The effect of different low salinities on growth, feed conversion ratio, survival rate and profit of Asian seabass cultivation

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Abstract. Asian seabass (*Lates calcarifer*) is one of marine fish that has a high selling value. Therefore, the development of Asian seabass cultivation technology in freshwater media and low-salinity artificial media is important for the fish farming industry in Asia-Pacific (including Indonesia) so that it can be cultivated on land far from coastal areas. The purpose of this study was to analyze the effect of different low salinities on growth, survival rate (SR) and feed conversion ratio (FCR) of Asian seabass cultivation. This research used Asian seabass seeds with sizes ranging from 7.03 to 12.52 cm (total length) and 5.55 to 21.52 g (weight) per fish which were reared in fibre tanks for 42 days with a fish density of 50 fish per m^3. We used salinity treatments of 0.5 ppt (A), 5 ppt (B) and 10 ppt (C). The research results showed that treatment B (5 ppt) generated the highest Asian seabass growth (SGR in weight 1.51% per day). However, the different salinity treatments had no statistically significant impact on SGR (in weight and length), SR, FCR and RC ratio ($p > 0.05$). The polynomial growth model is proven can be used to estimate the growth of Asian seabass with R^2 above 95%.
Key Words: FCR, growth, *Lates calcarifer*, RC ratio, salinity, SR.

Introduction. Asian seabass or barramundi (*Lates calcarifer*) is a marine fish that has high selling value in the Asia-Pacific region, making it become fish target for capture fisheries (commercial and recreational) and cultivated fish in aquaculture (Rajkumar et al 2006; WWF Indonesia 2015; Yudhiyanto et al 2017; Kumar et al 2016; Ghosh 2019). The production of Asian seabass in Indonesia has experienced an increasing trend, namely in 2012 amounting 6,198 tons to 8,431 tons in 2017 (KKP 2018). Asian seabass production in the world is still dominated by capture fisheries. In 2016, Asian seabass capture fisheries amounted to 85,349 tons, while Asian seabass aquaculture production was 56,933 tons. However, the production growth of Asian seabass aquaculture is higher than capture fisheries. In 2006 to 2016, the Asian seabass wild fishery experienced a negative growth of 0.03% per year, while the production of Asian seabass through aquaculture experienced a positive growth of 7.5% per year (http://www.fao.org). Therefore, it is very important to develop Asian seabass cultivation, both in Indonesia and the Asia-Pacific region.

Asian seabass production in Indonesia is dominated by marine cultivation using floating cages. The cultivation of Asian seabass in brackish water ponds has also been developed in Indonesia. Bali, East Java and Riau Islands are the main contributors to Asian seabass cultivation in Indonesia (WWF Indonesia 2015). Asian seabass is an euryhaline fish (Rajkumar et al 2006; WWF Indonesia 2015; Ridho & Patriono 2016; Ghosh 2019). Therefore, Asian seabass can be cultivated in freshwater media as well. Thailand and India have implemented Asian seabass cultivation in freshwater ponds (Cheong 1989; Venkatachalam et al 2018; Ghosh 2019).

The results of one of our preliminary research (unpublished) showed that Asian seabass can be reared in fresh water media (salinity 0 ppt). This is an opportunity for the development of Asian seabass farming in a location far from the sea and coastal areas. However, if Asian seabass are reared with a salinity of 0 ppt, they are relatively vulnerable to disease attacks. Therefore, we conducted follow-up studies with salinity of 0.5 ppt, 5 ppt and 10 ppt. The purpose of this study was to analyze the impact of (low level) salinity on the growth, feed conversion ratio (FCR), survival rate (SR) and revenue cost (RC) ratio of Asian seabass cultivation.

Material and Method

The location and time of research. Our research was conducted in the laboratory of Universitas Diponegoro-Semarang City for 42 days of cultivation (see Figure 1). The study was conducted from August to October 2020. We used Asian seabass seeds produced from the hatchery of the Brackishwater Aquaculture Development Center in Situbondo Regency. Asian seabass seeds were transported from Situbondo Regency to Semarang City using 5 ppt salinity water. Then the seeds were adapted to different water salinities as the treatment of our research.

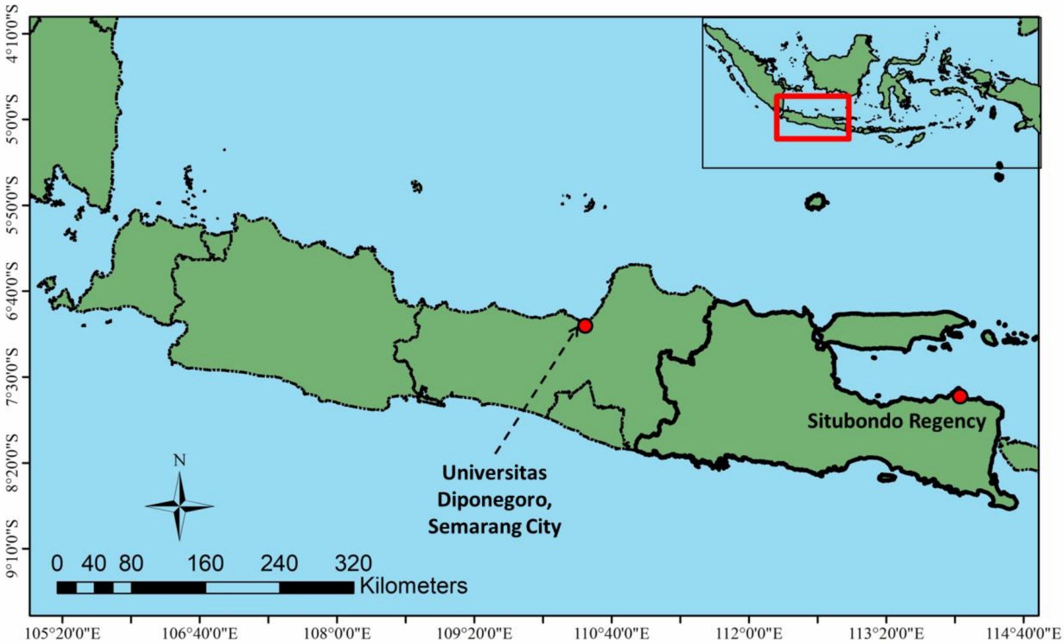

Figure 1. The research location.

The research materials. We used seeds from one cohort (144 days after hatching) with a size of 7.03 to 12.52 cm (total length) and 5.55 to 21.52 g per fish. Fish were cultivated in fibre tanks for 42 days with a density of 50 fish per m^3. We used sea salt and fresh water to adjust the salinity of experimental media. We also used commercial fish feed which is available in Semarang City with a protein content of around 35%. The blower pump was used to add dissolved oxygen (DO) to the experimental media. We used 6 fibre tanks which do not affect each other.

The experimental design. We used a completely randomized design with 3 different salinity treatments and 2 replications per treatment. We used 10 fish seeds per tank with a total number of fish used as much as 60 fish seeds. For salinity treatments, we used salinity of 0.5 ppt (A), 5 ppt (B) and 10 ppt (C). Measurement of fish length and fish weight was conducted every 14 days. We used feeding per day as much as 3% of fish biomass.

The data analysis. We analyzed fish growth, including specific growth rate (SGR in weight and length) and weight gains (WG). We also measured the revenue cost (RC) ratio, feed conversion ratio (FCR) and survival rate (SR) of fish. We used following equations in the data analysis (de Oliveira et al 2019; Wijayanto et al 2020):

$$SGR = [(\ln FW - \ln IW)/T \text{ (days)} \times 1000] \quad (1)$$

$$WG = FW - IW \quad (2)$$

where: FW is the final weight (g); IW is the initial weight (g).

$$SR = (Nf/Ni) \times 100 \quad (3)$$

where: Nf is the number of fish at the end of culture; Ni is the number of fish initially culture.

$$FCR = TFAO / WG \quad (4)$$

where: TFAO is the total amount of artificial feed.

$$RC \text{ ratio} = TR / TC \quad (5)$$

where: TR is the total revenue (IDR); TC is the total cost (IDR), including seed cost, feed cost, energy cost, water cost and sea-salt cost. The Asian seabass cultivation is categorized profitable if the RC ratio is greater than 1.0.

We used Anova (with $\alpha = 0.05$) for SGR (in weight and length), SR, FCR and RC ratio. We also developed polynomial growth model which can be used to estimate the growth of Asian seabass.

Results. A summary of the research results can be seen in Table 1. The 5 ppt treatment resulted in the highest average of SGR in weight, namely 1.51% per day, followed by 0.5 ppt treatment (1.37% per day) and 10 ppt treatment (1.35% per day).

Table 1

The growth, FCR and SR of Asian seabass

Variables	*Treatments*					
	A1 (0.5 ppt)	*A2 (0.5 ppt)*	*B1 (5 ppt)*	*B2 (5 ppt)*	*C1 (10 ppt)*	*C2 (10 ppt)*
Average of initial length (cm)	11.09	9.65	10.55	7.85	10.55	8.16
Average of final length (cm)	12.64	11.50	11.92	10.04	11.83	10.12
Average of initial weight (g)	15.51	11.74	13.75	7.36	14.85	7.89
Average of final weight (g)	26.76	15.69	25.30	14.26	24.65	14.70
Average of length gain (cm)	12.64	11.50	11.92	10.04	11.83	6.81
Average of weight gain (g)	1.55	1.85	1.37	2.19	1.28	1.96
SGR in length (% per day)	0.31	0.42	0.29	0.58	0.27	0.51
Average of SGR in length (% per day)	0.37 (A)		0.44 (B)		0.39 (C)	
SGR in weight (% per day)	1.30	1.44	1.45	1.57	1.21	1.48
Average of SGR in weight (% per day)	1.37 (A)		1.51 (B)		1.35 (C)	
FCR	3.20	2.82	2.88	2.81	4.01	2.89
Average of FCR	3.01 (A)		2.85 (B)		3.45 (C)	
SR (%)	90	90	90	80	90	100
Average of SR (%)	90 (A)		85 (B)		95 (C)	
RC ratio	1.01	1.06	1.00	1.07	0.99	1.22
Average of RC ratio	1.03 (A)		1.04 (B)		1.11 (C)	

FCR of Asian seabass is relatively high compared to the main commodities of freshwater fish cultivation in Indonesia. FCR of red tilapia (*Oreochromis* sp.) is around one (Wijayanto et al 2018), FCR of giant gourami (*Osphronemus goramy*) is around 1.5 (Wijayanto et al 2017a) and FCR of catfish (*Clarias* sp.) is around 1.4 (Kristiany 2020). The growth of Asian seabass is relatively lower than red tilapia and catfish. This affects the efficiency of feeding. In this study, the SR of Asian seabass was relatively high, which was above 80%. Water quality management and disease control are the key success of

Asian seabass cultivation to produce SR highly (WWF Indonesia 2015; Venkatachalam et al 2018). However, the control and handling of fish disease is more difficult in large pond.

Although the 5 ppt (B) treatment provided the highest growth, there was no statistically significant difference between treatments A, B and C in regard to SGR both in length and weight (Table 2). There is also no significant difference between treatments A, B and C in SR, FCR and RC ratio variables. The average value of RC ratio of more than one, both treatments A, B and C, indicates the Asian seabass cultivation could generate profits. This research proven that the Asian seabass can be reared at low salinity, even in freshwater media (including 0.5 ppt).

The growth model of Asian seabass in treatments A, B and C can be seen in Figure 2 with R^2 value above 95% for all treatments. Therefore, the polynomial model in this research can be used as a projection tool to predict the growth progress of Asian seabass. This polynomial model will be better if the research is conducted over a longer period of time, for example until the Asian seabass reach size of 500 g or more for fish consumption size.

Table 2

The statistical analysis

Variables	*Sig.*	*Note*
SGR in length	0.909	Not significance in α = 0.05
SGR in weight	0.498	Not significance in α = 0.05
SR	0.354	Not significance in α = 0.05
FCR	0.513	Not significance in α = 0.05
RC ratio	0.745	Not significance in α = 0.05

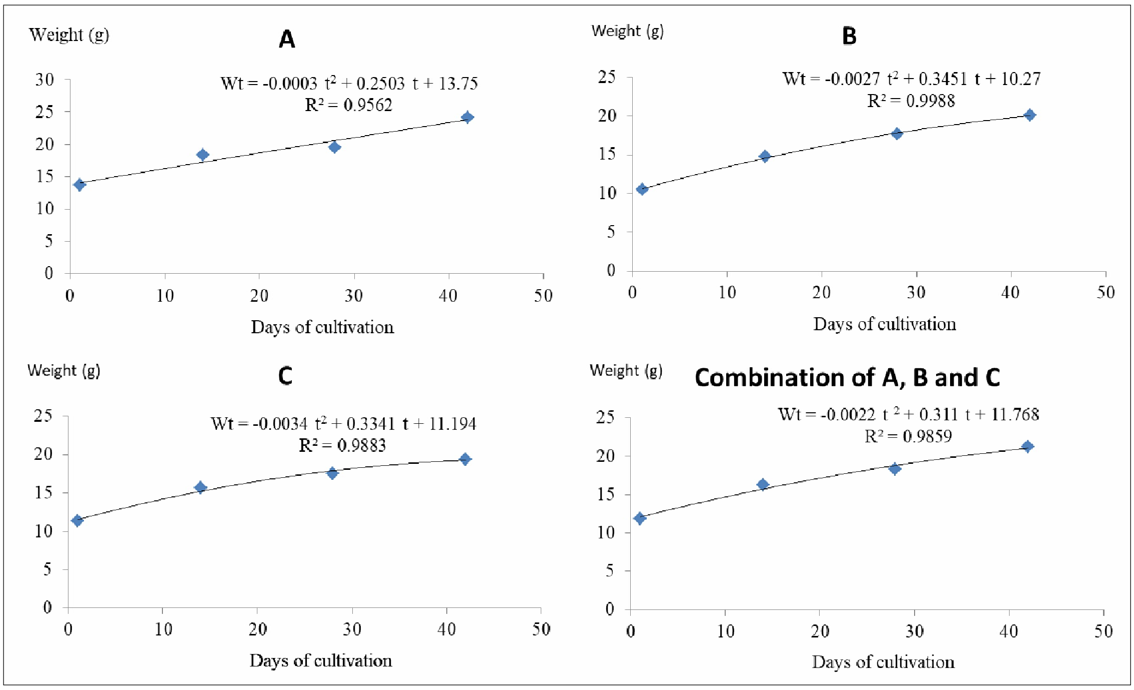

Figure 2. The polinomial growth model.

Discussion. In Indonesia, the cultivation of Asian seabass is dominated by marine cultivation using cages. In 2017, the production of Asian seabass in marine culture was 7,741 tons or 91.8% of the total production of Asian seabass (KKP 2018). Cultivation of Asian seabass in freshwater media is not popular in Indonesia yet. However, the results of this research proven that Asian seabass can be cultivated in both freshwater and artificial low-salinity media. Although according to Cheong (1989) cultivation of Asian seabass should be on medium with salinity of 10 to 30 ppt, but this study proven the 5 ppt salinity treatment produced the highest growth and the growth of Asian seabass at a salinity of 0.5 ppt was also higher than that of the 10 ppt treatment.

The growth of Asian seabass in this study was higher than in several previous studies. According to Kumar et al (2016), Asian seabass seeds (average length of 1.76 cm and weight of 0.132 g) had SGR (in weight) of 0.83% per day in 45 days of cultivation. According to Saputra & Gunawan (2020), Asian seabass seeds (average size of 3.67 g) reared for 60 days had SGR of 0.17 to 1.29% per day depending on the type of feed treatment. According to Noval et al (2019), the SGR (in weight) of Asian seabass was between 0.56 to 0.9% per day depending on the density of the fish for seed size of 7 cm. According to Rajkumar et al (2006), the weight of Asian seabass increases proportionally to the cube of the length as the exponent value was observed to be almost close to 3, namely $W = 0.0001\ L^{2.66}$.

The results of this study proven that Asian seabass can be cultivated in freshwater or low-salinity media because of the eury-haline nature of the Asian seabass. According to Noval et al (2019), Asian seabass is very tolerant for low-salinity environments because most of its life span is two to three years in fresh waters such as lakes and rivers. Although Asian seabass can live in fresh water, one of our preliminary research (unpublished) showed that it is susceptible to disease when it is cultivated using a salinity of 0 ppt. Therefore, fish farmers who are far from the coast can use sea-salt to make Asian seabass cultivation media with a salinity of 0.5 ppt or 5 ppt.

Asian seabass swim quickly to prey on their food. After eating the feed, Asian seabass will swim away and then returns to take feed again. If Asian seabass has no disease, then it tends to be active in swimming. Asian seabass which active, agile, swimming normally and does not separate from other fish are the characteristics of healthy Asian seabass (WWF Indonesia 2015). Asian seabass is a carnivorous fish and its diet includes smaller fish and shrimp. Asian seabass feeds voraciously on live fishes including young carps, mullets, gobies and shrimps (Ghosh 2019). According to Ridho & Patriono (2016), Asian seabass has natural diet consisting of shrimp as the main food and small fish as a complementary food.

Asian seabass cultivation is a prospective business to be developed on land far from the coast because this study proved that Asian seabass can be cultivated in freshwater and low salinity media. In practice, Asian seabass can be cultivated in various ways. According to Cheong (1989), Asian seabass cultivation can be conducted as an alternative to shrimp cultivation, namely using Asian seabass seeds with size of 1 to 2 cm that can be cultivated after the shrimp are harvested using Asian seabass seed density of 1 fish per m^2. Asian seabass can also be cultivated using the polyculture system with tilapia (*Oreochromis* sp.). According to Venkatachalam et al (2018), Asian seabass can be reared in ponds integrated with mangroves. Even growth and survival of Asian seabass in integrated mangrove ponds can be higher than ponds without mangroves (open aquaculture). The fish biomass was higher by 12.5% and the survival was more by 11% in the integrated mangrove-aquaculture system than the open aquaculture system without mangroves. According to WWF Indonesia (2015), optimal water conditions for Asian seabass cultivation include pH 7 to 8.5, temperature of 27-30°C, and DO more than 4 ppm. According to Yudhiyanto et al (2017), optimal water conditions for Asian seabass cultivation include pH 7 to 8.2, temperature of 26 to 32°C, and DO of 4 to 8 ppm.

The profit of Asian seabass farming is not only determined by the speed of fish growth. Therefore, financial and bioeconomic studies of Asian seabass need to be conducted as a follow-up to this study. We have conducted bioeconomic modeling for red tilapia, giant gouramy and vannamei shrimp (Wijayanto et al 2017a, 2017b, 2018). The selling price of harvested fish, the survival rate and the costs also affect profits. In intensive cultivation, the cost of feeding is relatively large in proportion to the cost structure of aquaculture. Feeding efficiency is reflected in the FCR value. According to Noval et al (2019), the FCR of Asian seabass culture ranges from 1.31 to 3.99 with different fish density treatments. In this study, the FCR value was between 2.82 and 4.01. When the appetite is low, the FCR tends to be large. According to de Oliveira et al (2019), the feeding rate has a greater influence on performance than frequency. Feeding frequency and rate directly influenced length and weight gains, feed efficiency, SGR, and FCR.

Conclusions. The results of research showed that treatment B (5 ppt) produced the highest growth (SGR in weight of 1.51% per day), while SGR for treatment A was 1.37% per day and SGR for treatment C was 1.34% per day. However, it is not statistical significantly different, both for the SGR (both in weight and length), SR, FCR and RC ratio variables. Polynomial growth models can be used in both treatments A, B and C with R^2 above 95%. This research can be followed up with bioeconomic research to optimize profit.

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