Morphometrics and Growth Patterns of Halfbeak Fish (*Nomorhamphus* sp.) in Moramo River, South Konawe Regency

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Abstract. Halfbeaks (*Nomorhamphus* sp.) are freshwater fishes that inhabit the Moramo River. Data and scientific information of this species are still limited. This study aims to determine the morphometric characters and growth patterns of halfbeak fish in the Moramo River. This research was conducted from April to June 2020. The fish was caught using a modified seine net. The length of the net is 15 m, width 1.2 m, and mesh size 0.5 x 0.5 inches. There is a pocket in the middle of the net with 40 cm of diameter and 1.5 m of length. The fish were separated by sex, weighed, and preserved using 4% formalin. Measurement of 22 morphometric characters using calipers with an accuracy of 0.1 mm. A total of 120 fish were caught, with 60 males and 60 females. Male fish have body lengths and weights ranging from 40.5-71 mm and 0.45-2.93 g, while female fish have body lengths and weights ranging from 43.5-91.5 mm and 0.5-5.74 g. The results of the growth patterns of male and female halfbeaks are negative allometric (b<3).

1 Introduction

Halfbeak fish is one of the freshwater fishes from Zenarchopteridae families with limited distribution in the Indo-West Pacific region [18, 26]. Halfbeak fish are divided into 2 types based on their habitat. First, halfbeak fish inhabit freshwater and brackish water ecosystems, including the genus of *Dermogenys*, *Hemirhamphodon*, *Nomorhamphus*, *Tondanichthys*, and *Zenarchopterus*. Second, halfbeak fish inhabit marine ecosystems, including *Arrhamphus*, *Chriodorus*, *Euleptorhamphus*, *Hemiramphus*, *Hyporhamphus*, *Melapedalion*, *Oxyporhamphus*, *Reporhamphus*, and *Rhynchorhamphus* [7,26]. Halfbeak fish are characterized by their upper jaws being shorter than their lower jaws [14,18]. Some species of halfbeak fish have unique and varied body colours.

Sulawesi is one of the islands in Indonesia that distributed several species of *Nomorhamphus*. Genus of *Nomorhamphus* is endemic to Sulawesi with 12 species including *N. brembachi*, *N. liemi* [10], *N. celebensis* [25], *N. ebrardtii*, *N. hageni* [8], *N. kolonodalensis* [2], *N. lanceolatus*, *N. sagittarius* [17], *N. megarrhamphus* [20], *N. rex* [16], *N. towoetii* [32], and *N. weberi* [11]. In Sulawesi, halfbeak fish can be found in rivers,

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swamps, lakes, and estuaries [7, 9, 16]. 3 ancient lakes are the habitat of halfbeak fish, namely Lake Poso in Central Sulawesi, Lake Matano, and Lake Towuti in South Sulawesi. At least there are more than one species of halfbeak fish that inhabits the lake [27].

Moramo River is one of the rivers in Southeast Sulawesi, which halfbeak fish inhabited. However, the specific species of *Nomorhamphus* in this river has not been clearly identified. There are no references or research data regarding this fish in the Moramo River. Several studies have been conducted on halfbeak fish in various locations other than the Moramo River are morphology [3, 16, 17], fish distribution [18, 23, 24], and food habits [33]. This study aims to determine morphometric characters and analyze the growth pattern to provide data and references regarding the halfbeak fish in the Moramo River. The benefit from this study is as basic information in further research to identify exact species of halfbeak fish in Moramo River.

2 Materials and Methods



2.1 Research site

Fig.1. Maps of Moramo River, South Konawe

This study was conducted for three months, from April to June 2020 in Moramo River, Moramo District, Southeast Sulawesi Province (Fig 1). The sampling locations were determined using the purposive sampling technique. Station 1 is located at the coordinates of $4^{\circ}13'33.61$ "S and $122^{\circ}44'14.84$ "E dominated by sand and small gravel. On the banks of the river, there are aquatic plants and rattan trees. Station 2 is located at the coordinates of $4^{\circ}13'28.84$ "S and $122^{\circ}44'20.84$ "E, dominated by muddy sand. On the banks of the river, there are rocks and grass.

2.2 Fish collection

This study uses a survey method, and the location is determined by purposive sampling. Fish were caught using a modified seine net (Fig 2) with capture intervals once every month. The net length is 15 meters, width 1.2 meters, and mesh size 0.5×0.5 inches. There

is a pocket in the middle of the net with 40 centimeters of diameter and 1.5 meters of length. The fish were separated into two different buckets according to sex. The fish was anesthetized using ice. After fainting, the fish were weighed and preserved with 4% formalin.



Fig. 2. Design of modified seine net

2.3 Data analysis

2.3.1 Morphometric

The morphometric measurement methods used in this study are common and truss morphometric. Measurement of morphometric characters using a caliper with an accuracy of 0.1 mm. The number of morphometric characters measured in halfbeak fish is 22 characters [17]. The characters measured in millimeter include Total Length (TL); Standard Length (SL); Bony Orbital Diameter (ORBL); Head Length (HDL); Lower Jaw Length (LJL); Lower Jaw Length Brembach (LJLB) [21]; Upper Jaw Length (UJL); Snout to Pectoral-Fin Distance (SN-P₁F); Body Depth at Pectoral-Fin Base (BDP₁B); Length of Pectoral-Fin (LP₁F); Length of Pectoral-Fin Base (LP₁B); Snout to Pelvic-Fin Distance (SN-P₂F); Body Depth at Pelvic-Fin Base (BDP₂B); Length of Pelvic-Fin (LP₂F); Length of Pelvic-Fin Base (LP₂B); Pelvic-Fin to Caudal-Fin Distance (P₂F-CF); Depth of Caudal Peduncle (DCP); Length of Dorsal-Fin (LCF); Length of Dorsal-Fin Base (LDB).

2.3.2 Growth pattern

The growth model is assumed from the analysis of the length-weight parameters. This means that in a section, it can be considered as a function of its length. The length-weight relationship information can be used to evaluate the fish condition and growth patterns, whether isometric or allometric [5, 6, 12, 22, 31]. The growth pattern equation has been calculated by the equation [1]:

$$W = aL^b \tag{1}$$

With; W is the fish weight (g); L is the total length (mm); a is regression intercept (the point at which relationship curve of length-weight intersects the y-axis), and b is regression coefficient (length-weight growth pattern estimator). The value of b shows a growth pattern with the following categories:

b = 3	isometric (total length gain increase equal the weight gain)						
b < 3	: allometric negative (total length gain increase exceeds weight gain)						
b > 3	: positive allometric (weight gain exceeds total length gain)						
T 1							

The statistical t-test was used to determine whether the value of b=3 was correct or not. If $b\neq3$, the fish has an allometric growth pattern. Whereas if b=3, the fish has an isometric growth pattern. In the length-weight relationship analysis, Microsoft Excel v.13 was used.

3 Results

3.1 Morphometric measurement

The total fish caught during the study was 120 halfbeak fish consists of 60 males and 60 females. Based on the measurement of morphometric of halfbeak fish in Moramo River (Table 1), it shows that there are size differences in some morphometric characters of male and female fish. Female halfbeak fish have morphometric characters sizes ranging from 0.5 -91.5 mm, and male halfbeak fish have a size of 0.5 - 71 mm.

No	Morphometric Characters	Female (in mm)			Male (in mm)		
		Min	Max	Mean	Min	Max	Mean
1	Standard Length (SL)	36	79	57.11	34.5	63	45.75
2	Total Length (TL)	43.5	91.5	66.94	40.5	71	53.99
3	Lower Jaw Length Brembach	2	5.5	3.33	2	4.5	3.13
	(LJLB)						
4	Lower Jaw Length (LJL)	5.5	15	9.81	6	12	8.38
5	Upper Jaw Length (UJL)	3.5	9.5	6.47	3.5	9	5.25
6	Bony Orbital Diameter (ORBL)	3	4.5	3.57	2.5	4	3.25
7	Head Length (HDL)	10	22	16.13	10	17	13.49
8	Snout to Pectoral-Fin Distance	11	23.5	17.34	11	18.5	14.48
	(SN-P ₁ F)						
9	Snout to Pelvic-Fin Distance (SN-	20	43.5	31.75	19	35	25.02
	P_2F)						
10	Body Depth at Pectoral-Fin Base	6	13	8.88	5.5	10	7.41
	(BDP ₁ B)						
11	Body Depth at Pelvic-Fin Base	5	11.5	8.23	5	9	6.95
	(BDP ₂ B)						
12	Depth of Caudal Peduncle (DCP)	2.5	6.5	4.30	2.5	4.5	3.38
13	Pelvic-Fin to Caudal-Fin Distance	13.5	33	22.18	13	25	17.66
	(P ₂ F-CF)				_		
14	Length of Pectoral-Fin (LP ₁ F)	5.5	12	8.54	5	10	7.50
15	Length of Pectoral-Fin Base	0.5	3	1.22	0.5	2.5	0.98
	(LP_1B)		10	0.04		10	
16	Length of Dorsal-Fin (LDF)	6	12	9.04	6	10	7.58
17	Length of Dorsal-Fin Base (LDB)	4	9.5	7.18	3	8.5	5.23
18	Length of Pelvic-Fin (LP ₂ F)	3	6.5	4.66	3	6	4.28
19	Length of Pelvic-Fin Base (LP ₂ B)	0.5	2	1.44	1	2	1.41
20	Length of Anal-Fin (LAF)	6.5	12.5	9.19	6	11	8.64
No	Morphometric Characters	Female (in mm)		Male (in mm)			

Table 1. Measurements of morphometric in millimeters

		Min	Max	Mean	Min	Max	Mean
21	Length of Anal-Fin Base (LAB)	4	9	7.11	4.5	8.5	6.45
22	Length of Caudal-Fin (LCF)	6.5	15	9.83	6	11	8.24

The differences of morphometric characters in male and female halfbeak fish were tested using an independent t-test with a 5% (0.05) confidence interval. The test results show that there are 7 different characters including Total Length (TL), Head Length (HDL), Snout to Pectoral-Fin Distance (SN-P₁F), Snout to Pelvic-Fin Distance (SN-P₂F), Pelvic-Fin to Caudal-Fin Distance (P₂F-CF), Length of Dorsal-Fin (LDF), and Length of Dorsal-Fin Base (LDB).

Based on the results of the analysis of the proportion of morphometric characters to standard length (SL) shown in Table 2, the proportion of morphometric characters that range from >80% of the Standard Length (SL) is Total Length (TL). Meanwhile, proportion characters ranged from 30-80% of the Standard Length (SL) were Snout to Pectoral-Fin Distance (SN-P₁F); Snout to Pelvic-Fin Distance (SN-P₂F); and Length of Caudal-Fin (LCF). The proportion of characters that ranged <30% were Lower Jaw Length Brembach (LJLB); Head Length (HDL); Body Depth at Pectoral-Fin Base (BDP₁B); Upper Jaw Length (UJL); Lower Jaw Length (LJW); Body Depth at Pelvic-Fin Base (BDP₂B); Depth of Caudal Peduncle (DCP); Pelvic-Fin to Caudal-Fin Distance (P₂F-CF); Length of Pectoral-Fin (LP₁F); Length of Pectoral-Fin Base (LDB); Length of Pelvic-Fin (LP₂F); Length of Pelvic-Fin Base (LDB); Length of Pelvic-Fin (LAF); and Length of Anal-Fin Base (LAB).

No	Mornhomotria Charactors	Fem	ale	Male		
	worphometric Characters	<u>Σ</u> (%)	Ratio	<u>Σ</u> (%)	Ratio	
1	Total Length (TL)	117.2	0.9	118	0.8	
2	Lower Jaw Length Brembach (LJLB)	6.8	14.6	6.8	14.6	
3	Lower Jaw Length (LJL)	18.3	5.5	18.3	5.5	
4	Upper Jaw Length (UJL)	11.5	8.7	11.5	8.7	
5	Bony Orbital Diameter (ORBL)	7.1	14.1	7.1	14.1	
6	Head Length (HDL)	28.2	3.5	29.5	3.4	
7	Snout to Pectoral-Fin Distance (SN-P ₁ F)	30.4	3.3	31.6	3.2	
8	Snout to Pelvic-Fin Distance (SN-P ₂ F)	55.6	1.7	54.7	1.8	
9	Body Depth at Pectoral-Fin Base (BDP ₁ B)	16.2	6.2	16.2	6.2	
10	Body Depth at Pelvic-Fin Base (BDP ₂ B)	15.2	6.6	15.2	6.6	
11	Depth of Caudal Peduncle (DCP)	7.4	13.5	7.4	13.5	
12	Pelvic-Fin to Caudal-Fin Distance (P ₂ F-CF)	38.8	2.57	38.6	2.59	
13	Length of Pectoral-Fin (LP ₁ F)	15	6.7	15	6.7	
14	Length of Pectoral-Fin Base (LP1B)	2.1	46.5	2.1	46.5	
15	Length of Dorsal-Fin (LDF)	15.8	6.3	16.6	6.0	
16	Length of Dorsal-Fin Base (LDB)	12.6	8.0	11.4	8.7	
17	Length of Pelvic-Fin (LP ₂ F)	8.2	12.3	8.2	12.3	
18	Length of Pelvic-Fin Base (LP2B)	3.1	32.5	3.1	32.5	
19	Length of Anal-Fin (LAF)	18.9	5.3	18.9	5.3	
20	Length of Anal-Fin Base (LAB)	14.1	7.1	14.1	7.1	
21	Length of Caudal-Fin (LCF)	18	5.6	18	5.6	

Table 2. The proportion of morphometric characters to standard length (SL)

3.2 Growth pattern

The growth pattern analysis revealed that both female and male halfbeak fish were negatively allometric, with female fish having a b-value ranging from 2.795-2.930 and male fish having a b-value ranging from 2.640-2.738.



Fig. 3. Growth pattern female halfbeak fish

4 Discussions

4.1 Morphometric characters

The morphometric study of halfbeak fish (Nomorhamphus sp.) in Moramo River found that the value of morphometric character in female fish is more significant than male fish. It indicates that female fish have a more substantial body proportion than male fish. This is inconsistent with Meisner's [3] finding that the males in *Dermogenys* and *Nomorhamphus* are smaller than the females. [16] also discovered that female *Nomorhamphus* fish have a larger and longer body than males.

Several studies on morphometric of halfbeak fish in other locations found differences in morphometric value. *Nomorhamphus aenigma* in Cerekang River, South Sulawesi, Indonesia, has a maximum standard length (SL) recorded 34.7 mm in males, 60.9 mm in females [13]. *N. rex* in Wewu River, South Sulawesi, Indonesia also recorded 44.4 mm maximum standard length (SL) in males, 63.9 mm in females [16]. Compared to both N. aenigma and N. rex, Nomorhaphus sp. in Moramo River has a longer maximum SL recorded 63 mm in males and 79 mm in females. The difference in the value of this morphometric character is influenced by various factors, including age, gender, and environment. This is in accordance with the statement by [30] that each fish has a different size, depending on age, sex, and environmental conditions. Morphometric variation responds to the physical environment in which the species lives, such as adaptation to specific habitats [15].

Based on the analysis, the proportion of morphometric characters to standard length (SL) found that body deep of *Nomorhamphus* sp. in Moramo River, BDP₁ was 15.5-16.2 % SL, BDP₂ was 14.4-15.2 %. Lower jaw length Brembach (LJLB) shown 14.6-17.1 times ratio in SL. These results are different from other *Nomorhamphus* species found in Southeast Sulawesi (*N. lanceolatus* and *N. sagittarius*). *N. lanceolatus* was found in Wawolambo River, between Kolaka and Kendari City with body deep, BDP₁ 18.2-20.6 % SL, BDP₂ 17.9-21.4% SL. Lower jaw Brembach (LJLB 15-25.3 times in SL). *N. Sagittarius* recorded in Mangolo River, North Kolaka Regency has body deep, BDP₁ 18.2-20.6 % SL, BDP₂ 17.5-20.7% SL. Lower jaw elongated (LJLB 6.4-15 times in SL) [17].

4.2 Growth pattern

There are variations in the value of b between males and females *Nomorhampus* sp. This is caused by variations in the size of males and female fish that are different each time they are caught. The difference in the value of b also be caused by differences in the number and size variations observed [29]. This study discovered that either males or females *Nomorhamphus* sp. in Moramo River has a negative allometric growth pattern (b<3). It means the length of the fish grows faster than its weight. Another study also reported halfbeak fish on the family of Zenarchopteridae (*Zenarchopterus dispar*) at Kuala Mamplam, Lhoksumawe City, Indonesia, had a value of b=2.23, indicating that the growth pattern of halfbeak fish is negatively allometric.

The morphometric of the observed organisms are also related to the b-value. The morphometric character of the genetic make-up of a fish's body will influence its environmental adaptation and growth pattern. Furthermore, environmental factors such as food availability, temperature, and current conditions influence the difference of b-value. This is in accordance with the statement of Arzita et al. [4] that fish food is a factor that determines the growth and condition of fish. Environmental factors such as currents and

waves are the main factors that affect the b value of the growth of aquatic animals. In general, aquatic animals that live in calm waters have a considerable b value, while animals living in fast waters tend to have a low b value [34]. Active swimming fish will also show a relatively lower b value than passive swimming fish. This is related to the level of activity of fish movement behavior which is closely related to the habitat where this fish lives.

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