

BIOLOGICAL ASPECTS OF MUDSKIPPERS: FEEDING CHARACTERISTICS AND GROWTH PATTERNS IN THE MANGROVE ECOSYSTEM OF KARANGTALUN, CILACAP

Aspek Biologi Ikan Gelodok: Karakteristik Makan dan Pola Pertumbuhan di Ekosistem Mangrove Karangtalun, Cilacap

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ABSTRACT

Mudskippers are characteristic inhabitants of mangrove ecosystems and utilize a variety of food resources available within intertidal habitats. This study investigated the feeding characteristics and growth patterns of mudskippers inhabiting the Karangtalun mangrove ecosystem, Cilacap, Indonesia. A field survey was conducted at three stations selected using purposive sampling. Fish specimens were obtained from local fishers and examined for mouth gape, relative gut length (RGL), stomach content composition, and length–weight relationships. Mean mouth gape ranged from 10.20 to 12.07 mm, while RGL values ranged from 2.16 to 2.34, indicating an omnivorous feeding tendency. Stomach content analysis revealed that phytoplankton was the dominant food component, with detritus, zooplankton, and algae occurring in varying compositions among stations. Length–weight analysis indicated positive allometric growth at all stations, with *b* values ranging from 3.14 to 3.63. Although feeding characteristics varied among stations, these variations did not consistently correspond to differences in growth patterns. Overall, the findings indicate that mudskippers in the Karangtalun mangrove ecosystem exhibit omnivorous feeding characteristics, utilize diverse food resources, and display positive allometric growth. These results provide baseline information on the feeding ecology and growth biology of mudskippers in mangrove habitats.

Keywords: Feeding ecology; Growth pattern; Mangrove; Mudskipper; Stomach contents

ABSTRAK

Ikan Gelodok merupakan salah satu ikan yang khas ditemukan di ekosistem mangrove dan mampu memanfaatkan berbagai sumber makanan yang tersedia di habitat intertidal. Penelitian

ini bertujuan untuk mengkaji karakteristik makan dan pola pertumbuhan ikan Gelodok di ekosistem mangrove Karangtalun, Cilacap. Penelitian dilakukan dengan metode survei pada tiga stasiun yang ditentukan secara purposive sampling. Sampel ikan diperoleh dari hasil tangkapan nelayan, kemudian dianalisis berdasarkan ukuran bukaan mulut, *Relative Gut Length* (RGL), komposisi isi lambung, dan hubungan panjang–berat. Hasil penelitian menunjukkan bahwa rata-rata bukaan mulut ikan Gelodok berkisar 10,20–12,07 mm. Nilai RGL berkisar 2,16–2,34 yang menunjukkan kecenderungan pola makan omnivora. Pengamatan isi lambung menunjukkan bahwa fitoplankton merupakan komponen makanan yang dominan, sedangkan detritus, zooplankton, dan alga ditemukan dengan komposisi yang bervariasi antarstasiun. Berdasarkan hubungan panjang–berat, ikan Gelodok pada seluruh stasiun menunjukkan pola pertumbuhan allometrik positif dengan nilai koefisien b berkisar 3,14–3,63. Variasi karakteristik makan antarstasiun tidak selalu menunjukkan kecenderungan yang searah dengan pola pertumbuhan. Secara keseluruhan, ikan Gelodok di ekosistem mangrove Karangtalun menunjukkan karakteristik makan omnivora dengan sumber makanan yang beragam dan pola pertumbuhan allometrik positif.

Kata Kunci: Ikan Gelodok, Isi lambung, Karakteristik makan, Mangrove, Pola pertumbuhan

INTRODUCTION

Mangrove ecosystems serve as vital habitats for a wide array of coastal organisms, providing shelter, foraging grounds, and a source of organic matter that sustains aquatic productivity. Tidal dynamics, muddy substrates, and high inputs of organic matter create a unique environment that supports biota capable of adapting to fluctuating aquatic conditions. One organism commonly found in these habitats is the mudskipper (*Boleophthalmus boddarti*)—an amphibious fish that utilizes the intertidal zone both when submerged and when the mudflats are exposed during low tide. Its capacity for bimodal respiration, tolerance to salinity fluctuations, and ability to move across the substrate make this fish a characteristic inhabitant of mangrove ecosystems (Belqis *et al.*, 2022; Amalia & Budijastuti, 2022).

The presence of mudskippers is not only intriguing due to their adaptations but also significant in terms of their role within the mangrove food web. Various studies indicate that mudskippers exploit a diverse range of food sources, including algae, detritus, and diatoms, as well as benthic organisms such as mollusks, crustaceans, nematodes, and polychaetes. The composition of their diet can vary depending on the species, the size of the fish, and the specific habitat conditions (Kumaraguru *et al.*, 2020; Sujono & Muzaki, 2021; Nurfajrin *et al.*, 2025). This variation suggests that the feeding habits of mudskippers are intrinsically linked to the characteristics of their environment and the availability of food resources.

Morphological traits also dictate how these fish utilize food sources. The size of the mouth opening determines the size of prey or food particles that can be consumed, while the relative length of the digestive tract provides insight into the types of food typically ingested. Consequently, data regarding the contents of the digestive tract become more meaningful when analyzed in conjunction with morphological characteristics related to feeding activity. This approach can provide a more comprehensive picture of the feeding strategies of mudskippers in their natural habitat.

The availability and utilization of food are linked to fish growth, as food provides the energy required for metabolism, activity, body maintenance, and tissue formation. Growth patterns can be evaluated through the length-weight relationship, while the relative condition of individuals can serve as an indicator of a fish's performance within a specific habitat. Previous research in the Karangtalun Mangrove Forest indicated that mudskippers exhibit a negative allometric growth pattern—meaning that an increase in body length occurs more

rapidly than an increase in body weight (Hastuti et al., 2023). However, this information does not yet explain how the feeding habits of this same population relate to its growth patterns.

The Karangtalun Mangrove Forest in Cilacap offers an intriguing environmental setting for examining these relationships. This area serves as a habitat for mudskippers, yet conditions vary across different parts of the site due to its proximity to mangroves, residential areas, aquaculture ponds, rice fields, industrial zones, and shipping lanes. Such variations in habitat conditions can influence the organic matter content in the sediment, water quality, and the availability of organisms that serve as food sources. Consequently, the diversity of food items consumed by mudskippers can offer insights into how this species responds to the availability of resources within its habitat.

Several studies in the Karangtalun area have examined mudskippers, covering aspects such as the nutritional content of their flesh, the amino acid profile of their mucus, and their length-weight relationships (Riviani et al., 2020; Imani et al., 2022; Hastuti et al., 2023). However, information regarding the feeding habits of *Boleophthalmus boddarti* and its connection to growth patterns in this region remains limited. Research that integrates dietary composition, morphological characteristics related to feeding activity, and growth patterns is necessary to provide a more comprehensive picture of the food-utilization strategies employed by mudskippers in mangrove habitats.

Given this, the present study aims to analyze the feeding habits and growth patterns of the mudskipper (*Boleophthalmus boddarti*) in the Karangtalun mangrove forest, Cilacap, and to describe the relationship between them. Data on water quality conditions are also included to help characterize the habitat where these fish forage. The findings are expected to enhance our understanding of the feeding ecology of *B. boddarti* and provide a scientific basis for comprehending the ecological role of mudskippers within the mangrove ecosystem.

RESEARCH METHODS

Place and Time

The research was conducted in the Karangtalun Mangrove Forest area, Cilacap, using a survey method with a quantitative descriptive approach. Site selection began with a literature review and mapping to gather information on the distribution of mangrove vegetation, site accessibility, and areas with the potential to serve as habitat for the mudskipper (*Boleophthalmus boddarti*). Subsequent field surveys were carried out during low tide to confirm the presence of mudskippers on the muddy substrate and around the mangrove roots.

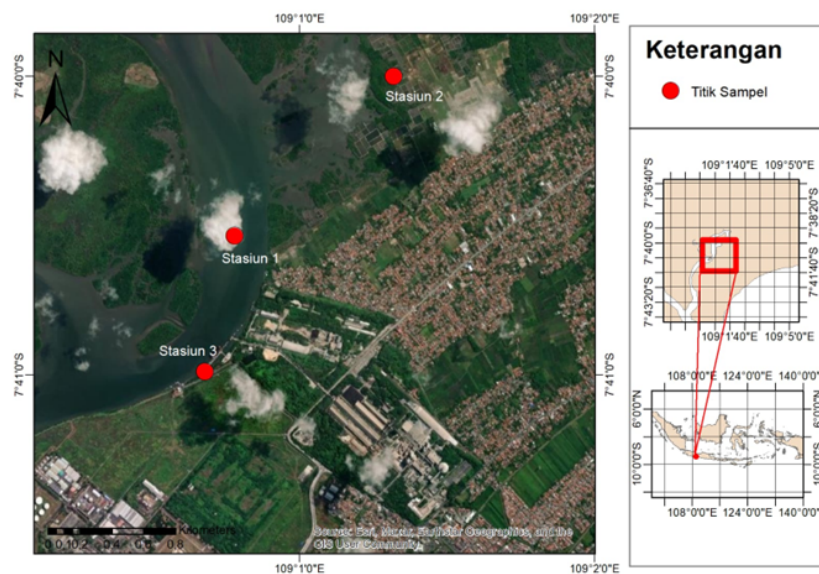


Figure 1. Map of the Research Location

Research stations were selected using purposive sampling, taking into account the presence of mudskippers, the existence of mangrove habitat, and the proximity of the sites to human settlements, aquaculture ponds, rice fields, industrial areas, or shipping lanes. As quantitative data on substrate type and mangrove density were not available, the characteristics of each station were described based on observed site conditions. The study was conducted at three stations: Station 1, located in a mangrove area near human settlements and industrial zones (7°40'32.10"S; 109°0'46.8"E); Station 2, situated in an area comprising mangroves, aquaculture ponds, and rice fields (7°40'00.00"S; 109°1'19.1"E); and Station 3, located in a mangrove area near industrial zones and shipping lanes (7°40'59.40"S; 109°0'40.7"E). A map showing the locations of the research stations is presented in Figure 1.

Sampling and Morphometric Measurements

Sampling of the mudskipper (*Boleophthalmus boddarti*) was conducted once at three research stations during low tide. Specimens were obtained from the catches of local fishermen using gill nets with a mesh size of 1.9 cm. Sampling followed a random selection process from the fishermen's catch, taking into account the availability of the fish at each station. A total of 100 individuals were used in this study. The collected specimens were placed into ziplock bags, labeled according to the sampling station, and stored in a cool box containing ice to preserve them prior to analysis.

Morphometric measurements included body weight, total length, and mouth opening. Body weight was measured using a digital scale with a precision of 0.01 g, while total length was measured using a ruler on millimeter-grid paper, spanning from the anterior tip of the head to the posterior tip of the caudal fin. Weight was recorded both before and after the removal of the digestive tract. The mouth opening was measured using calipers, specifically recording the vertical dimension (mouth depth) and horizontal dimension (mouth width) while the fish's mouth was in a naturally open position. The mouth opening measurements were used to characterize the morphology related to the fish's ability to utilize food, while the body length and weight data were used to analyze growth patterns through length–weight relationship analysis.

Growth Patterns and Condition Factors

The growth pattern of mudskippers was analyzed based on the length–weight relationship using an equation:

$$W = aL^b$$

where W is the weight of the fish (g), L is the total length of the fish, a is a constant, and b is the growth coefficient. The value of b is used to determine the fish's growth pattern: isometric when $b=3$, positive allometric when $b>3$, and negative allometric when $b<3$. In addition to the length–weight relationship, the condition of the fish is analyzed using a condition factor (K). The condition factor value is used to describe the physical condition of the fish based on the relationship between its actual weight and the weight estimated from the length–weight relationship.

Observation of Eating Habits

Observations on feeding habits were conducted by measuring the relative gut length (RGL) and analyzing stomach contents. The fish were dissected using surgical scissors, after which the digestive tract was removed and its length measured. The RGL value was calculated using the equation:

$$RGL = \frac{GL \text{ (cm)}}{TL \text{ (cm)}}$$

where GL (Gut Length) represents the length of the digestive tract, and TL (Total Length) represents the total body length of the fish. RGL values of <1 , $1-3$, and >3 are operationally used to indicate carnivorous, omnivorous, and herbivorous tendencies,

respectively. These categories serve as preliminary morphological indicators rather than definitive determinants of feeding type; therefore, they should be interpreted in conjunction with the analysis of stomach content composition (Silitonga and Batubara, 2025). The stomach is separated from the digestive tract and weighed using a digital scale to determine its initial weight. It is then carefully opened, and its entire contents are removed. The empty stomach is weighed again, and the weight of the stomach contents is calculated as the difference between the weights before and after emptying. These measurements are used to determine the quantity of food present within the stomach.

The stomach contents of the mudskipper (Gelodok) are diluted with 40 mL of distilled water and examined under a microscope at a total magnification of 400× (using a 40× objective lens and a 10× ocular lens). Food components are identified based on morphological characteristics, referencing the identification guides by Sani Iskandar (1982), Rosada and Sunardi (2021), and Padang (2023). The organisms found are identified to the lowest possible taxonomic level and subsequently categorized into phytoplankton, zooplankton, algae, and detritus. Dietary composition is analyzed based on the number of individual organisms or food particles identified within each category. The percentage composition for each food category is calculated by dividing the number of individuals or particles in that category by the total number of food components identified at each sampling station, then multiplying by 100%. The results are presented as percentages to illustrate the variation in the dietary composition of mudskippers across the research stations.

Water Quality Measurement

Water quality measurements were conducted in situ at each research station to provide supporting data on the habitat conditions of the mudskipper (*Boleophthalmus boddarti*). Each measurement was performed in duplicate at every station, and the results are presented as mean values. The parameters measured included temperature, salinity, pH, and dissolved oxygen (DO). Temperature was measured using a thermometer submerged directly into the water. Salinity was measured using a hand refractometer calibrated with distilled water, while pH was measured using a pH meter, with readings taken once they had stabilized. DO levels were measured using a DO meter that had been calibrated prior to use. The water quality data were analyzed descriptively to characterize the environmental conditions at each station and to serve as supporting information for interpreting variations in the feeding characteristics and growth patterns of the mudskipper.

Data Analysis

The research data were analyzed using descriptive quantitative methods. The coefficient b from the length–weight regression was interpreted descriptively; in the absence of statistical testing against $b = 3$ and an assessment of the associated uncertainty, a classification of positive allometry cannot be definitively confirmed through inferential analysis. [INCLUDE: number of individuals, regression equations per station, R^2 values, standard error or confidence intervals for b , and the results of the test for $b = 3$, if available.] The feeding habits of mudskippers were analyzed based on mouth gape size, the Relative Gut Length (RGL) index, and the weight and composition of stomach contents. Growth patterns were analyzed using length–weight relationships and condition factors. Data from the three stations were then compared descriptively to characterize the feeding habits, growth patterns, and the relationship between the two for mudskippers in the Karangtalun mangrove forest area.

RESULT

The results of the observations on the percentage composition of the stomach contents of mudskippers at 3 stations are presented in Figure 2.

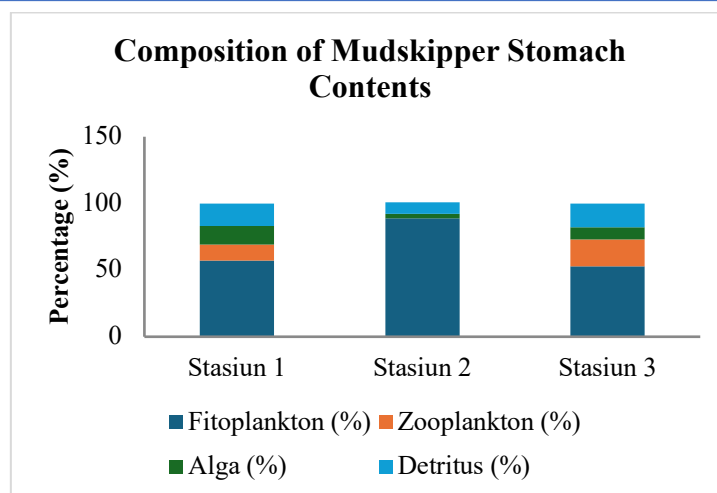


Figure 2. Composition of Mudskipper Stomach Contents

Data on growth pattern parameters and feeding habits of mudskippers at 3 stations are presented in Table 1.

Table 1. Growth Pattern Parameters and Feeding Habits of Mudskippers at 3 Stations

Station	Mean Mouth Opening (mm)	RGL to the track	Mean Body Length (cm)	Mean Body Weight (g)	Growth Patterns and Condition Factors	Digestive Tract Contents (%)
1	12,07	2,16	11,63	27,45	Positive allometry (b = 3,4581) Condition factor = 1,004	Fitoplankton: 59,52% (Synedra sp., Navicula sp., Nitzschia sp., Fragilaria sp., Coscinodiscus sp., Gyrosigma sp., Cymbella sp., Spirogyra sp.), Detritus: 16,67%, Zooplankton: 11,90% (Nematoda,), Alga: 11,90 Crustacea exuviae, Copepoda exuviae % (Oscillatoria sp., Cyanobacteria sp.)
2	10,65	2,34	11,43	23,81	Positive allometry (b = 3,1445) Condition factor = 1,003	Fitoplankton: 88,57% (Synedra sp., Navicula sp., Nitzschia sp., Fragilaria sp., Ghomphonema sp., Microspora sp., Closterium sp., Pediastrum sp.,

						Scenedesmus sp., Spirogyra sp, <i>Ceratium</i> sp, <i>Volvox</i> sp), Detritus: 8,57%, Alga: 2,86% (<i>Cyanophyceae</i> sp) Zooplankton: 0% Fitoplankton: 53,33% (<i>Synedra</i> sp., <i>Navicula</i> sp., <i>Nitzschia</i> sp., <i>Fragilaria</i> sp., <i>Gyrosigma</i> sp., <i>Cymbella</i> sp) Zooplankton: 20,00% (Nematoda, Crustacea Exuviae, Larva Copepoda), Detritus: 17,78%, Alga: 8,89% (<i>Cyanophyceae</i> sp.)
3	10,20	2,27	11,23	25,05	Positive allometry (b = 3,6265) Condition factor = 1,003	

Table 2. Results of water quality measurements at each research station

Parameter	Station 1	Station 2	Station 3
Temperature (°C)	28,6	31,9	29,4
Salinity (ppt)	16,3	8,3	16,3
pH	7,90	8,49	7,89
DO (mg/L)	5,0	4,0	4,2

DISCUSSION

Analysis of the stomach contents of the mudskipper (*Boleophthalmus boddarti*) at three observation stations in the Karangtalun mangrove forest area, Cilacap, reveals that phytoplankton is the most dominant food component at all stations, accounting for 53–89% of the total content. This is followed by zooplankton, algae, and detritus, with proportions varying by station. At Station 1, phytoplankton makes up approximately 60% of the total stomach contents, followed by detritus (16.67%), while zooplankton and algae are present in equal proportions, at 11.90% each. Station 2 shows the highest dominance of phytoplankton, reaching 89%, with minimal contributions from algae (2.86%) and detritus (8.57%); notably, no zooplankton was found at this station. Conversely, Station 3 exhibits the most diverse diet composition, with the lowest proportion of phytoplankton (approximately 53%) and higher contributions from zooplankton (20.00%) and detritus (17.78%) compared to the other two stations, although the proportion of algae (8.89%) is slightly lower than that at Station 1 (11.90%).

The dominance of phytoplankton—specifically the diatom group (Bacillariophyta)—in the stomach contents of the mudskipper in this study aligns with previous research on the feeding habits of *B. boddarti* in various regions. A study in the Mekong Delta, Vietnam, reported that Bacillariophyta is the primary food component for *B. boddarti*, accounting for 82.97% of its diet, alongside a 13.26% contribution from detritus (Quang, 2015). Similar

findings have been reported from the Pichavaram mangrove waters in India, where diatoms were found to constitute approximately 55% of the diet of *B. boddarti* throughout the year (Ravi, 2013). A consistent pattern has also been observed in Indonesia: in the Musi River Estuary, South Sumatra, *B. boddarti* was recorded to rely on benthic diatoms as its primary food source (Ridho *et al.*, 2019). The same genera of pennate diatoms—*Synedra*, *Navicula*, *Nitzschia*, *Gyrosigma*, and *Cymbella*—also dominated the stomach contents of the mudskippers in this study. This consistency suggests that a preference for benthic phytoplankton, particularly epipelagic diatoms that attach to mud surfaces, is a relatively stable trophic characteristic of this species across various mangrove habitats (Gabed *et al.*, 2022).

This consistency is determined not only by food availability but also by the morphological adaptations of the feeding apparatus in the genus *Boleophthalmus*. Morphological studies of the feeding structures in *B. pectinirostris* reveal flattened, tightly packed, and horizontally oriented lower jaw teeth, along with a jaw support mechanism that enables the fish to efficiently scrape microalgal layers from the substrate surface (Tran *et al.*, 2020). This structure differs from that of its relatives in the genera *Periophthalmus* and *Periophthalmodon*, which are carnivorous and rely on capturing mobile prey (Dinh *et al.*, 2021). These differences explain why the results of this study diverge from reports on the feeding habits of *Periophthalmus* spp.—which are dominated by crustaceans and larger benthic organisms (Juniar *et al.*, 2020; Nurfajrin *et al.*, 2025)—and confirm that the diet of mudskippers is specific at the genus level, rather than merely a reflection of food abundance in the environment.

Nevertheless, the varying proportions of zooplankton, algae, and detritus across stations indicate that the availability of food in the environment influences the composition of the diet consumed. Station 3, which exhibited the most diverse dietary composition, is likely linked to substrate characteristics and fertility levels that differ from other stations—such as the organic matter content on the bottom, the density of the plankton community, and the degree of environmental disturbance—thereby providing mudskippers with greater opportunities to prey on a wider variety of food sources (Hasan *et al.*, 2025). This reinforces the conclusion that mudskippers are omnivorous with an opportunistic tendency, meaning they exploit the most abundant food sources available in their environment (Sujono & Muzaki, 2021). This is further supported by the Relative Gut Length (RGL) values of 2.16–2.34 observed in this study. These RGL values fall within an intermediate range typical of omnivorous fish (Silitonga & Batubara, 2025)—higher than those of strictly herbivorous fish but lower than those of carnivorous fish—which morphologically corroborates the mixed diet observed through stomach content analysis.

The average mouth aperture of the mudskippers, ranging from 10.20 to 12.07 mm, helps explain why phytoplankton and microscopic organic particles are the dominant dietary components; the relatively small mouth size limits the fish's ability to capture larger prey, favoring a feeding strategy that involves scraping or filtering fine particles from the substrate or the water surface (Nasution *et al.*, 2018).

The differences in water quality across stations, as shown in Table 2, indicate variations in the environmental characteristics of the mudskipper habitats within the Karangtalan mangrove forest area. Station 2 exhibited the lowest salinity (8.3 ppt), the highest temperature (31.9°C), and the lowest dissolved oxygen concentration (4.0 mg/L), with a stomach content composition dominated by phytoplankton (88.57%). This contrasts with Station 3, which featured a more diverse diet, notably including 20.00% zooplankton and 17.78% detritus. These differences in environmental characteristics are likely linked to variations in the food sources utilized by mudskippers in each habitat. However, stomach content composition does not directly reflect food availability in the environment. Variations in environmental conditions were also observed alongside differences in the length–weight relationship coefficient (b)—

3.14 at Station 2 and 3.63 at Station 3. Nevertheless, a definitive causal link between water quality, diet composition, and the length–weight relationship cannot be established, as this study is descriptive in nature and did not involve statistical testing of relationships between these parameters. Consequently, the water quality data in this study are best viewed as supporting information to help explain differences in habitat characteristics between the stations.

The analysis of stomach content composition and the length–weight relationship of mudskippers reveals variations across stations that do not follow a consistent pattern. Station 2, which had the highest proportion of phytoplankton (88.57%), showed the lowest length–weight relationship coefficient (b) of 3.14, whereas Station 3, with a more diverse diet, exhibited the highest value ($b = 3.63$). These findings indicate that the dominance of a specific food group in the stomach contents does not necessarily correspond to a higher length–weight relationship coefficient. The variation in the ' b ' value across stations is likely influenced by several factors, including the characteristics of the food consumed, the size and biological condition of the fish, and differences in the environmental conditions of each habitat. However, since the nutritional content and biomass of the food items were not analyzed, the contribution of each food group to the growth of the mudskippers could not be directly determined. Thus, while the results of this study indicate variations in both diet composition and the length–weight relationship of the mudskippers across different stations, they do not yet establish a causal link between the two.

CONCLUSION

The mudskipper (*Boleophthalmus boddarti*) in the Karangtalun mangrove forest area, Cilacap, exhibits omnivorous feeding habits, as indicated by a Relative Gut Length (RGL) value of 2.16–2.34. The fish have an average mouth opening of 10.20–12.07 mm, and their stomach contents are dominated by phytoplankton (53.33–88.57%). The length–weight relationship across the three study stations follows a positive allometric pattern, with the coefficient b ranging from 3.14 to 3.63. Descriptively, the variation in dietary composition among the stations does not show a consistent pattern in relation to the length–weight coefficient b . The station with the highest proportion of phytoplankton recorded the lowest b value, whereas the station with a more diverse diet showed the highest b value. These findings indicate variations in the feeding characteristics and length–weight relationships of the mudskipper across different stations; however, a definitive causal link between these two aspects cannot yet be established.

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