concentration of dissolved oxygen and pH (Astria *et al.,* 2013). During the study, pH level was maintained in low level (acid) to adjust with the snakehead natural habitat. The pH level adjustment used *Terminalia catappa* leaves. The dissolved oxygen concentration during the study was also classified as low, but it was tolerable by the snakehead because of the additional respiratory organ called diverticula owned by snakehead to utilized feed oxygen in the air for respiration (Muslim & Syaefudin, 2012). The other water quality parameter, such as, temperature, alkalinity, nitrite, and ammonia during the study were still in the tolerable range to support growth and daily maintenance.

A great result of aquaculture depends on survival rate, growth, and stocking density. According to Sarah *et al.* (2009), a high production would be achieved in high stocking density. Production in this term was the profil from the aquaculture activity. If the optimal density was achieved, the facility and freshwater resource would be utilized efficiently, so that the production would be optimal (Budiardi *et al*., 2007). An intensive rearing using high stocking density was conducted to achieve maximum daily production. When the optimum production hasn't been achieved, stocking density addition would possible, even though the fish growth tend to decrease (Shafrudin *et al*., 2006). In this study, survival rate and growth of each treatment were classified as high.

There was no cannibalism occurred among treatments at snakehead juvenile rearing in recirculating system. This phenomena was supported by length diversity relatively in homogeneous condition for each treatment. The homogeneous length value supported high survival rate value, it was reach 94.58% at the end of rearing period (Table 1). In spite of RNA/DNA ratio (Fig. 2), total length (Fig. 3), total weight gain (Fig. 4.), and feed conversion ratio (Table 1) value were not significantly different among treatment, the water quality still in optimum condition to supporting fish growth in each treatment. Although those parameters were not significantly different, growth performance and survival rate value tendency higher for 3 juvenile/L. It produced higher productivity compared with the others.

CONCLUSION

Growth performance and survival of snakehead juvenile reared for 42 days was greatly gained at the 3 juveniles/L treatment. The water quality parameter of 3 juveniles/L was quite optimum to support the snakehead juvenile growth.

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