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Growth and Exploitation Rate of *Mystus nigriceps*

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Abstract. *Mystus nigriceps* is among the bagrid fish species that live in freshwater ecosystems, including Cicingguling River, Kebumen Regency, Central Java, Indonesia. Despite the economic importance and exploitation for food, the fish is rarely studied. Meanwhile, studies on the growth pattern and exploitation rate of *M. nigriceps* in the Cicingguling River are important because the population is also affected by river fragmentation due to reservoir development. Therefore, this study aims to analyze the growth pattern and exploitation rate of *M. nigriceps* in the Cicingguling River. Sampling was carried out using the *purposive random sampling method* in the Cicingguling River. A total of 9 stations were divided into 3 zones for 1 year, with a frequency of 12 times and an interval of once a month. The results showed that a length-weight relationship had an average b-value of 3.11, indicating a *positive allometric* pattern (b>3). The condition factor of female *M. nigriceps* (2.404) was higher than that of male fish (2.06). Total mortality (Z) was estimated at 4.85 per year, consisting of natural mortality (M) at 3.59 per year and fishing mortality (F) at 1.26 per year. These values suggest that the mortality of *M. nigriceps* is primarily driven by natural causes rather than fishing pressure. The exploitation rate was 0.26 per year, which is relatively low as it remains below the optimum threshold ($E_{optimum}$ = 0.5). This information is essential for fisheries management as a basis for *M. nigriceps* conservation in the Cicingguling River.

Keywords: exploitation; growth; Kebumen; *Mystus nigriceps*; river.

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INTRODUCTION

Overexploitation of fish is a global challenge in the management of aquatic resources. The rapid growth of the human population has increased the demand for fish consumption, which in turn raises the exploitation rate and potentially threatens the survival of species. When left unchecked, exploitation can lead to the extinction of a species, causing imbalances in aquatic ecosystems and disruption of the food chain (Arthington *et al*., 2016). One of the species feared to be overexploited in the fragmented Cicingguling River is *M. nigriceps*, which has high economic value and is in great demand by the public (Syafrialdi *et al*., 2020).

M. nigriceps is a group of fish from the Bagridae family, which live in slow-flowing waters with muddy substrates (Hee, 2002). This species is widely found in Indonesia on the islands of Sumatra, Java, and Kalimantan, as well as the island of Java, including the Cileumueh River, Cilacap, Central Java, Indonesia (Nuryanto *et al*., 2016), Batang River, South Kalimantan (Ahmadi, 2018), and Kampar River, Riau, Indonesia (Syafrialdi *et al*., 2020).

The increasing demand for *M. nigriceps* raises concern over excessive exploitation in the habitat. Although the IUCN (International Union for Conservation of Nature) Red List of Threatened Species categorizes *M. nigriceps* as Least Concern (LC) or an under-appreciated species (Ng, 2019), proper management is still required to ensure sustainability. Information on growth patterns and exploitation least concern rates is needed to keep fish species sustainable in their habitats (Syafrialdi *et al*., 2020).

Fish growth patterns, including length-weight relationship and condition factor, are important aspects in the study of fisheries biology and fish stock estimation (Haslina *et al*., 2024). The length–weight relationship helps evaluate the selectivity of fishing gear toward particular size classes and provides insights into fish condition, which serves as an indicator of health and well-being (Bhanja *et al*., 2024). Condition factor can indicate the specific state of the fish being caught, and is often associated with obesity, as well as the amount of feed available in the habitat (Ragheb, 2023). Fish with a high condition factor generally have better resistance to environmental changes. On the other hand, when the habitat conditions are less than optimal, it can increase the natural mortality of fish (Cheng *et al*., 2019).

Mortality includes natural and fishing aspects, having a significant impact on the abundance and lifespan structure of fish populations (López *et al*., 2017). Fish mortality due to overfishing is higher than the total mortality, which can result in a high rate of exploitation in a habitat (Ahirwal *et al*., 2025). When the rate of exploitation exceeds the threshold, this can lead to *overexploitation,* which has a negative impact on the sustainability of fish populations (Gordon *et al*., 2018). Therefore, sustainable management and strict monitoring of fishing practices are indispensable to maintain the balance of the fisheries ecosystem (Perissi *et al*., 2017).

Studies on the growth pattern and exploitation rate of *M. nigriceps* fish are important to estimate the potential for population growth and sustainability of fishery resources that can be threatened by overfishing activities. Therefore, this study aims to analyze the growth pattern and exploitation rate of *M. nigriceps* in the Cicingguling River. Data on the growth and exploitation rate of *M. nigriceps* are essential for fisheries management and the sustainable use of a target species.

METHODS

Study Location and Sampling Sites

This study was conducted in the Cicingguling River, Kebumen, Central Java, Indonesia (Figure 1) for one year, with a frequency of 12 times every month. A survey method was used with *a purposive random sampling technique*. The location was Cicingguling River, consisting of 9 stations divided into 3 zones, namely Upstream (Stations 1, 2, and 3), Central (Stations 4, 5, and 6), and Downstream (Stations 7, 8, and 9).

Fish sample collection and preservation

Fish samples were collected using cast nets with two different mesh sizes (0.5” and 1”). A smaller mesh size was used to collect fish in the upstream areas, while larger mesh sizes were used in the middle and downstream areas. Fish samples were placed in an ice box and then preserved in 10% formalin for two days. Final preservation was carried out using 70% alcohol.

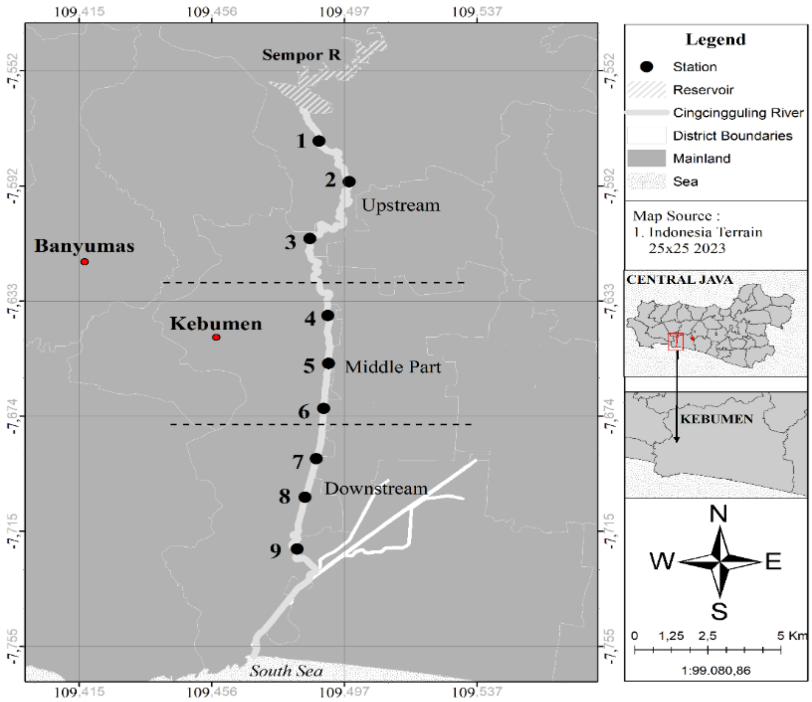

Figure 1. Sampling locations in Cicingguling River (**1**) -7,582; 109,494, (**2**) -7,589; 109,497, (**3**) –7,609; 109,489, (**4**) -7,642; 109,492, (**5**) -7,659; 109,491, (**6**) -7,679; 109,489, (**7**) -7,697; 109,486, (**8**) -7.712; 109.482, (**9**) -7.717; 109.482.

Fish body measurement

The total body length of *M. nigriceps* in the Cicingguling River was measured using millimeters of blocks. The body weight was measured using a digital scale with an accuracy of 0.01 (Sukmaningrum *et al*., 2023). All the data were recorded in a worksheet.

Data Analysis

The total body length and body weight data can be used to determine the long-weight relationship and condition factor. A statistical test was carried out to group the total length obtained into several classes. Mortality and exploitation rate data were obtained using *FiSAT* II software. The calculation formulas are as follows.

Length-Weight Relationship

$\mathbf{W = aL^b}$ (Syafrialdi et al., 2020)

Remarks: W = total weight of fish (g)
L = total length (cm)
a and b = regression result constants

Condition Factor

$= \frac{\mathbf{W}}{\mathbf{aL^b}}$ (Syafrialdi et al., 2020)

Remarks: K = Condition factor
W = total weight of fish (g)
L = total length (cm)
a and b = regression result constants

Natural Mortality

$\mathbf{\log(M) = -0.00660 - 279 \log L\infty + 0.6543 \log K + 0.4634 \log T}$ (Phan et al., 2023)

Remarks: M = mortality rate (years)
L∞ = asymptotic length (cm)
K = growth coefficient (years)
T = average temperature of the waters (^{0}C)

Fishing mortality

$\mathbf{F = Z - M}$ (Phan et al., 2023)

Remarks: F = Fishing mortality (years)
Z = Total mortality (years)
M = Natural mortality (years)

Exploitation rate

$\mathbf{E = \frac{F}{Z}}$ (Phan et al., 2023)

Remarks: E = Rate of exploitation (years)
F = Fishing mortality (years)
Z = Total mortality (years)

RESULTS AND DISCUSSION

Size distribution

Based on the results, *M. nigriceps* (Figure 2) in the Cicingguling River has body lengths ranging from 4.00 to 23.49 cm. The highest number of individuals (637) had a body length size distribution of 13.00 – 14.49 cm, and the lowest number of species (5 individuals) had a body length size of 4.00.2 – 5.49.8 cm (Figure 3).

The size was divided into two groups, namely young fish groups with a length of less than 14.89 cm and adults with a length greater than 14.89 cm (FishBase, 2024). The populations of *M. nigriceps* in the Cicingguling River were dominated by young fish (1902 individuals) compared to adults (381 individuals). The distribution of fish size, dominated by small sizes, indicates that the population may be experiencing a regeneration or recruitment process. Young fish were found to reflect more of a high natural recruitment process, and the potential for increased future population (Camp *et al*., 2020). However, this condition can also indicate a decrease in the number of adult fish due to overfishing or environmental changes that make it difficult for large fish to survive (Kuparinen *et al*., 2016). Premature fishing has a significant negative impact on fish populations and ecosystems. Consequently, fish spawning is disrupted, and abundance will decrease because fish cannot breed (Froese *et al*., 2016).

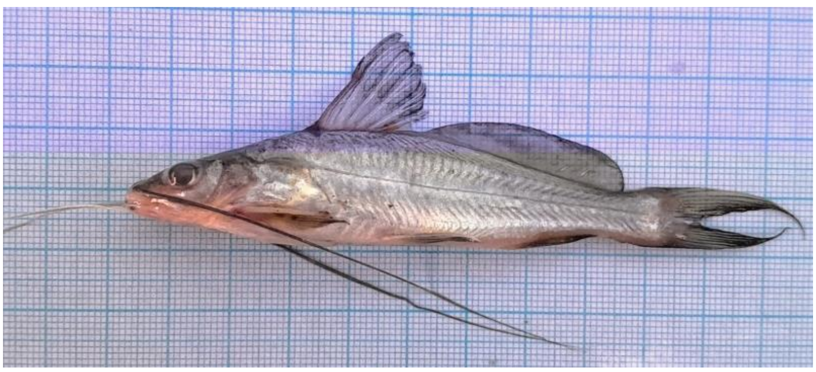

Figure 2. *Mystus nigriceps* sample from the Cicingguling River Kebumen

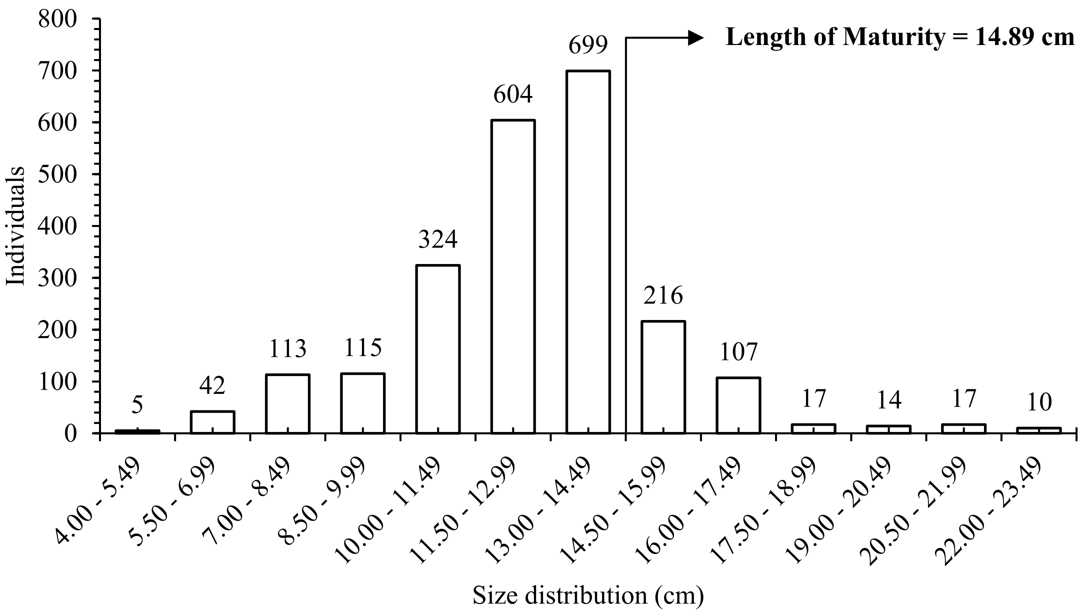

Figure 3. Size Distribution *of M. nigriceps* in the Cicingguling River

Size distribution results varied in each habitat as observed in Batang River, South Kalimantan, Indonesia, ranging from 14.49 – 14.9 cm (47 out of 188 individuals) (Ahmadi, 2018). This variation in size distribution in different rivers across various habitats reflects the differences in environmental conditions and human pressure (Hossain *et al*., 2017; Ahmadi, 2018). These environmental factors include food availability, water temperature, and food competition. The growth of fish in tropical waters is more influenced by the availability of feed than by the temperature (Chan *et al*., 2020).

Length-Weight relationship

The growth pattern of *M. nigriceps* showed the long-weight relationship. Figure 4 shows the analysis results for the growth pattern of *M. nigriceps* in the Cicingguling River.

Length-weight relationship equation based on the analysis is as follows: $W = 0.0353L^{3.11}$. This 3.11 b value indicated that *M. nigriceps* in Cicingguling River has a positive allometric growth (b>3). The grouping of growth patterns consists of three types, namely positive allometric (b>3), isometric (b=3), and negative allometry (b<3) (Ajibare & Loto, 2022). Fish with a positive allometric growth pattern or a value *slope* (b) greater than 3 indicates faster weight growth than body length, suggesting the condition of the fish is quite fat (Froese, 2006; Syafrialdi *et al*., 2020).

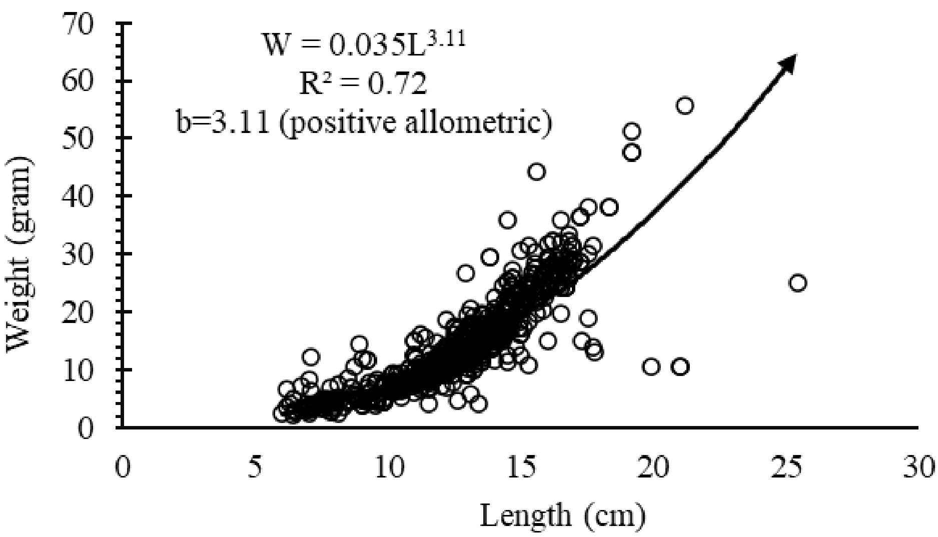

Figure 4. Length-Weight Relationship *of M. nigriceps* in the Cicingguling River

Growth patterns of *M. nigriceps,* including positive allometry, were also found in the Kampar River, Riau, Indonesia, as indicated by a value of 3.39 (Syafrialdi *et al*., 2020). The difference can be attributed to limited feed sources, environmental stress, or disturbed habitat quality, which causes unbalanced body mass growth with an increase in length. This pattern is often found in habitats that experience anthropogenic disturbances or limited resources (Ahmadi, 2018; Syafrialdi *et al*., 2020).

Condition factor

Based on the results, the condition factor was differentiated according to sex as shown in the block diagram (Figure 5).

Condition factor of *M. nigriceps* in the Cicingguling River was higher in female fish (2.40) than in male (2.06). This metric is used to assess the condition or health of fish and is expressed in the form of numbers based on body weight. Condition factor can be grouped into two classes; fish with poor conditions have a condition factor value of less than 1 (K<1), while those in good condition have a value of more than 1 (K>1) (Nash *et al*., 2006). In this study, *M. nigriceps* had a condition factor greater than 1, indicating that the habitat supports the growth of the population. This healthy population is presumably sustained by factors such as feed availability, water quality, and ecological competition (Marc, 2020). The condition factor of female fish is higher compared to males because female fish often prioritize energy storage, which results in weight gain (Dinh, 2017). On the other hand, male fish focus energy on mating behavior, such as territorial competition, which lowers the condition factor (Haslina *et al*., 2024).

A high condition factor for female (1.28) compared to male fish (1.21) was also found in Batang River, South Kalimantan, Indonesia (Ahmadi, 2018). Condition factor is influenced by nutrition, which supports increased growth and energy reserves. Environmental factors in different fish habitats can also affect fish condition (Ragheb, 2023).

Mortality and exploitation rate

The mortality and exploitation rate results were obtained in the form of a captured curve converted based on the length analyzed using FiSAT II (Figure 6).

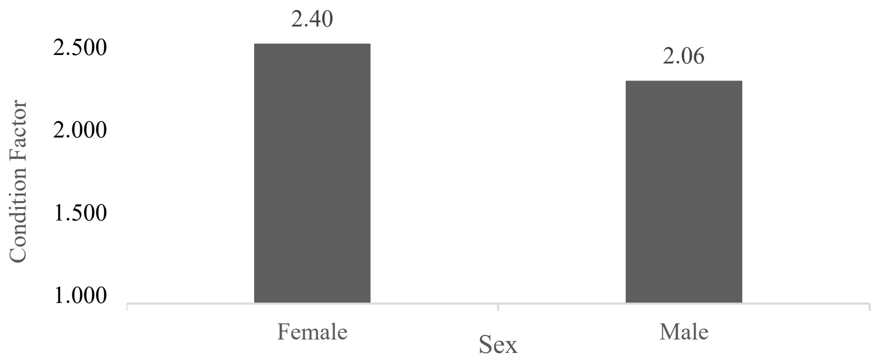

Figure 5. Condition factor of *Mystus nigriceps* in the Cicingguling River.

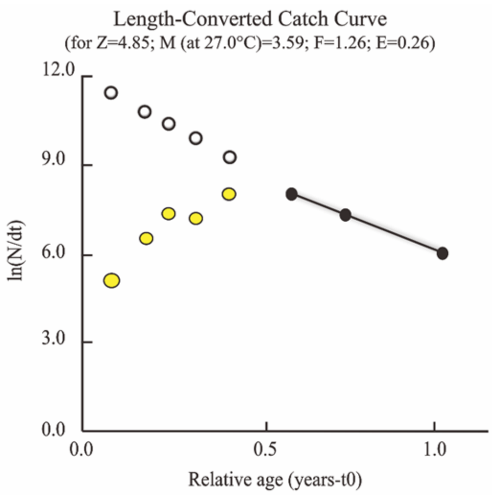

Figure 6. Mortality curve and exploitation rate of *Mystus nigriceps* in the Cicingguling River.

Mortality and exploitation rates were calculated to describe the stock of fish populations in the habitat. The water temperature obtained in the Cicingguling River for mortality analysis, and an average exploitation rate was estimated at 27°C. The results showed total mortality (Z) of 4.85 per year, consisting of natural mortality (M) at 3.59 per year and fishing mortality (F) at 1.26 per year. Based on these values, an exploitation rate (E) of 0.26 was obtained.

Natural mortality (M) was higher than fishing mortality (F), indicating that fish mortality is naturally higher than in the catch. Significant fish mortality can be caused by low dissolved oxygen and variable temperatures (Campos *et al*., 2024). In addition, inadequate feed availability and mortality due to old age are also considered to be consequences of natural mortality (M), which can be worsened by competition or habitat fragmentation (Lorenzen, 2022). The exploitation rate is below the threshold (E = 0.5 per year), indicating that the exploitation of the *M. nigriceps* is still quite low (Phan *et al*., 2023). This is presumably due to insufficient pressure or intensity of exploitation to achieve the level considered ideal for maximum sustainable catch. Differences in exploitation rate may be due to limited fishing efforts, restrictions on fishing activities, low demand or market access, or conservation measures that reduce overfishing (Ray *et al*., 2023).

Mortality and exploitation rate of *M. nigriceps* in the Cicingguling River showed variations from the Bagridae Family in various habitats. For example, *Mystus albolineatus* in the Hau River showed higher natural mortality (M) compared to fishing mortality (F), and the value of the exploitation rate was also below the maximum threshold (E = 0.5). Vietnam showed lower results, namely a total mortality of 2.63 per year, consisting of a natural mortality of 2.05 per year and a fishing mortality of 0.58 per year, as well as an exploitation rate of 0.22 per year (Nguyen *et al*., 2024). The exploitation rate obtained in the Cicingguling River is lower than that of *Mystus mysticetus* in the Mekong River, Vietnam (Phan *et al*., 2023). These differences in the exploitation rate can be attributed to variations in fishing intensity, type of fishing gear, and level of effort (Keskar *et al*., 2017).

This study provides the first data on the growth pattern and exploitation rate of *M. nigriceps* in Cicingguling River, Kebumen, Central Java, Indonesia. The information is essential for fisheries management as a basis for sustainable use of the fish in the river.

CONCLUSION

In conclusion, *M. nigriceps* in the Cicingguling River has a positive allometric growth pattern and a low exploitation rate. Further studies on reproductive characters and the reproduction season are needed to provide more comprehensive data on the biology and fisheries management of *M. nigriceps*.

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AUTHOR CONTRIBUTION STATEMENT

SR was in charge of conception and design, while WL assisted with data interpretation and provided support for data visualization. Throughout the manuscript drafting process, AN offered insightful criticism and comments. HHAM checked the grammar and writing flow of the manuscript. The final manuscript was read and approved by all authors, who also committed to taking responsibility for every part of the work.

CONFLICT OF INTEREST STATEMENT

Regarding the publication of this paper, each author affirms that they have no conflicts of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the study, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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