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Determining the Main Morphometrical Traits to Describe Body Weight in Male *Hampala* Barb Fish (*Hampala macrolepidota*)

Fuja Arsita Siregar [a], Deni Efizon [b], Efawani [b], Maestro Munru [a*], Panji Anugrah Ramadhan [a], Surahman Suwardi [a] and Widya Pintaka Bayu Putra [c]

[a] *Faculty of Fisheries and Marine Sciences, IPB University, Bogor, West Java, 16680, Indonesia.*
[b] *Water Resources Management, Riau University, Simpang Baru, Tampan, Pekanbaru City, Riau, 28293, Indonesia.*
[c] *Research Center for Applied Zoology – National Research and Innovation Agency, Bogor, West Java, 16911, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. Author FAS designed the research, conducted sampling, and wrote the first draft of the manuscript. Author MM analyzed the data, interpreted the results, and completed the literature. Author WPBP provided direction and input for writing, interpreted the results, and completed the writing. All authors read and approved the final manuscript.

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**Corresponding author: Email: maestromunru@gmail.com;*

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ABSTRACT

Aims: Determine the main morphometrical traits influencing body weight in male *Hampala* Barb (HB) fish.
Place and Duration of Study: The fish were taken from Kampar Kiri River at Mentulik Village, Kampar Regency, Riau Province. This research was conducted in February-April 2018.
Methodology: The survey method used in this research takes morphometric measurements of fish. *Hampala* fish is used as the object of research. The survey method is a research method that is carried out directly on the object of research without giving special treatment to the object under study. A total of 26 morphometrical traits were measured from 42 male HB fishes.
Results: Research showed that the average body weight of HB fishes was 245.24±136.54 g. Four morphometrical measurements of maximum body height, pre-dorsal length, pre-ventral fin length, and caudal pendulum height were selected as the leading four variables to predict body weight with the coefficient of determination (R^2) of 0.95. Therefore, a variable of maximum body height can predict the body weight with an R^2 value of 0.91.
Conclusion: The body weight of *Hampala* fish can be accurately predicted with morphometric measurements. The maximum body height can influence the body weight of *Hampala* fish with the R^2 value of 0.91. Overall morphometrical measurements of maximum body height, pre-dorsal length, pre-ventral fin length, and caudal peduncle height can describe the body weight of *Hampala* fish with R^2 = 0.95.

Keywords: Hampala barb fish; morphometrics; body weight; coefficient determination.

1. INTRODUCTION

Hampala, or *Hampala* barb (*Hampala macrolepidota*), is an economically important freshwater fish species in Southeast Asia. In Indonesia, this fish had a high economic value and ecologically controlled the ecosystem (Herlan & Wulandari, 2021). Although the fisheries sector has high benefits, knowledge of fish growth patterns and morphometric characteristics are not studied in aquaculture and capture fisheries (Risdawati, et al., 2020). A significant obstacle in the culture and management of *Hampala* fish is uncertain body weight estimation directly with or without fish measuring equipment. Hence, increasing fish production and efficiency are not reached. Despite this, the fish market and fish quality are not fulfilling (Risdawati, et al., 2020).

Another significant issue is the considerable morphometric variation between individual fish, particularly between males and females, which can result in various growth patterns. The specific morphometric parameters required for male fish body weight determination further complicate the issue, making accurate measurement challenging (Herawati, et al., 2022). Moreover, managing wild *Hampala* and aquaculture fish stocks can make assessing fish health and growth efficient. This study is important because an in-depth understanding of the relationship between morphometric characters and the body weight of these fish can provide important information for population management, optimization of aquaculture, and sustainable conservation of fisheries resources.

This study aims to predict the body weight of *Hampala* fish based on morphometrical measurements. These findings are also expected to solve the problem in fish weighing. The advantage of this research is that it can increase the efficiency of fisheries stock management, including managing *Hampala* fish in both wild environments and aquaculture.

2. MATERIALS AND METHODS

2.1 Sampling Stations

This research was conducted in February-April 2018 in Kampar Kiri River, Mentulik Village, Kampar Kiri Hilir District, Kampar Regency, Riau Province. Observations and sample measurements were conducted at the Aquatic Biology Laboratory of the Faculty of Fisheries and Marine Sciences, Riau University. The survey method is used in this research, *Hampala* fish is used as the object of research, and the Kampar Kiri River is used as the research location. The survey method is a research method that is carried out directly on the object of research without giving special treatment to the object under study. The research location in Kampar Kiri River can be seen in Fig. 1.

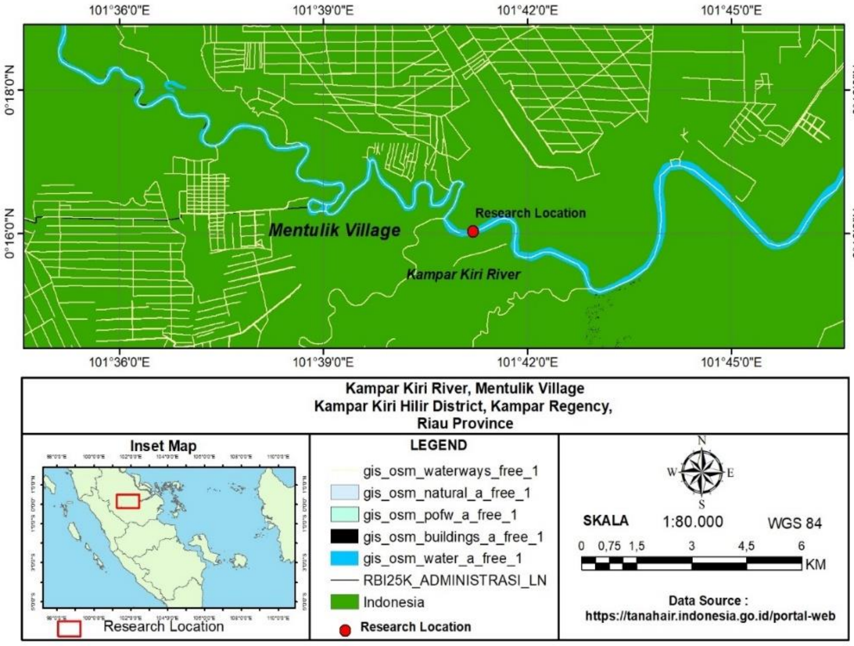

Fig. 1. Sampling stations in Kampar Kiri River, Mentulik Village, Kampar Kiri Hilir District, Kampar Regency, Riau Province

The sampling stations were determined using a purposive sampling method by considering different environmental conditions in the study area to represent the characteristics of the waters in the Kampar Kiri River, Mentulik Village. There are three sampling points: (1) Sampling Point I is located in the upstream part of the river, where there are no community activities; (2) Sampling Point II is in the middle of the river, which is surrounded by residential areas with toilet activities, fishing boat stopovers, and fisheries activities such as KJA and fishing; (3) Sampling Point III is located in the downstream of the river, where there are fish cages and fishing activities.

2.2 Fish Collection and Morphometric Measurements

Hampala fish sampling used the census method, with 42 samples of *Hampala* fish caught directly at the research site. Fish sampling was conducted once every 2 weeks in February-April 2018. Fish were taken in fresh and intact conditions with varying sizes ranging from the smallest to the largest, and then the fish were put into a cool box to be analyzed in the laboratory. Morphometrical measurements were performed using digital calipers, as shown in Fig. 2. While meristic characteristics were calculated manually.

2.3 Environmental Measurements Parameters

Environmental parameter measurements are conducted in tandem with the fish sampling process. This simultaneous approach, which measures temperature, brightness, pH, DO, and CO2, ensures an efficient research process. The results of these measurements are then compared with water quality standards to assess the environmental conditions of the research site and their impact on the survival of *Hampala* fish.

2.4 Regression Analysis

This research method uses multiple linear regression analysis to identify the relationship between several independent variables and one dependent variable. The multiple linear regression equation, according Kerzérho et al. (2023) as follows:

$$Y = a + b1X1 + b2X2 + \cdots + bnXn$$

In a multiple linear regression equation, Y is the dependent variable to be predicted or explained. The constant a, or intercept, is the value of Y when all the independent variables Xi are zero. Each independent variable, or predictor, is expressed as X1, X2,..., Xn and is used to help explain or predict the value of YY.

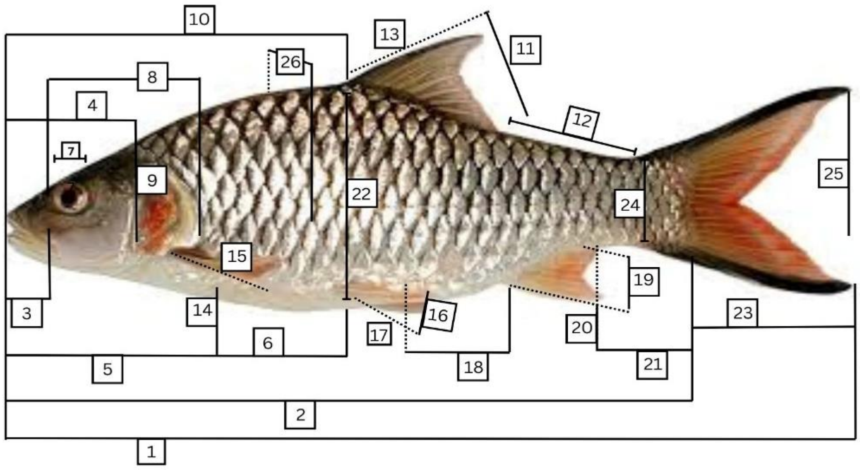

Fig. 2. The scheme of morphometrical measurements in *Hampala* Barb fish (*Hampala macrolepidota*) consisted of total length (1), standard length (2), snout length (3), head length (4), pre-ventral fin length (5), pre-anal length (6), eye diameter (7), pre-orbital length (8), head height (9), pre-dorsal length (10), dorsal fin length (11), post back distance (12), dorsal fin height (13), pelvic fin height (14), pectoral fin length (15), ventral fin length (16), ventral fin height (17), ventral anal distance (18), anal fin length (19), anal fin height (20), caudal peduncle length (21), maximum body height (22), caudal length (23), caudal peduncle height (24), caudal height (25) and body width (26).

The regression coefficients b1, b2,..., and bn show the influence each independent variable Xi has on Y, assuming the other variables remain constant. Finally, the error or residual (e) is the difference between the value of Y predicted by the model and the actual value of Y, which reflects the influence of other variables not included in the model or random variation.

3. RESULTS AND DISCUSSION

3.1 Morphology of *Hampala* Fish

The results of this study reveal the unique morphological characteristics of *Hampala* fish. These fish boast a distinctive flattened body shape protected by scales. Their subterminal mouth is protractile, and their body color, a silvery hue, is more intense on the dorsal part, with a slightly brighter abdomen (Makmur, et al., 2014). Specifically, *Hampala* fish sport a black spot between their dorsal and pelvic fins, which fades as they mature. Their fins are reddish, with the tips of the dorsal and caudal fins black, and they feature a cigar-shaped caudal fin (Roesma, et al., 2018). *Hampala* fish exhibit distinct differences between males and females. Male *Hampala* fish typically have a slimmer body, while females have a more rounded belly and a blunt mouth shape. Males are characterized by their brighter color and single genital hole, while females have two genital holes (Afriansyah, et al., 2023). Kenthao's and Jearranaiprepame research (2020) shows that fish morphology illustrates adaptability to different environmental conditions, including swimming speed and habitat preference.

This study revealed significant variation in the morphometrical measurements of the *Hampala* fish, particularly body weight, which had the highest coefficient of variation (CV) of 0.56. This high variation indicates a large variability among individuals, which poses a challenge in accurately predicting body weight. Some parameters, such as eye diameter and ventral fin length, have low variability, making them less relevant for use as primary predictors of body weight. In contrast, total length, standard length, and maximum body height with more moderate CVs (around 0.18-0.20) showed strong potential in influencing fish body weight. Neto et al., (2012) One of the parameters that influenced fish body weight the most was body height (BH). However, head length (HL) and body width (BW) were the variables with higher direct influence. Although BH is important, other variables, such as HL, should be taken into account together for more accurate estimation. Therefore, despite variations in morphometric influence, body length and height remain strong predictors in estimating fish body weight.

Table 1. Descriptive statistics of body weight (g) and morphometrical traits (mm) in male *Hampala* Barb fish (*Hampala macrolepidota*)

Parameters	Mean	SD	CV	Minimum	Maximum
Total length	263.24	48.91	0.19	131.00	380.00
Standard length	205.81	37.90	0.18	102.00	300.00
Snout length	19.70	3.71	0.19	9.16	29.49
Head length	62.01	11.21	0.18	32.27	88.72
Pre-ventral fin length	58.65	10.58	0.18	29.52	78.98
Pre-anal length	106.47	23.31	0.22	51.07	182.61
Eye diameter	11.56	1.56	0.14	7.52	14.45
Pre-orbital length	35.04	8.38	0.24	23.13	60.94
Head height	40.35	7.47	0.19	21.83	58.38
Pre-dorsal length	110.01	21.68	0.20	55.13	163.00
Dorsal fin length	28.81	6.17	0.21	14.48	42.56
Post back distance	75.40	14.82	0.20	38.16	107.67
Dorsal fin height	46.50	8.64	0.19	20.37	67.66
Pelvic fin height	10.55	2.22	0.21	4.91	15.61
Pectoral fin length	38.99	7.82	0.20	17.97	53.47
Ventral fin length	9.69	1.61	0.17	5.22	13.76
Ventral fin height	34.35	6.14	0.18	17.76	50.02
Ventral anal distance	43.80	8.96	0.20	22.29	63.07
Anal fin length	17.18	3.04	0.18	10.28	22.97
Anal fin height	34.81	6.47	0.19	18.30	48.46
Caudal peduncle length	39.03	8.56	0.22	20.96	62.51
Maximum body height	64.95	13.23	0.20	34.28	98.23
Caudal length	30.30	6.51	0.21	14.60	45.09
Caudal peduncle height	58.98	10.88	0.18	31.62	81.40
Caudal height	30.58	6.56	0.21	14.64	45.77
Body width	32.99	6.37	0.19	17.95	46.91
Body weight	245.24	136.54	0.56	30.92	700.00

SD: standard deviation; CV: coefficient of variation

Body length, both total and standard, and maximum height are essential indicators in describing the overall physical size of the fish. Total length (mean 263.24 mm) and maximum height (mean 64.95 mm) are directly related to body volume and mass, affecting fish weight. Other parameters, such as caudal peduncle length and dorsal fin length, although not directly correlated with body weight, still reflect essential aspects of the fish's physical condition and swimming ability, which can affect the fish's access to food and growth. Waters et al., (2016), states that body parameters such as total length, standard length, and body depth are critical for describing the relationship between fish size and weight. Morphometric traits such as head length, pre-pelvic distance, and post-dorsal length also contribute to understanding growth dynamics and morphological variation between species. However, they do not directly affect body weight. These findings are in line with the results of Jiang et al., (2022), showed that maximum body depth and total length are the main predictors of fish body weight due to their influence on body volume and mass. Integrating these insights provides a broader understanding of morphometric relationships in predicting fish body weight, reinforcing the importance of size-related parameters.

3.2 Environmental Parameters

The results illustrate that the waters of the Kampar River ecosystem have unique and dynamic characteristics. The temperature of the Kampar River waters during the study was obtained in the range of 26-27 ^{O}C. The results of this study are similar to research conducted with a temperature range of 26-27 Peronita et al., (2022), which describes these waters in a stable condition but relatively low compared to the temperature of tropical waters in general, which ranges from 28-32 ^{O}C. Meanwhile, the pH of the water tends to be acidic, with a value of 5, which illustrates that the waters are under much pressure from organic matter entering the water body; the optimum pH for aquatic organisms is 7-8 (Champasri, et al., 2021). The condition of dissolved oxygen (DO) obtained ranged from 3.2-3.9 mg/L. The DO concentration obtained is still in good condition and can be tolerated by aquatic biota, but indeed, the results obtained are not in optimal conditions in supporting the survival of living things (Maulidya, 2022); this emphasizes that there is an input of organic matter entering the water body to cause low DO used for the process of breaking down organic matter by microorganisms.

The Kampar River waters' brightness ranged from 20-34 cm. The optimum condition of water brightness is >2 m with a minimum limit of 30-40 cm (DeBreving & Rompas, 2013). The brightness of this water is very dependent on the ability of sunlight penetration to penetrate the waters; waters with low brightness are generally described as having a reasonably large suspended particle condition; this can be influenced by sedimentation, aquatic substrates, and waste entering the water body. On the other hand, the CO_2 conditions, ranging from 9.9 to 15.9, further accentuate the acidic conditions and indicate an ongoing decomposition process: This concentration of CO_2, although relatively high, is still within the conditions that aquatic organisms can tolerate (Melisa, et al., 2021). A high level of biological activity characterizes the overall environmental condition of the Kampar River. Water quality is essential for fish growth, and the measured water quality parameters showed significant variations during the study (Suranjit, et al., 2024). However, the significant pressure from human activities seriously threatens the ecosystem's biodiversity, leading to a decline in water quality.

3.3 Linear Regression Model

The morphometric analysis of *Hampala* fish (*Hampala macrolepidota*) utilized regression models to identify the factors that most influence fish body weight. Including predictor variables in each model led to a notable improvement in prediction accuracy across the four models (A to D) (Table 2). Model D emerged as the most effective of the four, with the highest R^2 (0.95) and the lowest SE (31.62). These findings suggest that the four variables in Model D offer the most accurate description of fish body weight. However, it is crucial to consider the potential for overfitting in overly complex models. This study underscores the importance of selecting the correct variables to accurately and effectively assess fish morphometrics, particularly in species with complex body characteristics. Such an approach aids in understanding fish biometric dynamics and provides a solid foundation for conservation efforts and population management of aquatic species.

The regression graphic shows the observation points close to the regression line with R^2= 0.91 and indicating the regression model is very good for predicting the body weight of fish (Fig. 3). The closeness of the observation points to the regression line, which reflects that the model predictions are close to the actual value. In addition, the value= of R2= 0.91 indicated that about 91% of the variation in the dependent variable (body weight) can be explained by the model's independent variables (maximum body height). Therefore, the remaining 9% is caused by other factors outside the model. This result shows the accuracy of the regression model for describing the relationship between body weight and morphometrical measurements in *Hampala* fish. Previous studies have shown a strong relationship between morphometric parameters and body weight in *Hampala* fish. Afriansyah et al., (2023), found that a regression model with R^2 of 0.89 effectively predicted body weight based on total body length. Meanwhile, Herawati et al., (2023), reported similar results, where body length was linearly related to body weight, indicating the high predictive ability of this model. These findings support the results of the current study with an R^2 value of 0.91, indicating high accuracy in describing the relationship between body weight and morphometric measurements, particularly maximum body height.

Table 2. The best linear regression models for predicting body weight (dependent variable) in male *Hampala* Barb fish (*Hampala macrolepidota*) based on selected morphometrical traits (independent variables)

Model	Equation	R^2	SE
A	$Y = 9.87X_1 - 395.64$	0.91	40.60
B	$Y = 6.26X_1 + 2.33X_2 - 417.44$	0.93	37.50
C	$Y = 5.95X_1 + 4.55X_2 - 4.41X_3 - 383.41$	0.93	34.91
D	$Y = 6.76X_1 + 6.76X_2 - 4.84X_3 - 5.14X_4 - 350.23$	0.95	31.62

Y: body weight; X_1: maximum body height; X_2: pre-dorsal length; X_3: pre-ventral fin length; X_4: caudal peduncle height; R^2: coefficient of determination; SE: standard error of regression

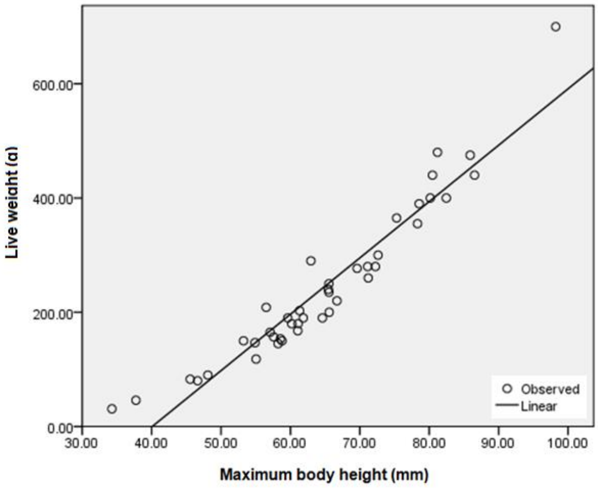

Fig. 3. The linear regression plots in the Model A (R^2=0.91) for male *Hampala* Barb fish (*Hampala macrolepidota*)

The research results of Khowhit et al., (2024) obtained similar results in this study, where the coefficient of determination was 0.99, which illustrates the strong relationship between length and weight in *Hampala* fish.

4. CONCLUSION

The body weight of *Hampala* fish can be accurately predicted with morphometric measurements. The maximum body height can influence the body weight of *Hampala* fish with the R^2 value of 0.91. Overall morphometrical measurements of maximum body height, pre-dorsal length, pre-ventral fin length, and caudal peduncle height can describe the body weight of *Hampala* fish with R^2 = 0.95.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:
1. Grammarly
2. Consensus
3. Deepl

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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