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Pola pertumbuhan, faktor kondisi dan fenomena plastisitas fenotipik ikan Red Devil (*Amphilophus labiatus*) di Danau Toba, Sumatera Utara, Indonesia
[Growth patterns, condition factors and phenotypic plasticity phenomena of Red Devil (*Amphilophus labiatus* Günther, 1864) in Lake Toba, North Sumatra, Indonesia]

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ABSTRACT | This study aims to analyze the growth patterns and condition factors of the red devil fish (Amphilophus labiatus Günther, 1864) in Lake Toba, North Sumatra, Indonesia. Growth patterns were measured by analyzing the relationship between length and weight of fish using the Linear Allometric Model (LAM) approach, while the condition factor parameters were measured using the Fulton's and relative weight (Wr) condition factor. This study was conducted in August 2024 and April-August 2025 in Lake Toba covering the locations of Porsea, Balige, Muara, Bakti Raja, and Onanrunggu Regency. The results of the length-weight relationship analysis showed that A. labiatus had a negative allometric growth pattern (b <3). The results of the determination analysis showed that total length was a factor that strongly influenced fish body weight with a value reaching R2 0.8829. The results of the analysis of the Fulton's and Wr condition factors showed values of 2.79 and 103.85, respectively, where these values indicate very good, minimal competitors, and stable conditions in A. labiatus. Morphological observations of A. labiatus samples found that the lip size was relatively thinner than in its natural habitat, indicating the phenotypic plasticity of the fish due to the new habitat.

Key words | Fulton's; length-weight relationship; linear allometric model; relative weight

ABSTRAK | Penelitian ini bertujuan untuk menganalisis pola pertumbuhan dan faktor kondisi ikan red devil (Amphilophus labiatus Günther, 1864) di Danau Toba, Sumatera Utara, Indonesia. Pola pertumbuhan diukur dengan menganalisis hubungan panjang dan berat ikan menggunakan pendekatan Linear Allometric Model (LAM), sedangkan parameter faktor kondisi diukur menggunakan faktor kondisi Fulton dan berat relatif (Wr). Penelitian ini dilakukan pada bulan Agustus 2024 dan April-Agustus 2025 di Danau Toba yang meliputi lokasi Porsea, Balige, Muara, Bakti Raja, dan Kabupaten Onanrunggu. Hasil analisis hubungan panjang-berat menunjukkan bahwa A. labiatus memiliki pola pertumbuhan alometrik negatif (b <3). Hasil analisis determinasi menunjukkan bahwa panjang total merupakan faktor yang sangat mempengaruhi berat badan ikan dengan nilai mencapai R2 0,8829. Hasil analisis faktor kondisi Fulton dan Wr menunjukkan nilai masing-masing sebesar 2,79 dan 103,85, dimana nilai-nilai ini menunjukkan kondisi yang sangat baik, minim kompetitor, dan stabil pada A. labiatus. Observasi morfologi pada sampel A. labiatus menemukan bahwa ukuran bibir relatif lebih tipis dibandingkan di habitat aslinya, yang menunjukkan plastisitas fenotipik ikan akibat habitat baru tersebut.

Kata kunci | Faktor kondisi Fulton; hubungan panjang-berat; model alometrik linier; berat relatif

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INTRODUCTION

Aquatic ecological degradation has reached alarming levels. In addition to anthropogenic and natural factors such as the introduction of invasive fish species have disrupted the diversity of stable ecosystems (Aqmal-Naser and Ahmad, 2020). This is also occurring in the aquatic ecology of Indonesia's largest lake, Lake Toba, which is approximately 87 km long, approximately 27 km wide, and approximately 500 m deep (Stankiewicz *et al*., 2010; T *et al*., 2021; Fukushima *et al*., 2023).

The presence of invasive introduced fish such as the red devil (*Amphilophus labiatus*) in this lake in recent years has caused alarming habitat degradation. The author's field observations indicate that the population explosion of *A. labiatus* is out of control in Lake Toba. This species continues to undergo habitat succession, affecting

the species composition and ecosystem structure that has been ongoing by invading the food sources and habitats of native fish in Lake Toba. Furthermore, stomach contents identification found that *A. labiatus* preys on other fish, thus categorizing this fish as a predator (Silitonga and Batubara, 2025).

The peak population growth of *A. labiatus* remains unpredictable. Therefore, its population is predicted to continue to grow over the next few years. This makes native fish of Lake Toba increasingly vulnerable, especially to competition for food sources and habitat niches, and even becoming prey for *A. labiatus*. Therefore, this research was conducted to evaluate the growth dynamics and condition factors of *A. labiatus* in Lake Toba, serving not only to assess its adaptability to this new environment but also to provide a critical basis for population control strategies aimed at minimizing further disturbance to the native aquatic ecosystem.

MATERIAL AND METHODS

Research location and time

This research was conducted in April-August 2025 in Lake Toba, North Sumatra, Indonesia, covering the locations of Porsea, Balige, Muara, Bakti Raja, and Onanrunggu (Fig. 1).

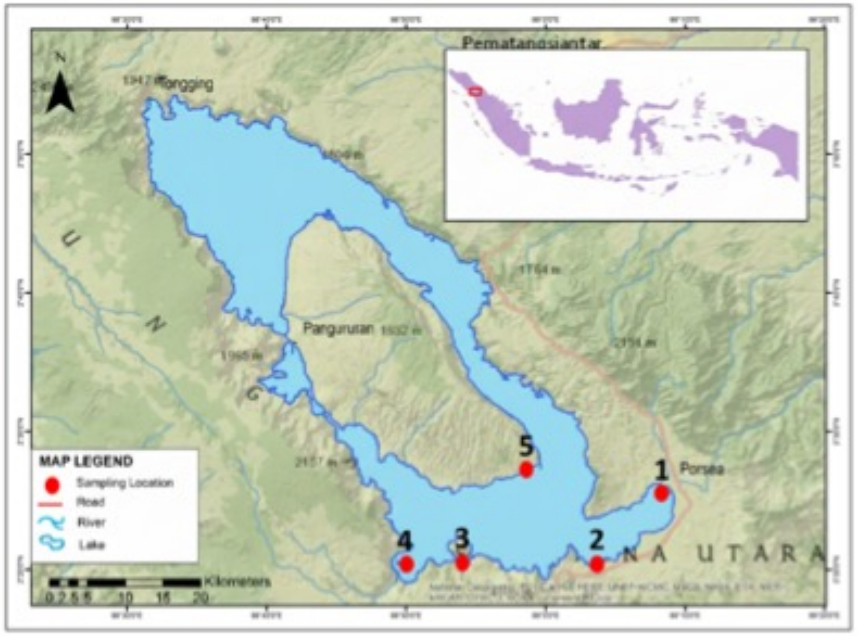

Fig. 1. Research location in the Lake Toba, North Sumatra, where (1) Porsea, (2) Balige, (3) Muara, (4) Bakti Raja, and (5) Onanrunggu.

Research implementation methods and parameters

Fish samples was collected using casting nets (mesh size 1 cm) and trap nets (mesh size 0.5 cm). Fish sampling was carried out in the morning at 09:00 by throwing the casting net five times at each location. While the trap net was placed for 30 minutes at the point where the fish were estimated to gather, this was repeated three times per location. The collected samples were then preserved using 4% formaldehyde and taken to the Biology Laboratory of Universitas Negeri Medan, Indonesia for further analysis. Total length measurements were taken using digital calipers (accuracy 0.01 mm) and weight using digital scales (accuracy 0.01 g).

Data analysis

The length-weight relationship analysis was assessed using the Linear Allometric Model (LAM) approach based on De-Robertis and William (2008), with Fulton's and relative weight (Wr) condition factor referring to Rypel and Richter (2008). The formula used is as follows:

$$W = e^{0.56}(aL^b)$$

Where: W is the body weight of the fish, L is the total length of the fish, *a* is a constant, and *b* is the geometric proportion of the fish body, *e* is the residual variance of the LAM, and 0.56 isthe correction factor.

$$K = (W \times L)^{-3} \times 100$$

Where: K is Fulton's condition factor, W is the fish body weight, L is the total length of the fish, -3 is the coefficient that directs the K value closer to 1. The K value is categorized into 5 (Morton and Routledge, 2006), namely: 0.8-1.0 (very bad), 1.0-1.2 (bad), 1.2-1.4 (stable), 1.4-1.6 (good), > 1.6 (very good).

$$Wr = (W / Ws) \times 100$$

Where: Wr is the relative weight condition factor, W is the body weight of the fish, Ws is the value of aL^b.

RESULTS

A total of 236 samples of *A. labiatus* were collected during the study. The size of the collected *A. labiatus* ranged from 44-250 mm (mean 112.34±38.52 mm) for total length and 1.70-219 g (mean 30.94±39.64 g) for body weight. The results of the length-weight relationship analysis (Fig. 2) showed that *A. labiatus* had a negative allometric growth pattern (b <3). The results of the determination analysis showed that total length was a factor that strongly influenced fish

body weight with a value reaching R^2 0.8829. The results of the relative weight (Wr) and Fulton's condition factors showed values of 103.85 and 2.79, respectively, where these values indicate very good values, minimal competitors, and stable conditions in *A. labiatus*.

Morphological observations indicate that the hypertrophic lip development of *A. labiatus* is abnormal. *A. labiatus*, which is identified as thick-lipped, appears to have undergone a relatively thinner lip size (Fig. 3). This evidence also reveals a plasticity response leading to the evolutionary process of *A. labiatus* to adapt to the environment and food sources available in new habitats.

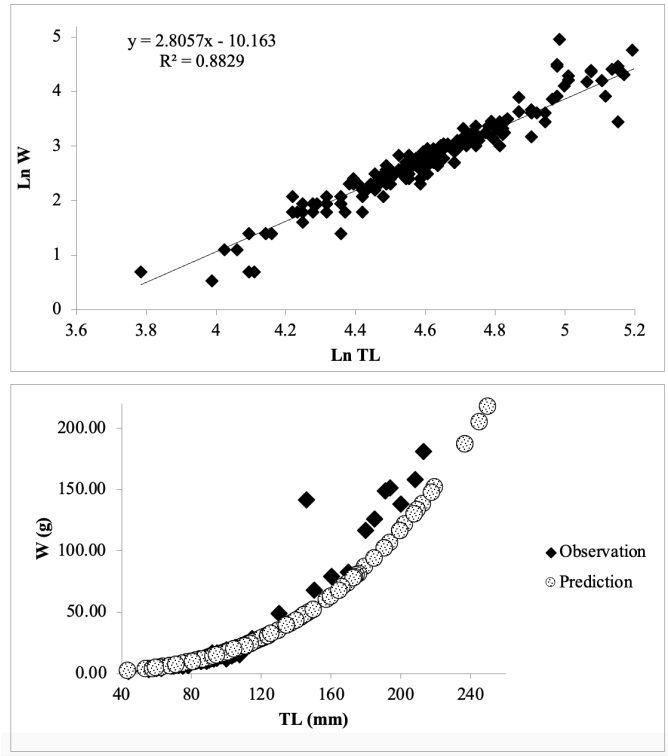

Fig. 2. Analysis of length-weight relationship (a) and estimated growth (b) of *Amphilophus labiatus* in Lake Toba, North Sumatra, Indonesia.

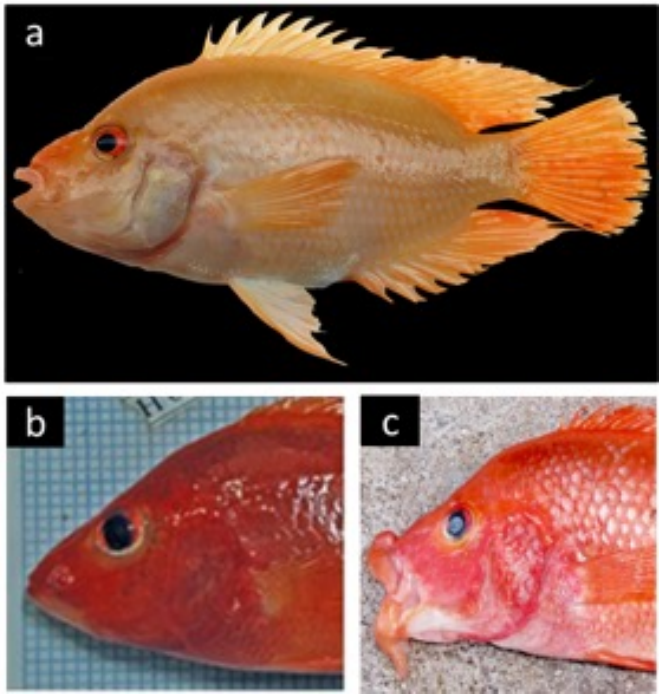

Fig. 3. Changes in the morphology of the lips of the red devil (*Amphilophus labiatus*) after being introduced to (a) Lake Toba, and (b) Australian waters (Sowersby *et al*., 2020), while in its natural habitat in (c) Nicaragua, Central America, the red devil fish has thicker lips (Angulo *et al*., 2023).

DISCUSSION

The negative allometric growth pattern in *A. labiatus* found in this study indicates an elongated body shape, while in Lake Sentani, Papua, it has a positive allometric growth pattern (b > 3) or an oval body shape (Ohee *et al*., 2024). Positive allometric also represents fish experiencing rapid growth due to the abundance of food sources in the aquatic environment. In other waters in the Jatibarang Reservoir, Semarang, *A. labiatus* has an isometric growth pattern (b = 3) or balanced growth (Sakti *et al*., 2024). In other fish species, namely *Puntrigrus tetrazona*, which was also collected in Lake Toba, the growth pattern shows isometric (Batubara *et al*., 2025).

The negative allometric growth pattern of *A. labiatus* in Lake Toba is likely related to limited food availability, which tends to cause the fish to become thin. New habitat factors may also influence this fish, as food sources have also changed from their natural habitat. Our previous research revealed that *A. labiatus* in Lake Toba tends to feed on plant-based food sources, with phytoplankton being the most dominant (Silitonga and Batubara, 2025). Different results were found for *A. labiatus* in Sermo Reservoir, Kulon Progo, where it predominantly feeds on animal food sources such as fish, crustaceans, detritus, and insects (Ariasari *et al*., 2018). Changes in the feeding habits of *A. labiatus* in Lake Toba are thought to have affected growth patterns and caused the fish to become relatively thin.

These changes in feeding behavior also likely cause phenotypic plasticity in *A. labiatus* in Lake Toba, where the lips are relatively thinner. Phenotypic plasticity is the ability of an organism to change its appearance, physiology, or behavior in response to environmental changes. Colombo *et al*. (2013) revealed that the diet of *A. labiatus* in its natural habitat is dominated by hard-shelled prey (67.6%), where hypertrophic lips are suspected to play an important role as a buffer for prey in rocky areas. It is suspected that to adapt to food types, environmental differences, and trophic levels, specialization and diversification in the size of the lips of *A. labiatus* introduced to new habitats occur. These results are in line with previous research that revealed a change in the size of the *A. labiatus* lips to become thinner due to adaptation to new habitats such as in Australia (Sowersby *et al*., 2020). Furthermore, the maintenance of *A. labiatus* in captivity with standard diets showed a change in lip size to become thinner (Barlow & Munsey 1976). Machado-Schiaffino *et al*. (2014) revealed that phenotypic plasticity adaptations related to the development of lip hypertrophy were shown to occur in *A. labiatus* but not in its sister *A. citrinellus*, opening up the possibility that selection has also affected genes that influence plastic responses.

CONCLUSION

The growth pattern of *A. labiatus* in Lake Toba reflects the fish's adaptation to new food resources, organism diversity, physicochemical factors, and habitat. In addition to the negative allometric growth pattern, *A. labiatus* also exhibits phenotypic plasticity, with its lips tending to become thinner. Negative allometric growth in *A. labiatus* also indicates that food availability is not yet adequate for the fish's nutritional needs, leading to an elongated shape.

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