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Length-weight relationship and condition factor of threadfin goby *Sicyopterus longifilis* de Beauford, 1912 (Teleostei: Sicydiinae) at Ummiding and Matama Rivers, West Sulawesi, Indonesia

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Abstract. *Tikawati, Omar SBA, Nur M. 2024. Length-weight relationship and condition factor of threadfin goby* Sicyopterus longifilis *de Beauford, 1912 (Teleostei: Sicydiinae) at Ummiding and Matama Rivers, West Sulawesi, Indonesia. Biodiversitas 25: 2074-2085.* Threadfin goby *Sicyopterus longifilis* (de Beaufort, 1912) is an amphidromous species known as 'penja' in the postlarval phase. Therefore, this research aimed to analyze the length-weight relationship and condition factors of goby fish in Ummiding and Matama Rivers, West Sulawesi. Fish sampling was conducted 12 times, twice monthly, during new and full lunar phases from July to December 2023. Each fish was measured for the total length, weighed, and dissected to determine the sex. The results showed that the length-weight relationship of goby fish in Ummiding River for male and female fishes were $W = 0.000011L^{3.0250}$ and $W= 0.000023L^{2.8422}$, respectively. In Matama River, the length-weight relationship for male and female fish was $W = 0.000008\ L^{3.1193}$ and $W = 0.000005\ L^{3.2228}$, with a combined sexes value of $W = 0.000006\ L^{3.1839}$. According to the statistical tests, the Ummiding River male fish had isometric growth due to a balanced length and body weight increase. In contrast, female fish had hypoallometric growth type ($b<3$), where the increase in length was faster than body weight. Male, female, and the combined sexes of the species in Matama River had hyperallometric growth type ($b>3$) since the increase in length was slower than body weight. The condition factor values exceeded 1.0, showing that Ummiding and Matama Rivers supported threadfin goby life. The acquired threadfin goby length-weight relationship and condition factors are now used as a guide for managing and conserving the species in this region.

Keywords: Amphidromous goby, condition factor, growth pattern, Penja, West Sulawesi

INTRODUCTION

The length-weight relationship of fish is widely used in sustainable fisheries management (Masoumi et al. 2021), specifically in the 20th century (Purrafee-Dizaj et al. 2020; Masoumi et al. 2021). Long-term relationships too this is an important parameter adopted for various purposes such as estimating biomass, assessing environmental impacts and population dynamics (Tran et al. 2020), comparing and describing the characteristics of fish populations between species, sexes, and seasons, as well as monitoring changes in condition relative throughout the year (Aini et al. 2020).

The origin condition factor was first introduced by biological scientists by Ricker (1975) and appeared to be associated with certain fisheries biologists who referred to maritime law (Nash and Geffen 2006). Furthermore, F Heincke in the Heincke laboratory (1908), Helgoland uses K (often known as a factor of Fulton conditions) as an indicator of fish conditions for the first time. The condition factor is an index commonly used in fish biology research (Sunarni et al. 2019; Panicker and Katchi 2021). This can also indicate fish growth in a water region, measuring environmental suitability and comparing the conditions of various habitats (Aini et al. 2020). A higher condition factor value shows a better match between fish and the environment (Sunarni et al. 2019).

The threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) is an amphidromous species divided into two groups, namely freshwater and marine habitats with brackish water, which are prevalent in tropical and subtropical waters (Keith et al. 2012; Hasan et al. 2021; Simanjuntak et al. 2021). Primarily found in swift-moving freshwater streams with substrates of gravel, rock, and sand (Keith et al. 2017). However, nothing is known about their life history (Chen et al. 2001; Maeda et al. 2017). Freshwater amphidromous fish spend the most time in freshwater but spawn and lay eggs on rocky substrates in strong river currents several of the species in this group were amphidromous larvae that lived in the sea (Keith 2003; McDowall 2007; Teichert et al. 2013; Ndobe et al. 2022). It is believed that the plantonic phase, which lasts between 91 to 265 days, has a significant role in understanding temporal and spatial patterns of dispersal (Yamasaki and Tachihara 2006; Taillebois et al. 2014). River currents carry fish eggs, and the embryos hatch into larvae before reaching estuaries and spend their lanthonic life in sea waters (McDowall 2007; Valade et al. 2009; Gani et al. 2020). Subsequently, the postlarval threadfin goby returns to freshwater, serving as the original habitat. These postlarval fish are known as 'penja,' which are economically valuable consumption fish and are heavily caught by fishermen (Nurjirana et al. 2021, 2022a). Adult goby fish spend time in the upstream flowing rivers and adapt to the habitat due to unique patterns, which include climbing rocks with a ventral sucker formed by the fusion of pelvic fins (Keith and Lord 2011; Keith et al. 2011). The ventral sucker is located on the abdomen and is used as a method of attachment to rocky substrates, allowing the fish to move against strong currents upriver (Keith 2003; Lord et al. 2019). A group of threadfin goby in West Sulawesi can be found in large rivers with strong currents throughout the year; during each month, a large migration pattern is seen from the dark moon to the new moon phase. On the other hand, monthly observations of small-scale fish circulation are also made (Nurjirana et al. 2022b, 2023). Threadfin gobies are listed on the worldwide Union for Conservation of Nature's (IUCN) red list under the low category species (Least Concern).

Research on the length-weight relationship has been conducted in West Sulawesi but remains limited to a few species and locations. This has also been conducted on fish from the genus *Sicyopterus* in Karama River, Mamuju Regency, West Sulawesi, as well as *S. zosterophorus* in Bohi River, Central Sulawesi (Gani et al. 2020). Recent related research is still limited to the identification of freshwater goby (Gani et al. 2019), morphometric and meristic research (Sahami et al. 2020), DNA Barcoding of postlarval amphidromous goby (Nurjirana et al. 2021), postlarval migration (Nurjirana et al. 2022b), mitochondrial and morphological research (Astuti et al. 2022).

The fish distribution is extensive, but the population has declined recently. Several rivers in Majene and Polewali Mandar Regency, including Mandar River, which used to be habitats for threadfin goby, are now difficult to find. This shows excessive fishing activities, which have led to population degradation and even species extinction. Catching threadfin goby larvae at the mouth of the Mandar River has become a routine for coastal communities. This fishing occurs monthly during the dark moon phase when threadfin goby larvae migrate to the river. Post larvae of the threadfin goby fish (*Sicyopterus longifilis*) are called penja fish by the people of West Sulawesi. Some contributing factors include using environmentally unfriendly fishing gear (non-selective) and unregulated fishing.

The threadfin goby which lives in the Ummiding and Matama Rivers, is in danger of extinction. This is because of post-catching activities involving threadfin goby larvae and detergent waste that locals use to wash in the rivers, which can lower the water quality and negatively affect the fish. Information about the biology of fish in these two rivers is therefore necessary. This research analyzes threadfin goby's length-weight relationship and condition factor in Ummiding and Matama Rivers. The biological aspect of the fish can serve as a basis for domestication efforts, determining conservation areas for habitat protection, and sustainable fishing management.

MATERIALS AND METHODS

This research was conducted in Ummiding River (3°23'46" S, 118°59'14" E) and Matama River (3°23'19" S, 118°59'51" E) located in the Alu Sub-district, Polewali Mandar District, West Sulawesi Province, Indonesia. Both are tributaries of the Mandar River and empty into this river. (Figure 1). Fish sampling was conducted twice monthly during the full moon and dark moon lunar phases from July to December 2023, and the sampling stations had different habitat characteristics. The Ummiding River has a width of 20 m and a depth of 5.2 m, with a substrate dominated by large and small rocks and sand. In contrast, Matama River has a width and depth of 43 and 7.8 m, with a substrate dominated by small rocks, sand, and mud.

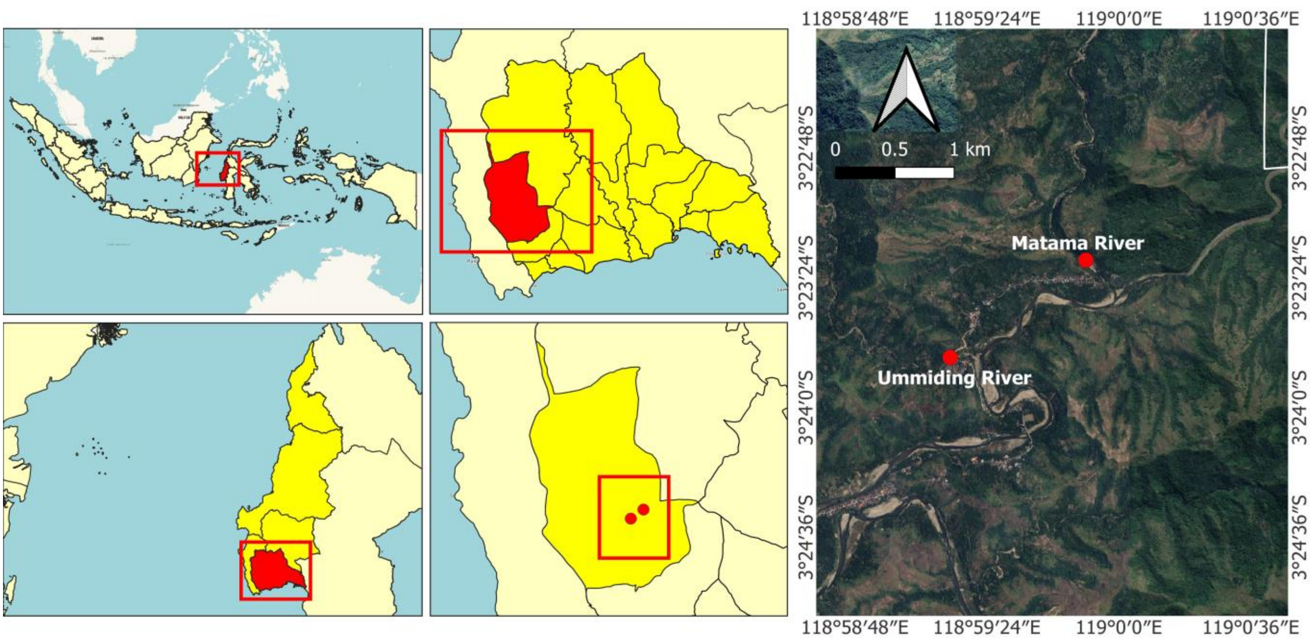

Figure 1. Fish sampling site at Ummiding and Matama Rivers, Alu Sub-district, Polewali Mandar District, West Sulawesi Province, Indonesia

Fish sampling was conducted by operators using a 12-volt, 9-amp electric shocker and a zig-zag pattern opposite the river current over 200 m for 30 minutes. Therefore, to preserve the samples and prevent damage, the caught fish were first cleaned and placed in a container filled with 10% formalin. The material is then transferred to the laboratory for further examination. Sample analysis was conducted at the Fisheries Department Laboratory, Technical Implementation Unit Integrated Laboratory, University of Sulawesi Barat. The fish were counted and placed in 1000 mL bottles containing 10% formalin labeled with the location and collection date. After 24 hours, the fish were thoroughly rinsed with running water and transferred to containers containing 70% alcohol before placing the samples on a dissecting board. Subsequently, the total length was measured using a digital caliper with a precision of 0.01 mm from the mouth's front tip of the mouth to the rear part of the tail. The fish samples were weighed using a digital scale with a precision of 0.001 g and dissected to determine the sex.

Data analysis

Length-weight relationship

The length-weight relationship of fish is conducted to determine the growth pattern of fish (Gani et al. 2020; Ningsih et al. 2023). The relationship is analyzed and determined using the following formula (Omar et al. 2020; Ningsih et al. 2023): $W = a L^b$, where W is the body weight (g), L is the total length (mm), a is the intercept, and b is the slope (regression coefficient). This equation is transformed into logarithmic form to obtain a linear equation: log W = log a + b log L. The values a (intercept), b (regression coefficient), and r (correlation coefficient) are obtained through the least square method (Omar et al. 2020). Growth patterns in fish consist of two types, namely isometric (b = 3) and allometric (b ≠ 3) growths when the increase in length and weight is balanced and unbalanced, respectively (Ningsih et al. 2023). The fish growth is positively allometric or hyperallometric when b>3; hence, the increase in weight is greater than the length. In contrast, when b<3, the fish growth is negatively allometric or hypoallometric; hence, the increase in length is more dominant than weight (Omar et al. 2020). Therefore, to determine the isometric or allometric nature of the length-weight relationship pattern, the test is conducted on the value of b using the following formula (Omar et al. 2020):

$$t_{value} = \left| \frac{3-b}{Sb} \right|$$

Where: S_b is the standard error of 'b' and the $t_{value} > t_{table}$ when b is different from 3. Conversely, when $t_{value} < t_{table}$, b equals 3.

A test is conducted according to Ningsih et al. (2023) to compare the coefficient b between male and female fish with the following formula:

$$t_{value} = \frac{(b_1 - b_2)}{SE_{(b1-b2)}}$$

$$SE_{(b1-b2)} = \sqrt{(S_{b1})^2 + (S_{b2})^2}$$

Where:

b_1 and b_2 : Female and male fish regression coefficients

SE_{b1} and SE_{b2}: Standard error of female and male fish regression coefficients

The length-weight relationship of female and male fish is not significantly different when the $t_{value} < t_{table}$. Therefore, the data are combined to determine the length-weight relationship of combined male and female fish, compare the length-weight relationship of fish based on sampling locations, and look at differences based on the dark and light moon phases at the two locations. The conclusion is that the length-weight relationship significantly differs when the $t_{value} > t_{table}$. Regression analysis (r) and determinant coefficient (R2) were used to determine the relationship between fish length and weight. The total length and body weight data are analyzed using Microsoft Excel version 2018.

Condition factor

The condition factor can be determined by measuring the length and weighing the fish (Lanzoni et al. 2018; Amin and Sabrah 2019). If the fish growth is isometric, then the formula used to calculate the condition factor is (Omar et al. 2020): $PI = 10^5 W / L^3$, where PI is the condition factor (ponderal index), W is the mean body weight in a given size class (g), and L is the mean total length in the same size class (mm). When growth follows a hypoallometric or hyperallometric pattern, then the condition factor formula used is (Ricker 1975; Omar et al. 2020): $PI_n = Wb/W^*$, where Wb = The observed mass of an individual (g) and W* = The theoretical weight of an individual of a given length. This is obtained from the linear regression of the length-weight relationship of the respective population sample (aL^b) in g. Furthermore, t-tests were conducted to determine the difference in condition factors between male and female fish and the dark and full moon lunar phases in Ummiding and Matama Rivers using Microsoft Excel version 2018.

RESULTS AND DISCUSSION

Specifically, the Ummiding and Matama rivers are tributaries of the Mandar River in Pao-Pao Village which is located in the geographical area to the north, east, west and south of Majene Regency, as well as to the north of Tubbi Taramanu District. The two rivers are geographically located in the same area. Even though they are close together, there is no small river flow that connects the two rivers at different points. While the Ummiding River is vulnerable to drought throughout the dry season, the Matama River runs quickly and never experiences it.

The threadfin goby has a fusiform and elongated body shape with a whitish brown color and has 7-8 black bands on ITS body. There is a black triangle at the posterior end of the mouth. The caudal fin measures approximately 1.44-23.31, pale to gray in color and rounded. The pectoral fins are black with a white band at the tip. Threadfin gobies have two dorsal fins consisting of the first dorsal fin numbering from 5-6 hard fin rays, the second fin having

11-12 weak fin rays, the pelvic fin numbering from 11-12 weak fin rays, pectoral fin rays number 14-19 weak fin rays, anal fin rays 10-11, tail fin rays number 11-19 segments, scales on the lateral line 60-98, scales above the lateral line 10-21, scales below the lateral line 15-28, scales on the caudal peduncle 11-18.

The threadfin goby samples comprised 2,273 individuals, with 1,515 and 758 collected from the Ummiding and Matama Rivers. The number of male and female fish obtained in Ummiding River was 611 and 904 individuals, with a total length range of 21.29-79.08 mm and 19.60-75.15 mm, as well as body weight of 0.030-5.900 g and 0.058-4.863 g, respectively. In Matama River, 281 and 477 male and female fish were obtained, with a total length range of 24.01-95.28 mm and 23.91-127.49, as well as a body weight range of 0.049-9.656 g and 0.046-26.410 g, respectively. Statistically, there was no significant difference ($p>0.05$) in the total length and body weight of male and female fish in the Ummiding and Matama Rivers. At these two locations, more female fish than male fish were captured. However, the body weights and lengths of the male and female fish at both sites varied (Table 1).

The number of threadfin goby samples obtained during the new lunar phase was higher in the Ummiding River. During the new and full lunar phase, the number of captured fish was 763 and 752 individuals, respectively. In Matama River, the number of fish caught during the new and full lunar phase was 316 and 442 individuals, respectively. The range and mean total length and body weight of the species found in the Ummiding and Matama Rivers based on the lunar phase can be seen in Table 2.

Figure 2. Threadfin goby *Sicyopterus longifilis* (de Beauford, 1912)

Table 1. Based on sampling location, the range and mean total length and body weight of male and female threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912)

Sampling location	Sex	n	Total length (mm)		Body weight (g)	
			Range	Mean±SE	Range	Mean±SE
Ummiding River	M	611	21.29-79.08	44.93±0.44	0.030-5.900	1.304±0.038
	F	904	19.60-75.15	49.53±1.51	0.058-4.863	1.324±0.044
	C	-	-	-	-	-
Matama River	M	281	24.01-95.28	57.61±0.98	0.049-9.656	3.062±0.136
	F	477	23.91-127.49	56.94±0.82	0.046-26.410	3.310±0.171
	C	758	23.91-127.49	57.19±0.63	0.046-26.410	3.218±0.119

Note: M: Male fish, F: Female fish, C: Combined sexes (male and female), n: Number of fish (ind.), SE: Standard Error of the mean, -: Data combination not performed because statistical analysis results indicate significantly different regression coefficients for male and female fish

Table 2. Range and mean total length and body weight of male and female threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) based on lunar phase

Sampling location	Lunar phase	Sex	n	Total length (mm)		Body weight (g)	
				Range	Mean±SE	Range	Mean±SE
Ummiding River	New lunar	M	342	21.29-79.08	42.90±0.58	0.030-6.250	1.133±0.050
		F	421	19.60-70.60	44.07±0.45	0.058-4.014	1.176±0.037
		C	763	19.60-70.60	43.55±0.36	0.030-6.250	1.157±0.030
	Full lunar	M	269	25.37-78.86	47.51±0.63	0.109-5.900	1.532±0.057
		F	483	21.96-75.15	46.79±0.99	0.209-4.863	1.455±0.016
		C	-	-	-	-	-
Matama River	New lunar	M	98	24.01-83.56	52.22±1.44	0.152-7.803	2.231±0.180
		F	218	23.91-88.07	55.59±0.95	0.054-9.109	2.733±0.143
		C	-	-	-	-	-
	Full lunar	M	183	24.49-95.28	60.51±1.24	0.049-9.656	3.507±0.176
		F	259	24.07-127.49	58.07±1.28	0.046-26.410	3.745±0.287
		C	442	24.07-127.49	59.08±0.91	0.046-26.410	3.676±0.183

Note: M: Male fish, F: Female fish, C: Combined sexes (male and female), n: Number of fish (ind.), SE: Standard Error of the mean, -: Data combination not performed because statistical analysis results indicate significantly different regression coefficients for male and female fish

The total length and body weight of male and female fish during the new and full lunar phases in the Ummiding and Matama Rivers did not show significant differences ($p>0.05$). However, a significant difference in body weight was shown in the Matama River during the new lunar phase ($p<0.05$). The total length and body weight between male and female fish in the Rivers showed significant differences ($p<0.05$) during the new and full lunar phases.

The length-weight relationship of male and female threadfin goby in Ummiding River follows the equation $W = 0.000011 L^{3.0250}$ and $W = 0.000023 L^{2.8422}$, respectively. Based on the regression coefficient (b) statistical analysis, male and female fish show isometric and negative allometric or hypoallometric growth. Further regression coefficient analysis obtained significantly different results ($p<0.05$) since there was no data combination, and the length-weight relationship graph is presented in Figure 2. The regression equations for male and female fish in Matama River are $W = 0.000008 L^{3.1193}$ and $W = 0.000005 L^{3.2228}$, respectively. The statistical analysis of the regression coefficient showed no significant differences ($p>0.05$). Therefore, a data combination was performed, obtaining a regression equation of $W = 0.000006 L^{3.1839}$. Based on the statistical analysis, male, female, and combined genders showed positive allometric or hypoallometric growth. Figure 3 reports the length-weight relationship graph of male, female, and combined genders threadfin goby in the Matama River.

The length-weight relationship of male and female threadfin goby in Ummiding and Matama Rivers can be seen in Table 4. The growth type during the new and full lunar phase in Ummiding and Matama River is entirely isometric and hypoallometric, respectively. Further statistical analysis of the regression coefficient resulted in significantly different results ($p<0.05$) since no data was collected on the combination of both genders.

During the lunar phase and in both locations, more female threadfin goby fish were recovered than male fish. This shows a close relationship between the increase in body weight and total length. The coefficient of determination values obtained are also high to very high, ranging from 0.9011-0.9022 and 0.9406-0.9574 in Ummiding and Matama Rivers, respectively. Based on the lunar phase, the coefficient of determination values range from 0.8662-0.9522 and 0.9270-0.9740, respectively.

According to findings from studies on threadfin goby condition factors in Ummiding River, this variable ranges from 0.0812-2.3800 (1.2291±0.0093) and 0.0990-2.3533 (1.0186±0.0339) for male and female fish, respectively. In Matama River, the male and female fish have a condition factor values ranging from 0.1012-2.3472 (0.9994±0.1284) and 0.1126-2.0899 (1.0780±0.0088), as well as a combined gender value of 0.1053-2.4711 (1.0217±0.0074). The values obtained based on the lunar phase range from 0.0812-3.2316 and 0.3602-2.7996 in Ummiding and Matama Rivers, respectively.

The condition factor values of male and female fish in the Ummiding and Matama Rivers differ significantly ($p<0.05$). The results show that the condition factors between the rivers are also significantly different ($P<0.05$) but not significantly different ($P>0.05$) during the new lunar phase. In Ummiding River, this variable is significantly different ($P<0.05$) but not significantly different ($P>0.05$) in Matama River during the full lunar phase.

Discussion

The number of female threadfin goby obtained was higher during both locations' new and full lunar phases. This threadfin goby is a phytobenthic eater as a food source. Phytobenthic-eating gobiid fish grind hard substrates at the bottom of the water to obtain attached phytobenthic fish (Gerking 1994).

Maturbongs et al. (2020) found the opposite in *Kurtus gulliveri* in the Maro River, Merauke, Indonesia, where they found the opposite, from what we found, that the number of male fish was greater than that of female fish. Male and female fish caught during the full moon had larger total lengths and body weights than those during the new moon phase. These findings are consistent with Purayil et al. (2024) on *Acanthopagrus berda* in India, which showed 31.00±7.38 cm and 21.58±2.47 cm sizes during the full and new lunar, respectively. The largest male and female goby fish in West Sulawesi were 95.28 mm and 127.49 mm, respectively. Allen (1991) stated that the species in New Guinea could reach a maximum length of 75 mm SL or equivalent to 96 mm TL. Meanwhile, Maeda and Saeki (2018) reported that goby fish in Japan had a 74.7 mm SL or 95.6 mm TL length.

Table 3. The parameter of the total length-body weight relationship of male and female threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) is based on sampling location

Sampling location	Sex	n	Length-weight regression parameters				Growth type
			a	b	R^2	r	
Ummiding River	M	611	0.000011	3.0250	0.9011	0.9493	Isometric
	F	904	0.000023	2.8422	0.9022	0.9497	Hypoallometric
	C	-	-	-	-	-	-
Matama River	M	281	0.000008	3.1193	0.9406	0.9698	Hyperallometric
	F	477	0.000005	3.2228	0.9574	0.9785	Hyperallometric
	C	758	0.000006	3.1839	0.9510	0.9752	Hyperallometric

Note: M: Male fish, F: Female fish, C: Combined sexes (male and female), n: Number of fish (ind.), a: Intercept, b: Slope (regression coefficient), R^2: Coefficient of determination, r: Correlation coefficient, -: Data combination not performed because statistical analysis results indicate significantly different regression coefficients for male and female fish

Table 4. Parameter of the total length-body weight relationship of threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) male and female based on sampling location

Sampling location	Lunar phase	Sex	n	Length-weight regression parameters				Growth type
				a	b	R^2	r	
Ummiding River	New lunar	M	342	0.000010	3.0433	0.8662	0.9307	Isometric
		F	421	0.000017	2.9110	0.8862	0.9414	Isometric
		C	763	0.000013	2.9846	0.8755	0.9357	Isometric
	Full lunar	M	269	0.000016	2.9415	0.9522	0.9758	Isometric
		F	483	0.000035	2.7358	0.9197	0.9590	Hypoallometric
		C	-	-	-	-	-	-
Matama River	New lunar	M	98	0.000013	3.0003	0.9728	0.9863	Isometric
		F	218	0.000006	3.1951	0.9740	0.9869	Hyperallometric
		C	-	-	-	-	-	-
	Full lunar	M	183	0.000006	3.1849	0.9270	0.9628	Hyperallometric
		F	259	0.000005	3.2357	0.9500	0.9747	Hyperallometric
		C	442	0.000005	3.2117	0.9415	0.9703	Hyperallometric

Note: M: Male fish, F: Female fish, C: Combined sexes (male and female), n: Number of fish (ind.), a: Intercept, b: Slope (regression coefficient), R^2: Coefficient of determination, r: Correlation coefficient, -: Data combination not performed because statistical analysis results indicate significantly different regression coefficients for male and female fish

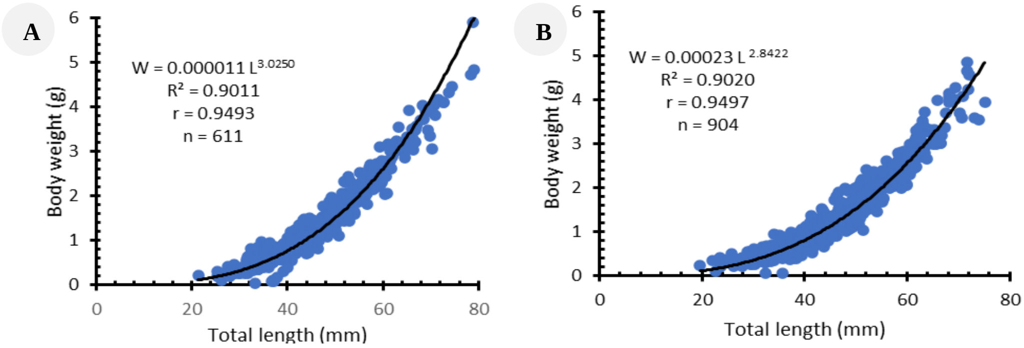

Figure 3. Graph the length-weight relationship of threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) A. Male; and B. Female in Ummiding River

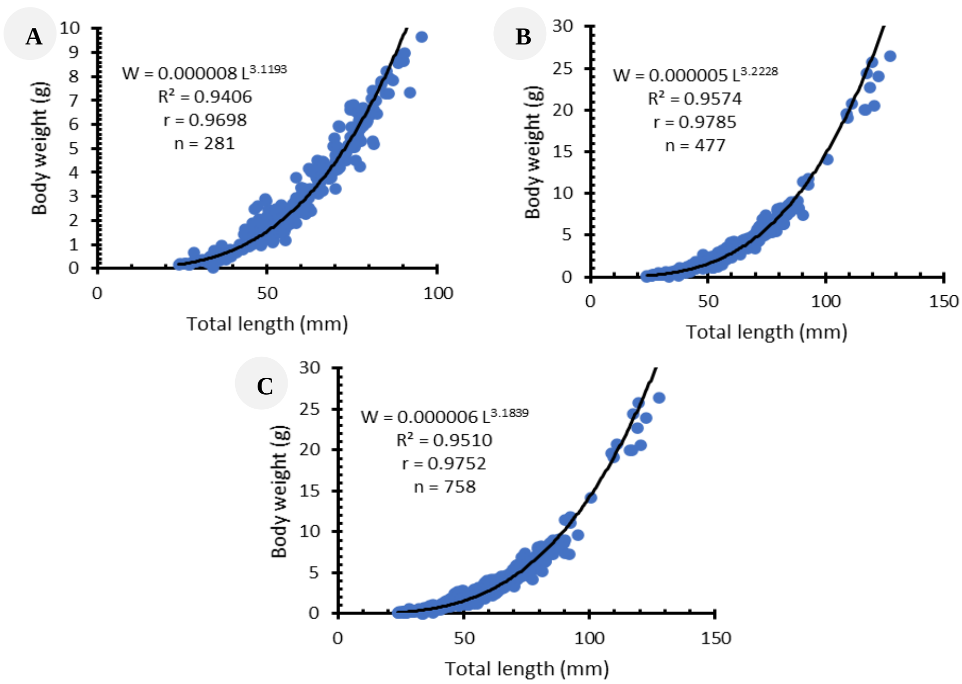

Figure 4. Graph of the length-weight relationship of threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912). A. Male; B. Female; and C. Combined male and female in Matama River

The differences in the size ranges of length and weight at different times and places can be caused by several factors, such as variation in habitat and food availability, environment, season, age, size at first gonad maturity, spawning, and riparian vegetation (Nur et al. 2023). The riparian areas of the Ummiding River are dominated by agricultural such as cocoa plants (*Theobroma cacao*), gamal (*Gliricidiasepium*) and banana plants (*Musa paradisiaca*), and bamboo (Bambusoideae), fields resulting in low fish food availability. In contrast, the Matama River, which is more extensive, has riparian areas dominated by primary forests, leading to greater availability of food, specifically plankton and detritus. This river has abundant water sources and does not dry up during the dry season, ensuring a continuous water flow.

The regression coefficient value of male fish is larger than females in Ummiding River, while the value of female fish is larger in Matama River. Furthermore, the values of male fish are greater than females in the Ummiding River during the new and full lunar phases. In the Matama River, female fish have larger b values than males, as shown in Tables 3 and 4. The growth pattern can be observed from the b values and is influenced by differences in age, gonad development, and gender (Suwarni et al. 2022). Based on the result, the growth type of threadfin goby tends to be isometric in the Ummiding River but hyperallometric or positive allometric in the Matama River. Isometric growth shows that the rate of body length increase is equal to body weight. In contrast, hyperallometric growth reports that the rate of body length increase is slower than the body weight. The hypoallometric or negative allometric growth type was found in female fish in the Ummiding River, showing that the rate of body length increase is faster than the weight. Differences in growth patterns can vary within the same species living in different habitats and can also differ between male and female fish. This occurs due to differences in the observed sample sizes, times, habitat influences, seasons, food availability, spawning times, and fishing pressures. The b coefficient values can also be influenced by several factors including species, gender, gonad maturation level, season, and habitat (Septyowati 2019; Eagderi et al. 2020; Esmaeili et al. 2020; Omar et al. 2020; Purrafee Dizaj et al. 2020; Al Jufaili et al. 2021; Masoumi et al. 2021; Mouludi-Saleh et al. 2021; Situmorang et al. 2021; Masoumi et al. 2023) and further reported by (Jirs et al. 2018; Muthiadin et al. 2020), the values are also affected by physiological and environmental conditions such as climate change, conductivity, geographic location, temperature, dissolved oxygen, and sampling techniques. Furthermore, the b values vary between species and within the same stocks (Omar et al. 2020). The differences in length-weight relationships in Ummiding and Matama Rivers can be attributed to internal and external factors at both locations. The isometric and hyperallometric growth types in West Sulawesi are also found in other species of threadfin goby, as seen in Table 6.

The correlation coefficient values r for male and female threadfin goby during the new and full lunar phases are close to 1.0, ranging from 0.9307 to 0.9869. This shows a high correlation and relationship between total length and body weight. Similarly, the coefficient of determination values r^2 are greater than 0.90, except during the new lunar phase in the Ummiding River; increased values of the variable show good predictive power and small data dispersion. According to Hanif et al. (2020), ideal fish growth has a coefficient of determination R^2 ranging between 0.9 and 1.0. The low number of individuals and the limited range of fish sizes can affect the value of R^2 (Purrafee Dizaj et al. 2020).

The mean values of the condition factor during the new and full lunar phases are all greater than 1.0, as shown in Table 5. Therefore, the fish in both locations were in good condition during the research. Conditions, however, can vary at the same place and various periods. The results were consistent with Maturbongs et al. (2020) on *K. gulliveri* in the Maro River, Merauke, where the mean of condition factor values was greater than 1.0 during the new and full lunar phases. According to Lloret-Lloret et al. (2022), the fish individuals are in good condition when the condition factor value (PI) exceeds 1.0. A PI value >1.0 shows the suitability of the water environment conditions for fish growth (Mouludi-Saleh and Eagderi 2019; Mouludi-Saleh et al. 2021).

Table 5. Based on sampling location and lunar phase, condition factor values of threadfin goby (*Sicyopterus longifilis* de Beaufort, 1912) are male and female

Sampling location	Sex	n	New lunar		n	Full lunar	
			Range	Mean±SE		Range	Mean±SE
Ummiding River	M	342	0.0812-2.3800	1.2009±0.0136	269	0.6033-1.9802	1.2680±0.0117
	F	421	0.1273-3.2316	1.2284±0.0125	483	0.5279-2.0819	1.0145±0.0947
	C	763	0.0812-3.2316	1.2161±0.0092	-	-	-
Matama River	M	98	1.0019-2.7996	1.2812±0.0219	183	0.1087-2.0630	1.0344±0.0194
	F	218	0.3602-1.8740	1.0088±0.0090	259	0.1068-1.9741	1.0270±0.0132
	C	-	-	-	442	0.1074-2.0211	1.0303±0.0111

Note: M: Male fish, F: Female fish, C: Combined sexes (male and female), n: Number of fish (ind.), SE: Standard Error of the mean, -: Data combination not performed because statistical analysis results indicate significantly different regression coefficients for male and female fish

Table 6. Length-weight relationship coefficients and growth pattern of gobi species from several locations

Species	Location	Sex	n	Regression parameters a	b	R^2	Growth type	References
Acentrogobius caninus	Pabean Bay, Indonesia	C	152	0.000009	3.0356	0.8336	Isometric	Syafei (2021)
Acentrogobius cyanomos	Pulicat lagoon, India	C	18	0.0199	2.693	0.930	Hypoallometric	Nallathambi et al. (2020)
Acentrogobius dayi	Iran	M	52	0.010	2.860	0.939	Hypoallometric	Sadeghi and Esmaeili (2018)
		F	67	0.010	2.897	0.934	Hypoallometric	
		C	119	0.010	2.871	0.933	Hypoallometric	
Acentrogobius moloanus	Red River, Vietnam	C	36	0.003	3.408	0.801	Hyperallometric	Tran et al. (2021)
Acentrogobius virdipunctatus	Red River, Vietnam	C	109	0.008	3.164	0.975	Hyperallometric	Tran et al. (2021)
Apocryptodon madurensis	Red River, Vietnam	C	188	0.005	3.266	0.888	Hyperallometric	Tran et al. (2021)
Arcygobius baliurus	Pulicat lagoon, India	C	69	0.0144	2.847	0.880	Hypoallometric	Nallathambi et al. (2020)
Aulopareia unicolor	Red River, Vietnam	C	196	0.004	3.451	0.910	Hyperallometric	Tran et al. (2021)
Awaous jayakari	Muscat, Oman	M	5	0.002183	3.723	0.985	Hyperallometric	Masoumi et al. (2021)
		F	19	0.0052	3.282	0.970	Hyperallometric	
Babka gymnotrachelus	Danube River, Serbia	C	40	0.009	3.05	0.83	Hyperallometric	Krpo-Ćetković et al. (2018)
Bathygobius meggitti	Iran	M	79	0.013	2.961	0.967	Isometric	Sadeghi and Esmaeili (2018)
		F	122	0.010	3.120	0.951	Hyperallometric	
		C	201	0.011	3.041	0.958	Isometric	
Chaenogobius gulosus	South-eastern Korea	M	178	0.0085	3.151	0.987	Hyperallometric	Park and Jeong (2020)
		F	152	0.0086	3.157	0.989	Hyperallometric	
		C	330	0.0086	3.155	0.990	Hyperallometric	
Cryptocentroides arabicus	Iran	M	155	0.011	2.704	0.957	Hypoallometric	Sadeghi and Esmaeili (2018)
		F	178	0.012	2.697	0.955	Hypoallometric	
		C	333	0.011	2.702	0.950	Hypoallometric	
Favonigobius reicheri	Pulicat Lagoon, India	C	44	0.0041	3.538	0.984	Hyperallometric	Nallathambi et al. (2020)
Glossogobius giuris	Mekong Delta, Vietnam	M	297	0.009	2.94	0.95	Isometric	Phan et al. (2021)
		F	363	0.007	3.06	0.93	Isometric	
	Red River, Vietnam	C	270	0.009	2.909	0.966	Hypoallometric	Tran et al. (2021)
	Lake Lapompakka, Indonesia	M	153	0.0001	2.4667	0.9600	Hypoallometric	Suwarni et al. (2022)
		F	59	0.0001	2.3770	0.9175	Hypoallometric	
Glossogobius olivaceus	Red River, Vietnam	M	334	0.005	3.276	0.93	Hyperallometric	Ta et al. (2022)
		F	345	0.005	3.300	0.95	Hyperallometric	
		C	679	0.005	3.285	0.95	Hyperallometric	
Glossogobius sirkumspelitus	Pabean Bay, Indonesia	C	29	0.0247	2.4919	0.7225	Hypoallometric	Syafei et al. (2022)
Glossogobius sparsipapilus	Bassac River, Vietnam	M	408	0.016	2.70	0.924	Hypoallometric	Truong et al. (2021)
		F	356	0.017	2.69	0.916	Hypoallometric	
Gobiopsis macrostoma	Red River, Vietnam	C	56	0.005	3.391	0.934	Hyperallometric	Tran et al. (2021)
Neogobius caspius	Southern Caspian Sea, Iran	C	102	0.032	2.47	0.831	Hypoallometric	Nikmehr et al. (2021)
Neogobius fluviatilis	Danube River, Serbia	C	37	0.004	3.24	0.93	Hyperallometric	Krpo-Ćetković et al. (2018)
Neogobius melanostomus	Danube River, Serbia	C	115	0.005	3.41	0.98	Hyperallometric	Krpo-Ćetković et al. (2018)
Neogobius pallasi	Southern Caspian Sea, Iran	C	178	0.003	3.45	0.902	Hyperallometric	Nikmehr et al. (2021)
Oxyurichthys microlepis	Pulicat Lagoon, India	C	370	0.0106	2.677	0.834	Hypoallometric	Nallathambi et al. (2020)
Oxyurichthys omanensis	Arabian Peninsula, Oman	C	23	0.00387	3.128	0.939	Hyperallometric	Masoumi et al. (2023)
Paracheaturichthys ocellatus	Mumbai, India	M	685	0.000015	2.9159	0.9790	Hypoallometric	Panicker and Katchi (2021)
		F	489	0.000044	2.7216	0.9400	Hypoallometric	
Ponticula bathybius	Southern Caspian Sea, Iran	C	165	0.003	3.32	0.988	Hyperallometric	Nikmehr et al. (2021)
Proteorhinus nasalis	The Anzali Wetland, Iran	C	25	0.0027	3.04	0.97	Isometric	Heidari et al. (2018)
Rhinogobius similis	Pasikhan Stream, Iran	C	30	0.0131	2.99	0.95	Isometric	Heidari et al. (2018)
	Bacme Reservoir, Vietnam	C	195	0.005	3.257	0.826	Hyperallometric	Ha et al. (2022)
	Hoabinh Reservoir, Vietnam	C	349	0.005	3.330	0.858	Hyperallometric	
	Lak Lake, Vietnam	C	638	0.010	3.025	0.913	Isometric	
	Red River, Vietnam	C	1326	0.007	3.131	0.921	Hyperallometric	
Sicyopterus longifilis	Kalumpang, Indonesia	C	13	0.000014	3.0037	0.9606	Isometric	Muthiadin et al. (2020)
	Bonehau, Indonesia	C	15	0.000070	2.6107	0.8948	Hypoallometric	
	Arassi, Indonesia	C	17	0.000023	2.8884	0.8179	Hypoallometric	
	Kalonding, Indonesia	C	17	0.000149	2.4685	0.8551	Hypoallometric	
Sicyopus zosterophorus	Bohi River, Indonesia	M	34	0.000055	2.607	0.8281	Hypoallometric	Gani et al. (2020)
		F	21	0.003	1.546	0.2401	Hypoallometric	
Yongeichthys criniger	Pulicat lagoon, India	C	65	0.0074	3.235	0.942	Hyperallometric	Nallathambi et al. (2020)

Note: n: Number of fish (ind), F: Female, M: Male, C: Combined sexes (male and female), a: Intercept, b: Slope (regression coefficient), R^2: Coefficient of determination

Table 7. Condition factor of gobi species from several locations

Species	Locations	Sex	Condition factor	References
Acentrogobius caninus	Pabean Bay, Indonesia	C	0.798-1.322	Syafei (2021)
Babka gymnotrachelus	Danube River, Serbia	C	0.97	Krpo-Ćetković et al. (2018)
Glossogobius giuris	Mekong Delta, Vietnam	M	0.99±0.01	Phan et al. (2021)
		F	1.02±0.01	
	Lake Lapompakka, Indonesia	M	0.6369-1.6753	Suwarni et al. (2022)
		F	0.7605-1.2513	
Glossogobius sirkumspelitus	Pabean Bay, Indonesia	C	1.074	Syafei et al. (2022)
Glossogobius sparsipapilus	Bassac River, Vietnam	M	0.97±0.01	Truong et al. (2021)
		F	0.98±0.01	
		C	0.89-1.10	
Neogobius fluviatilis	Danube River, Serbia	C	0.67	Krpo-Ćetković et al. (2018)
Neogobius melanostomus	Danube River, Serbia	C	1.18	Krpo-Ćetković et al. (2018)
Sicyopterus longifilis	Kalumpang, Indonesia	C	1.997	Muthiadin et al. (2020)
	Bonehau, Indonesia	C	1.974	
	Arassi, Indonesia	C	2.134	
	Kalonding, Indonesia	C	2.282	
Sicyopus zosterophorus	Bohi River, Indonesia	M	0.76-1.41	Gani et al. (2020)
		F	0.64-1.43	

Note: F: Female, M: Male, C: Combined sexes (male and female)

Table 5 presents spatial and temporal variations in the condition factor, which can be associated with biotic and abiotic environmental conditions. Biotic factors (living creatures) where at this location there are several types of goby fish from the Eleotridae, Butidae and Gobiidae families as well as several other species such as eels, tilapia, snakehead fish, shrimp and crabs. The abiotic factors found at this location consist of large rocks, small rocks, sand, gravel, water substrate, and wind and oxygen, light which greatly influence the life of organisms in the water. Other factors can influence differences in condition values, including sex, abundance of organisms in the aquatic environment, food availability, gonad weight, size, and water quality parameters (Zuh et al. 2019; Nur et al. 2020; Omar et al. 2020; Nasyrah et al. 2021).

Meanwhile, the condition factor values of other threadfin goby species can be seen in Table 7. The condition factor at the two places in question can also be influenced by species-specific behaviors or the presence of other species in addition to environmental factors. Since there hasn't been any research on condition variables specifically for the threadfin goby type, condition factors for other goby fish species were compared (Table 7). The table shows that *S. longifilis* caught in the Ummiding and Matama Rivers had condition factor values that were not too different from other reported results.

The length-weight relationship between fish is one of the complimentary sets of information used in fisheries biology to evaluate fishing gear selectivity in fish management and conservation. Producing fish captures that correspond to the size of fish that are appropriate for catching is the primary objective.

According to this research, the threadfin goby fish populations in the Ummiding and Matama rivers can be utilized as a sign that the fish populations in both rivers have started to fall recently. When this fish reaches its adult stage, it migrates from the sea to rivers where it will grow and spawn. During its larval stage, the fish lives in sea waters as plankton. The society has long exploited the larvae of threadfin goby fish as a source of meal fish. West Sulawesi people, particularly the Mandar tribe, frequently turn threadfin fish larvae into processed foods including pepes fish, dried fish, and penja chili sauce.The study could consider collecting and analyzing data on water temperature, pollution levels, and other relevant environmental factors that may affect the fish population to address the potential impact of environmental factors on the length-weight relationship and condition factor of threadfin goby in Ummiding and Matama Rivers in West Sulawesi. The study could also look into the impact of fishing practices on the threadfin goby population and their length-weight relationship and condition factor in these rivers.

To address concerns about the sample size and sampling method used in the study, researchers could consider expanding the sample size or using a different sampling method to obtain a more representative sample. They could also acknowledge the limitations of their study and note that their findings may not necessarily apply to all rivers in West Sulawesi. By doing so, they can help mitigate potential criticism and ensure that their research is viewed as credible and reliable.

In conclusion, the growth pattern in Ummiding River during the new and full lunar phase was isometric and hypoallometric in male and female threadfin goby, respectively. Conversely, in Matama River, hyperallometric and isometric growths were observed during the full and new lunar phases in male and female threadfin goby. The condition factor of female fish in the Ummiding River was higher during the new lunar phase than males. In Matama River, the male fish had a higher condition factor than females during the new and full lunar phases. This research provided basic information on the length-weight relationship and condition factor of threadfin goby used for management.

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