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Effects of different feeding rate on growth and condition factor of *Chitala lopis*

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ABSTRACT

Chitala lopis, also known as giant featherback*,* is a fully protected fish species on Indonesian official list due to the susceptibility to exploitation. Several studies showed that the conservation of aquatic resources, such as giant featherback*,* could be achieved through the implementation of fish farming practices and optimization of feed use. Therefore, this study aimed to determine effect of different feeding rate on growth pattern, performance, and condition factor of the first generation of giant featherback. The first generation of fish was collected from the natural reproduction of broodstock in the earthen ponds. A total of 5 samples were then randomly divided into three treatment groups and reared in the nine net cages installed in the earthen pond. The stocking density in each group was three fish per cage, and the treatments were carried out in triplicates. Feed given comprised fish bycatch as control (T0) (5% of the total weight) and freshwater shrimp, *Caridina* sp. with two different feeding rates, namely 5% (T1) and 7% (T2) of the total weight. The mean initial weight of all the samples in this study was 41 ± 3.85 g. The results showed that the highest survival and absolute growth rates (29.9±6.38 g, 78± 11%) were obtained in T1, but were not significantly different ($p>0.05$). Furthermore, the highest average relative growth rate was also found in T1 (76.28±18.61%) and significantly different compared to other treatments ($p<0.05$). Growth pattern of fish at the beginning of the experiment was negative allometric (0.54), showing a low correlation (0.03), but became positive allometric (4.17) at the end, with moderate correlation (0.66). The results also showed that the highest condition factor was obtained in T2 (0.78±0.03), and there was a significant effect ($p<0.05$). Based on the results, *Caridina* sp. had a positive and significant impact on the weight growth of the first generation of giant featherback compared to other studies.

Introduction

The Notopteridae family consists of the genera *Chitala*, *Notopterus*, *Papyrocranus,* and *Xenomystus,* with distribution across South Asia, Southeast Asia, and Africa (Maneechot *et al*., 2015). Furthermore, three Chitala species, including *Chitala lopis* (giant featherback), *Chitala borneensis,* and *Chitala hypselonotus,* have been reported to be native to Indonesia and are primarily found in Java, Sumatra, and Kalimantan (Nugroho *et al*., 2019). According to the Indonesian government regulation (Decree of the Minister of Marine Affairs and Fisheries no.1 of 2021), these species are fully protected along with *Notopterus notopterus*, thereby prohibiting the use except for study and development. Despite the protective measures, the exploitation of these Chitala species, locally known as belida, has persisted for decades due to the economic value (relatively expensive) (Khairul *et al*., 2020). To meet consumption demands, belida consumers have heavily relied on catches by inland fishermen, leading to a significant decrease in population (Mustafa *et al*., 2015). This decline can primarily be attributed to massive fishing and environmental gradation (Nugroho *et al*., 2020; Haniffa *et al*., 2017). Giant featherback is a superior fish commodity in several regions of Indonesia, including Jambi and South Sumatra (Anjarsari, 2020). Several studies also reported its usage as an indigenous fauna mascot, particularly in South Sumatra.

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Previous studies focused on comprehending the biological aspects of *Notopterus notopterus*, including the reproductive and digestive aspects (Gustomi *et al*., 2016; Sontakke *et al*., 2019). A report on belida in Kampar River showed that the primary food comprised fish, while the secondary feed consisted of shrimp, pieces of meat, and plants. The biological aspects of *Chitala* genera have also been extensively explored, including the food habits, reproduction, habitat (Rapita *et al*., 2021; Kohinoor *et al*., 2012; Nugroho *et al*., 2019; Gustomi *et al*., 2016), environmental factors (Setijaningsih and Sutrisno, 2013), genetic aspects through protein analysis (Wibowo and Marson, 2012; Wibowo and Subagja., 2014), embryogenesis (Srivastava *et al*., 2012), ecobiology (Wibowo and Subagja, 2014), and spawning (Gustomi *et al*., 2016; Yanwirsal *et al*., 2017). Despite this extensive knowledge base, efforts to domesticate these species through aquaculture technology have not been optimal due to discontinued study programs. Fish domestication program is crucial in preserving biodiversity and population stability, meeting the demand for meat-based sustenance, and generating blue economic value (Sukendi *et al*., 2019; Dewi *et al*., 2019).

The abundance of fish in both natural and aquaculture environments significantly depends on the availability of food resources (Sukendi *et al*., 2019). In the initial stages of domestication program, growth and survival of captive-bred species often depend on live feed (Melanie *et al*., 2023). The provision of feed has been reported to play a significant role in achieving optimal levels of production (Yanuar, 2017). Wibowo (2011) stated that the dietary composition of giant featherback in the natural habitat primarily consisted of small fish and prawns. The giant featherback is a nocturnal species, which actively hunts for preys at night (Sunarno *et al*., 2015). Several studies showed that successful fish cultivation faced challenges related to appropriate feeding management, considering feed nutritional preference and feeding rate (Bassey and Ajah, 2010; Simanjuntak *et al*., 2017). The optimal feeding rate is an essential factor in the culture of freshwater fishes to reduce excessive expenses, with variations observed across species and different life stages (Md Mizanur *et al*., 2014). Although captive giant featherback has been predominantly fed with bay-caught fish and live shrimp, there is a lack of information regarding the optimal feeding rate in the management. Therefore, this study aims to evaluate the optimal feeding rate of live feed on growth, survival rate, and condition factor of the first-generation experiment (G1) of giant featherback.

Materials and Methods

Experimental design

This study was conducted from May-July 2023 at the small-scale fish cultivation group (Pokdakan) Ulam Jaya, Banyuasin Regency, South Sumatra. Furthermore, the first generation of fish was collected from the natural reproduction of broodstock in the earthen ponds, and the broodstock of belida was obtained from South Sumatra. Belida progeny used comprised 27 individuals with a length and weight of 22.18±0.42 cm and 41±3.85 g, respectively. A complete randomized design consisting of two different treatments and one control was used. Fish was randomly selected into three different groups replicated three times and reared in nine net cages with dimensions of 1 x 1 x 1.2 m, which were installed in a 10 x 10 x 2 m earthen pond. The stocking density of the samples in each group was three fish per cage. The first group was fed with bycatch of approximately 5% of the total weight used as control (T0). The two other groups were fed with freshwater shrimp (*Caridina* sp.) with two different feeding rates of 5% (T1) and 7% (T2). Fish was fed twice a day at 8:00 and 16:00., and the daily consumption of feed ability was estimated to be between 3-10% of the total body weight (Sunarto and Sabariah, 2009).

Observations and measurements of fish

Fiant featherback in each cage net (3 fish/cage) was sampled every 14 days and transferred to a plastic basin containing aerated freshwater. To avoid stress caused by handling, the samples were anesthetized using an anesthetic solution (Stabilizer, dose of 1 ml per 3 L of water) based on product protocol. Subsequently, fish size (total body length) was measured using a ruler (accuracy of 0.1 mm), and the total body weight was measured using a digital scale (Joil) with an accuracy of 0.1 mg. After measurement, all samples were returned to the cage nets and no mortality was observed during sampling activities. The observation of survival rate was carried out every day until the end of the study procedures.

Data calculation

Effects of different feeds on growth and survival performances of giant featherback were examined by calculating the following parameters.

Growth rate was calculated using absolute growth (g) and relative growth (%) was based on the formula proposed by Lugert *et al.* (2014). The formula for absolute growth (g) is presented below:

$$AG = W_t - W_o$$

Where:
AG = Absolute growth (g)
W_t = Final weight (g)
W_o = Initial weight (g)

The formula for calculating relative growth rate in percentage terms is as follows:

$$RGR = \frac{W_t - W_i}{W_i} \times 100$$

Where:
RGR = Relative growth rate (%)
W_t = Final weight (g)
W_i = Initial weight (g)

The formula representing the survival rate follows Mustafa *et al.,*(2019):

$$SR = \frac{N_{t} - N_o}{N_o} \times 100\%$$

Where:
SR = Survival rate (%)
N_t = The quantity of fish that has been harvested
N_o = The quantity of fish that has been stocked

Growth pattern was predicted by length-weight relationship formula proposed by Khairul *et al.*, (2020):

$$W = aL^b$$

Where:
W = Total weight (g)
L = Total length (cm)
a = Intercept
b = Slope

Growth pattern followed the specified criteria:
- If b = 3, hence, both length and weight growth is balanced (isometric).
- If b < 3, hence, length growth is more dominant than weight growth (negative allometric).
- If b> 3, hence, weight growth is more dominant than length growth (positive allometric).

Condition factor analysis was carried out to assess the health and growth of organisms, which was influenced by the carrying capacity of the environment (Muslimin *et al.*, 2022). The condition factor was calculated using the formula of Jonsson *et al.* (2012):

$$CF = \frac{W \times 100}{L^3}$$

Where:
CF = Conditional factor
W = Body weight (g)
L = Total length (cm)

Data analysis

Statistical analysis was carried out to compare effects of different feed on absolute growth, relative growth, length-weight relationship, condition factor, and survival rate using Analysis of Variance (ANOVA), followed by Duncan tests. Furthermore, statistical regression tests were used to calculate data on growth pattern, and all analyses were performed using the IBM SPSS version 23.0.

Results

Growth rate

Fish growth during the study period is presented in Table 1. T1 had the highest average absolute growth and survival and was not significantly different (29.9 ±6.38 g and 78 ±11%). However, the highest relative growth rate value in T1 differed significantly (76.28 ± 18.61%) from others. The lowest absolute growth, relative growth rate, and survival rate parameters were recorded in T2 (12.1±2.05 g, 8.66±0.88, and 33±0). To, T1, and T2 values were different because T0 was the control value using fish feed with a concentration of 5%, while T1 and T2 used 5% and 7% shrimp feed, respectively.

Table 1. The average and standard error of *Chitala* sp growth rate during the study (T0, T1 and T2).

Parameter	T0	T1	T2
Initial weight (cm)	47±4.58	41±3.85	141±36.87*
Final weight (cm)	63.14±4.56	70.92±7.4	153.46±38.7*
Absolute Growth (g)	15.68±5.28	29.9±6.38	12.1±2.05
Relative Growth Rate (%)	37.2±14.45	76.28±18.61*	8.66±0.88
Survival Rate (%)	66.66±19.00	78±11.00	33±0.00

*Significantly different ($p<0.05$)

Growth pattern

Figure 1 shows growth pattern and regression between weight and length at the beginning and end of the study. Growth pattern at the beginning of the study showed a slope value (b) (0.54) and the R^2 value was low (0.03). Meanwhile, at the end of the study, the slope increased (4.17) with a moderate R^2 value (0.66).

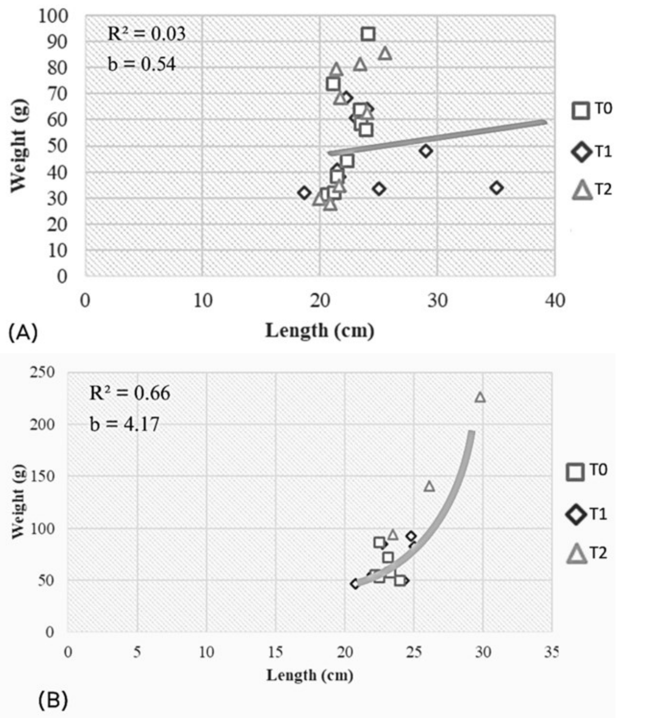

Figure 1. Growth pattern at the beginning (A) and end of the study (B). b is growth pattern and R2 is the regression value between length and weight.

Conditional factor

Figure 2 shows a graph of conditional factors at the beginning and end of the study. The results showed that T2 had the highest value at the beginning of the study (0.51), while the lowest value was recorded in T1 (0.37), with no significant difference. At the end of the procedure, the highest and lowest conditional factor were found T2 (0.78) and T0 (0.51), respectively, with a significant difference.

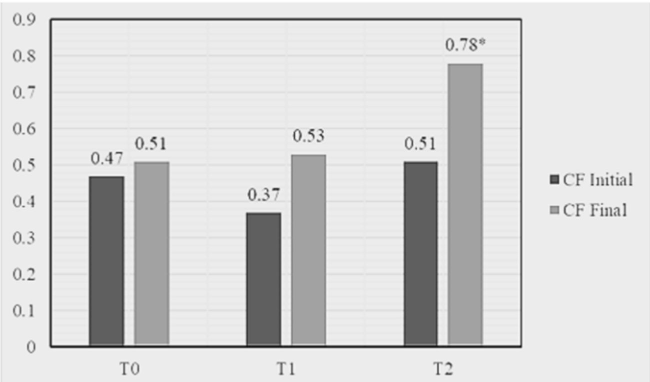

Figure 2. Conditional factors at the beginning of the study (blue) and at the conclusion (yellow) of the study. The superscript shows significance ($p<0.05$).

Discussion

The biological conditions of fish, such as growth, health, and reproduction were influenced by the nutrient content of the food. Energy, anabolism, essential amino acids, and growth were often supported by feed nutrients (Halver and Hardy, 2003; Bertucci *et al.*, 2019). Furthermore, the treatment used in this study comprised freshwater shrimp (*Caridina* sp) and fish food, namely Seluang fish (*Rasbora* sp). In this experiment, live feed consisting of 5% freshwater shrimp (*Caridina* sp.) relative to fish weight showed better growth compared to other treatments. The protein content of *Caridina* sp was estimated at approximately 56% (Mugo-Bundi *et al.*, 2013), while *Rasbora* sp contained approximately 15.29% protein (Munthe *et al.*, 2016). This was in line with Nafidza and Djumanto (2019) in Rawa Pening Semarang, where the highest preference for belida was freshwater shrimp due to the high protein content compared to others. Giant featherback fed with a protein content of 35% exhibited significantly higher growth (Hien *et al.*, 2022). The protein value of featherback meat was 25-40% (Hien *et al.*, 2022), showing that the samples fed with *Caridina* sp. in T1 and T2 had higher levels compared to *Rasbora* sp. Therefore, *Chitala* sp fed with the shrimp had more optimal growth due to the fulfillment of protein requirement. The difference in protein content could cause varying weight values, particularly in relative growth, which had a significantly effect, as shown in Table 1. Effect of differences in the protein content of treatment on fish growth had also been reported in other studies, particularly among *Chitala chitala* and *Oreochromis niloticus* (Hien *et al.*, 2022; Mugo-Bundi *et al.*, 2013). According to Nafidza and Djumanto (2019), crustaceans were the main feed for the other species of featherback *Notopterus notopterus*, as shown by the presence of shrimp (31%) and small fish (26%) in the digestive system. However, this composition could vary based on the level of feed availability in the environment. Sunarto and Sabariah (2009), the daily consumption of carnivorous fish ranged between 5 and 10% of the total fish weight. Feeding rate of 5-7% of shrimp on featherback could be tolerated in this study and a 5% composition treatment provided a positive impact on growth. However, further studies were required to determine an optimal daily feeding range.

Fish growth pattern was changes in size and the relationship between the weight and length of the samples at a particular time. In this study, growth pattern showed different trends at the beginning (negative allometric) and end of the experiment (positive allometric) (Figure 1). According to Mitra *et* al. (2014) and Sarkar *et al.* (2008), pattern in *Chitala* sp. was tentative. Growth phase of *Chitala* sp. could be divided into four stages (Mitra *et al.*, 2014), including yolksac (age 1-8 days with a total length of 10.2-13.2 mm), preflexion (age 9-12 days with a total length of 13.81-16.9 mm), flexion (age 13-20 days with a length of 17.89-25.25 mm), and post flexion (age 20-30 days with a total length of 21-30 mm). Growth pattern in all phases was positive except isometric in the post-flexion phase. This study showed that similar growth pattern could be caused by factors, such as feed availability, population density, age, maturity, and genetics (Muslimin *et al.*, 2022).

The condition factor, also known as the condition coefficient or length-weight factor, delineated the biotic and abiotic carrying capacity of the environment, influencing the phenotype of fish (Fafioye and Ayodele, 2018). Despite the generally positive allometric growth pattern observed in this study, the condition factor had a relatively low value of <1. Previous studies on Chitala in natural inland waters reported varying condition factors, such as 0.7 and 0.9 (Chandran *et al.*, 2020). This diminished parameter could contribute to the flat and elongated shape exhibited by Chitala.

Conclusion

In conclusion, the consumption of freshwater shrimp (concentration 5% of weight) had a more optimal effect on growth factors (weight gain) and survival compared to other feed treatments. Furthermore, growth pattern and condition factor showed a positive trend during the cultivation process.

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