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Growth and Survival of Bronze Featherback (*Notopterus notopterus,* Pallas 1769) Reared on Net Cages in Kelekar River

Pertumbuhan dan Kelangsungan Hidup Ikan Putak (*Notopterus notopterus*, Pallas 1769) yang Dipelihara dalam Waring di Sungai Kelekar

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ABSTRAK

Ikan putak (*N. notopterus*, Pallas 1769) merupakan spesies ikan asli Indonesia. Spesies ini sudah dilindungi Pemerintah Indonesia. Domestikasi spesies ini sangat penting untuk kelestariannya. Tujuan penelitian ini adalah mengevaluasi dampak kepadatan tebar yang berbeda terhadap pertumbuhan, kelangsungan hidup, dan efisiensi pakan. *N. notopterus* yang dipelihara dalam waring. Perlakuan penelitian yakni padat tebar yaitu 1, 3, dan 5 ekor.m^{-2} dengan tiga kali ulangan. Bobot tubuh awal *N. notopterus* masing-masing perlakuan yakni 55,40±3,40; 55,41±2,90; dan 56,07±1,06 g. Uji coba pertumbuhan berlangsung selama 60 hari, dari bulan Mei hingga Juli 2023. Bobot individu ikan di setiap waring dicatat setiap bulan. Bobot tubuh akhir ikan yang ditebar pada kepadatan 1, 3, dan 5 ekor.m^{-2} mencapai 66,87±2,17, 67,63±3,06, dan 64,93±0,72 g, masing-masing. Nilai laju pertumbuhan spesifik adalah 0,45, 0,48, dan 0,34% hari^{-1} pada suhu antara 25,1 dan 30,3°C. Nilai efisiensi pakan adalah 8,36, 9,04, dan 6,30%, dan tingkat kelangsungan hidup dihitung masing-masing 100, 100, dan 93,3%. Hasil penelitian menunjukkan bahwa kepadatan tebar memiliki pengaruh yang signifikan terhadap pertumbuhan dan efisiensi pakan *N. notopterus*. Hasil studi ini menunjukan bahwa perlakuan padat tebar 3 ekor m^{-2} adalah perlakuan terbaik.

Kata kunci: Domestikasi, padat tebar, pertumbuhan spesifik, spesies asli Indonesia, spesies dilindungi

ABSTRACT

The bronze featherback (*N. notopterus*, Pallas 1769) is one of Indonesia's native fish species. This species has been protected by the Indonesian government. Domestication of this species is very important for its sustainability. The aim of this study was to evaluate the impact of different stocking densities on growth, survival, and feed efficiency. *N. notopterus* is reared in net cages. The research treatments were stocking densities of 1, 3, and 5 fish.m^{-2} with three replications. The initial body weights of *N. notopterus* were 55.40 ± 3.40; 55.41 ± 2.90; and 56.07 ± 1.06 g, respectively. The growth trial lasted for 60 days, from May to July 2023. The individual weights of fish in each net cage were recorded monthly. The final body weights of the fish stocked at densities of 1, 3, and 5 fish.m^{-2} reached 66.87±2.17, 67.63±3.06, and 64.93±0.72 g, respectively. The specific growth rate values were 0.45, 0.48, and 0.34% day^{-1} at temperatures ranging between 25.1 and 30.3°C. The feed efficiency values were 8.36, 9.04, and 6.30%, and the survival rates were calculated at 100, 100, and 93.3%, respectively. The results revealed that stocking density had a significant effect on the growth and feed efficiency of *N. notopterus*. The results of this study showed that the stocking density of 3 fish.m^{-2} was the best treatment.

Keywords: Domestication, Indonesian native species, protected species, stocking density, specific growth

INTRODUCTION

Density is an important aquaculture parameter. It has a significant impact on the variable growth performance of fish (Liu *et al*., 2017; Li *et al*., 2021). In fisheries production, stocking density refers to the number of fish initially cultivated per unit area (Battisti *et al*., 2020). The stocking density of the fish is one of the most important factors to reflect and evaluate the level of physiological stress (Barton, 2002). Stocking density has a significant impact on growth, water quality, and fish welfare in aquaculture systems (Riche *et al*., (2013), all of this impact have related to production efficiency (Yang *et al*., 2020). The welfare and growth of fish can be affected positively or negatively by extreme low or high densities, depending on the species (Millán-Cubillo *et al*., 2016; Liu *et al*., 2019; Yang *et al*., 2020). Fish wellbeing is especially affected by stocking density, which is a significant factor affecting fish health in commercial production (Li *et al*., 2021). In aquaculture, stocking density is a crucial factor and a topic of frequent debate. It can cause chronic stress, leading to physiological changes such as stress responses, reduced growth, and health impairment. It is important to carefully consider stocking density to ensure the well-being of aquatic animals (Carbonara *et al*., 2020). Determining optimal stocking densities is difficult due to the complex relationship between fish welfare and stocking density (Kozłowski & Piotrowska, 2023).

The bronze featherback (*N. notopterus*, Pallas 1769) is one of the freshwater fish species. Its distribution in Asia includes Indonesia, Malaysia, Philippines, Vietnam, Thailand, Cambodia, Laos, Myanmar, Pakistan, India, and Bangladesh (Naeem *et al*., 2010; Gupta *et al*., 2013; Mustafa *et al*., 2014; Achakzai *et al*., 2015; Mohanty & Samanta, 2016; Conallin *et al*., 2023; Winn *et al*., 2021). In Indonesia, *N. notopterus* is found in South Sumatra, Lampung, Riau, Riau Island Jambi, Bangka Islands, and Kalimantan (Ammar *et al*., 2014; Mulyani & Budijono, 2020; Rapita *et al*., 2021; Muslim & Syaifudin, 2022; Muslim, 2023). *N. notopterus* belongs to the omnivorous fish group; its diet consists of insects, small fish, insect larvae, crustaceans, nematodes, shrimps, annelids, and detritus (Srivastava *et al*., 2012; Achakzai *et al*., 2015). *N. notopterus* is a nocturnal fish species, has unique with shape body and has the potential to be used as an ornamental fish commodity (Muslim *et al*., 2023). Several studies on *N. notopterus* in Indonesia has done like aspects of reproductive biology (Gustomi *et al*., 2016), feeding habits (Rapita *et al*., 2021), rearing with different stocking densities and different feeds (Sukendi *et al*., 2020), rearing in box container and aquarium (Muslim *et al*., 2023), rearing in buckets (Muslim & Simanjuntak, 2023), and length-weight relationships and condition factors (Muslim, 2023).

In South Sumatra, Indonesia, *N. notopterus,* is highly valued. The price of fresh fish ranges from IDR 50.000 to 100.000 kg^{-1}, depending on the size of the fish. As an ornamental fish, *N. notopterus* with a total length of 10 cm, is sold for IDR 20.000 to 30.000 fish^{-1}. In addition, the price of pulverized *N. notopterus* meat ranges from IDR 100.000 to 150.000 kg^{-1}. This fish meat paste is used to make pempek and crackers, a culinary specialty of South Sumatra (Muslim *et al*., 2023). The increasing demand for this fish has led to increased exploitation of this commodity.

This increase in exploitation has caused the population of *N. notopterus* in the wild to decline dramatically. The production of *N. notopterus* still from wild-caught, while aquaculture is not yet available. Studies on stocking density of *N. notopterus* reared in net cages have not been conducted. The objective of this study was to evaluate the growth and survival of *N. notopterus* reared in a net cage.

MATERIAL AND METHODS

Study site and time

This study was conducted in Kelekar River, Tanjung Pering Village, North Indralaya District, Ogan Ilir Regency, South Sumatra, at ordinate point 3°14'48.0012 "S 104°38'43.674 "E (Figure 1) in May-July 2023.

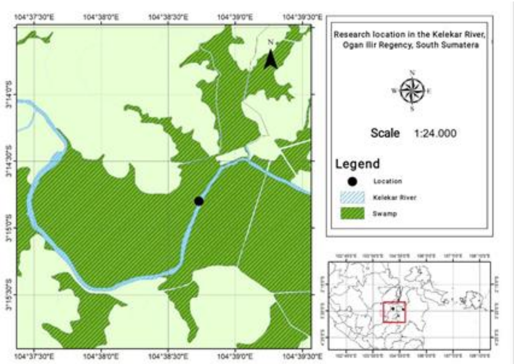

Figure 1. Map of the research location of the bronze featherback (*Notopterus notopterus*, Pallas 1769) in Kelekar River, Ogan Ilir Regency, South Sumatra

Experimental Design

This study used nine net cages measuring 1 m in length, 1 m in width, and 1 m in depth. A net cage is made of high-density polyethylene by weaving it using a flat loom. Bamboos were anchored to the riverbank to serve as pillars for the net cage. Each corner of the net cage was strapped to the bamboo using a strap, and the bottom of the net cage was tied to a stone so that the net cage would not float. The water level in the net cage ranged from 70–80 cm from the water surface to the bottom. The experimental design used in the study was a complete randomized design. The treatments had different stocking densities. Each treatment was repeated three times.

Fish Stocking

The *N. notopterus* used were caught by local fishermen. The body weight of the fish used ranged from 55 to 58 g, and the total length ranged from 19 to 20 cm. The number of fishes was stocked in net cages according to the treatment (1, 3, and 5 fish.m^{-2}). The body weight and total length of the fish were measured individually before being stocked into the net cages. The fish were stocked into the net cage in the afternoon at 4:00 p.m to reduce the stress level of the fishes.

Fish Rearing and Feeding

The *N. notopterus* was reared for 60 days (May–July 2023). During the rearing period, the fish were fed with silver rasbora (*Rasbora argyrotaenia*) at a feeding rate of 3% daily. The frequency of feeding was twice a day, at 8:00 a.m. and 4:00 p.m. The silver rasbora used as feed are live fish, not dead ones. The proximate test results of silver rasbora protein content were 15.25%, fat 4.46%, ash 15.2%, and fiber 0.8%.

Measured Parameters

The growth in body weight was calculated as follows:

$$W = Wt - W0$$

(where W is growth in body weight (g), Wt is the final body weight of fish (g), and W0 is the initial body weight of fish (g). The growth in total length was calculated as follows:

$$L = Lt - L0$$

(where L is growth in total length (cm), Lt is the final total length of fish (cm), and L0 is the initial total length of fish (cm). The specific growth rate (SGR) and feed efficiency (FE) were calculated as follows:

$$SGR = \frac{\ln Wt - \ln Wo}{t} x\ 100$$

$$FE = \frac{(Wt + D) - Wo}{F} x\ 100\%$$

where t is the day of feeding, W0 is the initial body weight of fish (g), Wt is the final body weight of fish (g), D is the body weight of the dead fish (g), and F is the amount of feed given (g).

The survival rate (SR) was calculated as follows:

SR = [Nt/N0] x 100

(where N0 is the number of fishes at the beginning of the experiment (fish), and Nt is the number of fishes at the end of the experiment (fish). The water quality parameters measured included temperature using a thermometer, pH using a pH-meter, dissolved oxygen using a DO-meter, and ammonia using a spectrophotometer. Water temperature and pH measurements were taken daily at 7:00 a.m. and 5:00 p.m., while dissolved oxygen and ammonia were measured weekly.

Statistical Analysis

Data were represented as arithmetic means of individual weight. Data on body weight growth, total length growth, specific growth rate, survival, and feed efficiency were analyzed with one-way analyses of variance (ANOVA) and the Duncan's multiple range test using SPSS version 20.0. Water quality data were analyzed descriptively.

RESULTS AND DISCUSSION

This study successfully reared *N. notopterus* in net cages in the Kelekar River for 60 days. The growth performance, feed efficiency, and survival of *N. notopterus* from this study are presented in Table 1, Figure 2, and Figure 3. The growth of body weight, total length, and specific growth rate was best in the 3 fish.m^{-2} treatment. There was no significant difference (P > 0.05) between the 1 fish.m^{-2} treatment and the 3 fish.m^{-2} treatment. Feed efficiency in the three treatments was significantly different (P<0.05). The survival rate of fish was not significantly different for all treatments (P > 0.05). Water quality parameters during rearing were within the tolerance range for the growth and survival of *N. notopterus*. The water temperature ranged from 25.1 to 30.3 ^{o}C, the pH value ranged from 5.63 to 7.15, and the dissolved oxygen ranged from 3.6 to 5.5 mg. L^{-1}, the ammonia ranged from 0.09 to 0.017 mg. L^{-1}, and the transparency of water ranged from 50 to 57 cm.

The results of this study showed that different stocking density treatments had a significant effect on the growth of body weight and total length of *N. notopterus*. The best treatment for growth in body weight and total length of *N. notopterus* was a stocking density of 3 fish.m^{-2}. A significant determining factor in fish productivity in cages is stocking density, which is based on the volume of water or surface area per fish. The higher stocking density causes more stress, which increases energy requirements and slows growth and food consumption (Aksungur *et al*., 2007; Jia *et al*., 2022). In teleost fish, growth processes follow steps that are characteristic for each species and directly under the control of environmental factors (Xu *et al*., 2022; Abdel-Latif *et al*., 2023). The fish depends on internal and external factors, which control or synchronize many activities or functions, including growth performance (Bœuf & Payan, 2001). Internal factors include health, stress, and reproductive status, while external factors include food quality and quantity, water temperature, and some water quality parameters. In the 3 fish.m^{-2} treatment, feed utilization by fish is more efficient than other treatments. Competition for food and niches is low, so food is fully utilized for the growth process. Fish reared in low densities will be more aggressive (Andersson *et al*., 2022). The body weight growth of *N. notopterus* in this study was higher than the results of Sukendi *et al*., (2020).

The specific growth rate of *N. notopterus* in this study ranged from 0.34% to 0.48%. Specific growth rate is closely related to body weight growth. The growth of body weight is in line with the specific growth rate; the higher the growth of body weight, the higher the specific growth rate. In this study, the highest specific growth rate was observed in the stocking density treatment of 3 fish.m^{-2}. According to Li *et al*., (2021), the specific growth rate of fish increases significantly at low densities. A low stocking density provides more space for movement than a high stocking density, resulting in less competition for niches and food (Ullah *et al*., 2018). The results of this study showed that different stocking density treatments significantly affected the feed efficiency of *N. notopterus* reared. The highest feed efficiency was 9.04% in the stocking density treatment of 3 fish.m^{-2}. Feed efficiency value is closely related to the growth value of fish. The feed efficiency is an essential indicator, as high-quality feed and effective aquaculture management can reduce the amount of feed used and result in better fish growth with less feed consumed (Zlaugotne *et al*., 2022, Komariyah, *et al*, 2021).

The survival of *N. notopterus* in the treatment of 1 and 3 fish.m^{-2} was 100.00%, and in the treatment of 5 fish.m^{-2}, it was 93.33%. These results show that stocking density has no significant effect on survival. According to Budiardi *et al*., (2007), the optimal stocking density is when a high number of fishes are stocked, but competition for food and space is still tolerated by the fish, resulting in high survival rates, fish growth rates, and low size variations.

Table 1. The growth performance, feed efficiency, and survival of the bronze featherback (*Notopterus notopterus*, Pallas 1769)

Parameters	Treatments		
	1 fish.m^{-2}	3 fish.m^{-2}	5 fish.m^{-2}
Initial body weight (g)	55.40±3.40^{a}	55.41±2.90^{a}	56.07±1.06^{a}
Final body weight (g)	66.87±2.17^{b}	67.63±3.06^{b}	64.93±0.72^{a}
Growth in body weight (g)	11.47±1.29^{b}	12.22±1.09^{b}	8.86±0.57^{a}
Initial total length (cm)	20.03±0.42^{a}	20.16±0.40^{a}	19.87±0.09^{a}
Final total length (cm)	22.30±0.70^{b}	22.52±0.33^{b}	21.33±0.06^{a}
Growth in total length (cm)	2.27±0.32^{b}	2.37±0.12^{b}	1.46±0.10^{a}
Specific growth rate (% day^{-1})	0.45±0.07^{b}	0.48±0.05^{b}	0.34±0.03^{a}
Feed efficiency (%)	8.36±1.03^{b}	9.04±0.81^{c}	6.30±0.05^{a}
Survival rate (%)	100.00±0.00^{a}	100.00±0.00^{a}	93.33±11.55^{a}

Note: Value in the same column with different superscript (a, b, c) are significantly different ($P < 0.05$)

CONCLUSION

In conclusion, the results of this study showed that stocking density affected the growth performance and feed efficiency of *N. notopterus* but not its survival. The results of this study showed that the stocking density of 3 fish.m^{-2} was the best treatment. This study indicated that *N. notopterus* can be adapted to a net cage. This study provides a valuable reference for the domestication of *N. notopterus* in the future.

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