The effect of feeding rate on growth and BC ratio of Asian seabass reared in artificial low salinity water

by Dian Wijayanto

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Abstract. Asian seabass or barramundi (*Lates calcarifer*) has high economic value that is also one of main fishery commodities in Indonesia. This makes Asian seabass cultivation quite important, including the need for optimized feeding. Feed costs the highest in fish farming that is why it is necessary to find ways for better feeding efficiency and effectiveness in Asian seabass cultivation. This study examined the effect of feeding rate on growth and BC (benefit cost) ratio of Asian seabass reared in artificial low salinity media. An experiment was carried out for 56 days using Asian seabass fry with an average size of 20.7 g per fish reared in fiber tanks with a density of 25 fish per m^3. There were three treatments applied; artificial feed containing 3% fish biomass per day (treatment A), 4% fish biomass per day (treatment B), and 5% fish biomass per day (treatment C). The results indicated a significant effect of feeding rate treatment on growth and BC ratio, where treatment B was found the best treatment (4% fish biomass per day). Based on the results of second-order polynomial modeling, the most optimal feeding is 3.95% fish biomass for specific growth rate and 3.96% fish biomass for BC ratio.

Key Words: absolute growth, BC ratio, feeding rate, SGR, *Lates calcarifer*.

Introduction. *Lates calcarifer* (the giant sea perch, Asian seabass or barramundi) is one of main fish commodities in Indonesia that can be cultivated through fish farming. This fish is also one of the important fishery commodities in the Indo-Pacific region. Southeast Asia has been the largest producer of Asian seabass in the world, where Indonesia names the largest one. The cultivation of Asian seabass in Indonesia began in the 1970s (Cheong 1989; Boonyaratpalin et al 1998). The Ministry of Marine Affairs and Fisheries (MMAF) has set a production target for Asian seabass cultivation of 14,000 tons per year by 2024 (MMAF 2020). The cultivation Asian seabass in Indonesia applies brackish water ponds and floating net cages in the sea (Cheong 1989; Yusuf 1995; Wijayanto et al 2020a).

Wijayanto et al (2020a) found out that Asian seabass could be cultivated in low salinity artificial media. This provides opportunities for the development of Asian seabass farming for households located afar from coastal areas. In Thailand, Asian seabass can be cultivated in freshwater ponds (Cheong 1989), but the study of Wijayanto et al (2020a) showed that Asian seabass are susceptible to disease if cultivated at 0 ppt salinity.

The cost of artificial feed takes up the largest working capital in intensive-scale aquaculture. According to El-Sayed et al (2015), feed costs can reach 75 to 90% of the total operational costs in fish farming. Efforts to reduce feed costs have been made, among others, by finding alternative for fish meal as a source of fish feed protein (Boonyaratpalin et al 1998). Hence, research on optimal feeding rate in Asian seabass cultivation should be conducted, both related to the fish growth and economic benefit. Several researchers have conducted research on the optimization of artificial feeding for Asian seabass, including: Boonyaratpalin et al (1998), Ribeiro et al (2015), and Hassan et al (2021). This study was done to determine the effect of feeding rate on growth and BC ratio (benefit cost) of Asian seabass reared in artificial low salinity media.

Material and Method

Time and location of research. This experimental research was carried out from December 2020 to February 2021. The research was conducted for 56 days at the Fisheries Laboratory-Universitas Diponegoro.

Research material. Asian seabass fingerlings of the same age with an average size of 20.75 g per fish were used. The fingerlings were reared in fiber tanks (indoor) with a density level of 25 individuals per m^3. Fish were fed commercial feed with a minimum protein content of 52%, a minimum fat content of 14.5%, a maximum fiber content of 3% and a maximum moisture content of 10%. According to Williams et al (2003), the optimal dry pellet crude protein for Asian seabass juvenile ranges between 40 and 55%. To maintain water quality, water recirculation system was installed. Water filtration was created using stone, coral, sand and synthetic polyester fibers.

Research treatment. We used 3 types of treatment; using artificial feed containing 3% fish biomass per day (treatment A), 4% fish biomass per day (treatment B), and 5% fish biomass per day (treatment C). Each treatment was done in 3 replications. We used 20 fish per experimental unit with a total number of experimental fish as many as 180 fish.

Water quality measurement. Water quality measurements was carried out weekly to assess the dissolved oxygen (DO), salinity, temperature and pH. We used a water quality checker (Horiba U-50).

Data analysis. We analyzed fish growth, both absolute growth (W), specific growth rate (SGR), and also benefit:cost (BC) ratio. We performed statistical tests including Anova and LSD (least significant difference) test, and also optimization modeling (second-order polynomial model) to assess the optimal feeding rates. Some formulas used in this study were as follows (de Oliveira et al 2019; Daet 2019; Wijayanto et al 2020a, 2020b):

$$W = Wt - Wo \quad [1]$$

$$SGR = (Ln\ Wt - Ln\ Wo) / t \quad [2]$$

$$BC = B / C \quad [3]$$

where: W is the absolute biomass growth of Asian seabass (g per fish); SGR is specific growth rate (% per day); Wt is average weight of Asian seabass in t days; Wo is the average initial weight of Asian seabass; B is the benefit, i.e. additional revenue due to fish growth (IDR); C is the cost, namely the cost of feeding (IDR).

The Asian seabass cultivation generates profit if the BC ratio is greater than 1.0. The results of the BC ratio in this study can be a starting point for researching the profitability of Asian seabass cultivation because the experiment only took 56 days. In practice, the cultivation of Asian seabass in Indonesia is carried out for 6 to 12 months depending on the fish size target, cultivation method and the location of cultivation.

Results. According to Hassan et al (2021), the feeding regime is an important issue in fish farming development, including the Asian seabass feeding scenario. In general, fish growth is influenced by a number of factors, including: environmental conditions, fingerling quality, feed (quantity and quality), gonad development, age, and fish health (Hart & Reynolds 2002).

The growth of Asian seabass is presented in Figure 1. Meanwhile, the analysis of growth (W and SGR) and BC ratio of Asian seabass are shown in Table 1. In general, the feeding rate treatment that produced the highest average SGR was the treatment using 4% fish biomass (treatment B). There was a statistically significant difference in the effects of treatments on fish growth, both the W variable and the SGR variable (Table 2). The results of the BC ratio analysis for each type of feed treatment also showed that 4% fish biomass treatment (treatment B) resulted in the highest average BC ratio.

Table 1

Average fish weight, W, SGR, and BC ratio of Asian seabass cultivation

Days	*Treatment A*			*Treatment B*			*Treatment C*		
	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
1	20.46	20.36	21.41	20.45	20.31	20.87	20.89	20.84	21.14
14	22.40	23.00	21.86	21.27	25.16	26.32	21.94	21.24	21.82
28	23.27	23.81	24.57	23.81	25.60	26.32	23.06	23.84	24.14
42	25.06	26.22	25.08	25.13	26.00	31.83	23.44	24.07	25.25
56	25.41	25.57	26.09	30.89	27.07	33.74	23.79	24.67	26.64
W (g)	4.95	5.22	4.68	10.44	6.75	12.86	2.90	3.83	5.50
Average of W (g)	4.95±0.27			10.02±3.08			4.08±1.31		
SGR (%)	0.39	0.41	0.35	0.74	0.51	0.86	0.23	0.30	0.41
Average of SGR (%)	0.38±0.0003			0.70±0.0017			0.32±0.0009		
BC ratio	0.72	0.74	0.67	1.15	0.70	1.15	0.70	1.22	0.26
Average of BC ratio	0.71±0.038			1.37±0.285			0.60±0.109		

Note: Assumed price of Asian seabass (life) of IDR. 140,000 per kg and the price of fish feed of IDR. 25,000 per kg.

Table 2

Statistical analysis

Variables	*Statistical significance values*	*LSD test*
W	0.019*	A-B: 0.018*
		A-C: 0.601
		B-C: 0.009*
SGR	0.013*	A-B: 0.014*
		A-C: 0.502
		B-C: 0.006*
BC ratio	0.011*	A-B: 0.077
		A-C: 0.051
		B-C: 0.004*

Note: * significant at 95% confidence level.

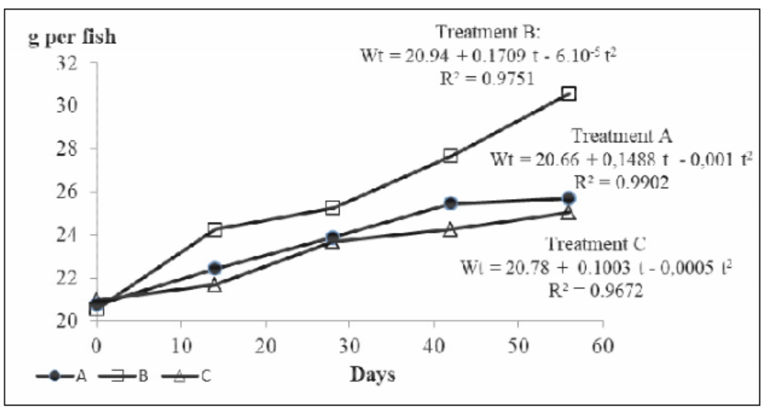
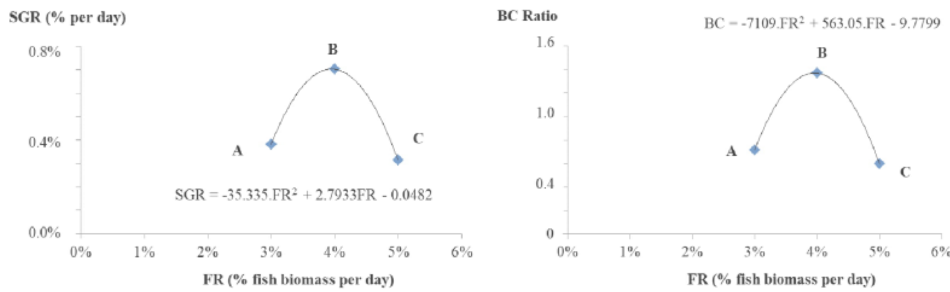


Figure 1. Asian seabass growth during experiment.

The feeding using 4% biomass per day (Figure 2) was found as the most optimal treatment. The polynomial equation related to the SGR and BC ratio related to feeding rate (FR) was based on these following equations:

$$SGR = -35.335.FR^2 + 2.7933.FR - 0.0482 \quad [4]$$

$$BC = -7109.FR^2 + 563.05.FR - 9.7799 \quad [5]$$



a. Relationship between SGR and FR. b. Relationship between BCR and FR.

Figure 2. Feeding rate optimization model.

Through the optimization process using the first derivative equal to zero for equation [4] and [5], the optimal feeding rate for SGR was obtained in the use of 3.95% fish biomass, while the optimal feeding rate for BC ratio was obtained from using 3.96% fish biomass. However, the optimal feed weight level may change due to fish age. The water quality of the experimental media during the study was relatively ideal for the growth of Asian seabass. The DO of experimental media during the study was relatively stable, ranging from 4.40 to 5.90 ppm. According to Cheong (1989), the optimal DO for Asian seabass is between 4 to 9 ppm. Meanwhile, the pH of the experimental media was relatively stable between 7.34 and 8.06. According to WWF Indonesia (2015), the optimal pH for Asian seabass cultivation ranges from 7.0 to 8.5. The water temperature was also stable, ranging from 25 to 27.6°C, which ideal temperature range is between 26 and 32°C (Cheong 1989). The salinity of the experimental media was maintained at 5 ppt based on the recommendation proposed by Wijayanto et al (2020a) and Wijayanto et al (2021).

Discussion. Fish need specific nutritional intake, both in terms of quality and quantity. Commercial feed producers have made Asian seabass feed that contain certain nutritional contents needed by the fish, including protein, carbohydrates, fat, vitamins and minerals. Since the cost for fish feed is quite high, attempts have been made to find feed alternatives with high protein content. According to research by Boonyaratpalin et al (1998), the replacement of fish feed with 37.5% soybean feed did not bring any significant difference in the survival and growth of Asian seabass. Meanwhile, Aldon (1997) suggested that the composition of feed for seabass should be close to the composition of seabass meat that consists of 43% crude protein and 10% fat. It is also recommended that the amino acid composition of seabass feed should be proportional to the composition of seabass meat. Practically, fish farmers can buy good quality fish feed produced by fish feed factories. El-Sayed et al (2015) recommended to use local raw materials in producing fish feed for better efficiency while maintaining the quality of fish feed.

The amount of artificial feed given to the fish needs to be adjusted to the optimal needs of the fish. Insufficient amount of fish feed can inhibit fish growth and reduce fish resistance to various disease. However, excessive feeding willl cause inefficiency and lead to low water quality. According to Eroldogan et al (2004), fish feed is one of the most important factors in commercial fish farming because it affects the growth of fish and feed waste in the culture media.

According to Hassan et al (2021), a feeding rate of 6.5% per day is optimal for fish growth, survival and it prevents cannibalism among Asian seabass weighing approximately 5 g. Eroldogan et al (2004) explained in a case of European seabass (*Dicentrarchus labrax*) that the optimal level of feeding on SGR differs in the use of freshwater media with salinity of 0.4 ppt (optimal at 3% biomass) and marine water with salinity of 40 ppt (optimal at 3.5% biomass).

According to Ridho & Patriono (2016), the natural diet of Asian seabass consists of shrimp (as the main feed) and fish (as a complementary feed). Whilst, Panchakshari et al (2016) explained that the main food of Asian seabass is crustaceans (34%), fish (22%), and mollusks (13%). Algae from the Bacillariophyceae type were also found in the stomach of the Asian seabass.

Greater fish population density can lead to higher chance of cannibalism. Increasing feeding frequency and decreasing fish can reduce fish size diversity and cannibalism of Asian seabass (Ribeiro et al 2015). According to Biswas et al (2010), seabass fingerlings should be fed 3 times per day with feed containing crude protein content of about 55%.

In this study, treatment B generated a profit with a BC ratio value of 1.37, while treatment A and C actually loses (BC ratio value is less than 1). The amount of feed will determine the profit of fish cultivation. If it is too low, then fish growth is not optimal. On the other hand, if it is too large, it will not be efficient. The BC ratio is determined by revenues and expenses, while income is affected by fish growth and fish prices. Furthermore, the total cost is mainly influenced by feed prices, feed effectiveness and other factors other than feed. Considering the cost of artificial feed in Asian seabass farming that takes the largest proportion, feeding management needs to be carefully done. Bozoglu & Ceyhan (2009) reported that the benefit:cost ratio of seabass cultivation reached 1.103 with feed costs taking up 47.73% of the total cost. Meanwhile, Gammanpila & Singappuli (2012) found the benefit:cost ratio of Asian seabass cultivation was 1.12. In a separate study, Aswathy & Joseph (2018) showed that the cultivation of Asian seabass in cages resulted in BC ratios of 1.04 and 1.26 which were influenced by cage dimensions, density, cultivation time and location.

During this research, the water quality of the experimental media was controlled and supported the life of the fish, in terms of temperature, pH, DO and salinity. Water quality is an important factor in fish farming. Poor water quality can trigger stress, cause diseases and lead to fish death. Asian seabass reared in floating net cages showed higher growth than in ponds due to DO and ammonia factors (Aldon 1997). The SGR of Asian seabass reared in hapa ranges from 1.51 to 1.65%, causing lower the stocking density and higher fish growth (Daet 2019).

Asian seabass is euryhaline, meaning that it can adapt to culture media with different salinity levels. In Thailand, Asian seabass is cultivated in freshwater ponds, while in Tahiti it is cultivated in water with 35% salinity (Cheong 1989). Excessive amount of inedible food and fish feces can degrade water quality. Water recirculation treatment can maintain water quality and the efficiency of the use of water. In Asian seabass cultivation in coastal area, an integrated mangrove cultivation system can improve water quality to support the growth of Asian seabass (Venkatachalam et al 2018).

Conclusions. The results of this study indicated a significant effect of feeding treatment on fish growth (W and SGR) and the BC ratio, where treatment B (feed containing 4% fish biomass per day) appeared as the most optimal treatment. The results of polynomial modeling also showed that the most optimal feeding is 3.95% fish biomass for SGR and 3.96% fish biomass for BC ratio as an indicator of profitability in Asian seabass farming.

Acknowledgement. Gratitude is expressed to LPPM Universitas Diponegoro for funding this research (RPI scheme) with agreement number 233-17/UN7.6.1/PP/2021.

Conflict of interest. The authors declare that there is no conflict of interest.

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Received: 07 January 2022. Accepted: 20 January 2022. Published online: 25 January 2022.
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How to cite this article:
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