Distribution map and first record of *Nomorhamphus* sp. (Beloniformes, Zenarchopteridae) in Southeastern Sulawesi, Indonesia

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Abstract. The purpose of this study were to know the distribution of *Nomorhamphus* genus in Southeastern Sulawesi and to examine the first record of *Nomorhamphus* sp. in Loea river east Kolaka Regency Southeast Sulawesi Indonesia. *Nomorhamphus* is as one of Sulawesi’s endemic fish. The distribution map of *Nomorhamphus* based on primary and secondary data. Both visualized using System Information Geography (SIG) through QGIS application. First record of *Nomorhamphus* sp. in Loea river describe by morphometric and meristic data. *Nomorhamphus* sp. catched by used a beach seine. Each individual caught was put into a plastic sample which was given formalin about 4%. This study recorded the fiftythree specimen consist of twentytwo males and thirtyone females. Several locations are known as the *Nomorhamphus* sp. habitat, namely Fotuno fountain, Moramo waterfall, Balano fountain, Laweau river, Moramo river, Anduna river and Asinua river. Furthermore, other *Nomorhamphus* found in Wawolambo river (*N. lanceolatus*) and Mangolo river (*N. sagittarius*). Several character of male and female of present study including total length, standard length and head length about 30.0-87.7 mm, 24.2-70.5 mm and 7.3-30.7 mm, respectively. The meristic showed both males and females have relatively the same number of fin rays. The relationship between total length and body weight of male and female followed the equation $W = 0.0385L^{1.1355}$ ($r = 0.90664$) and $W = 0.0647L^{2.2221}$ ($r = 0.87756$), respectively.

1. Introduction
Halfbeaks distributed in Southeast Asia, including Indonesia (Southeastern Sulawesi, South Sulawesi, Kalimantan, Sumatera, Jawa, Bangka Belitung), Thailand (Siam river) and Malaysia (Peninsular river) [1]. The distribution of *Zenarchopteridae* in the world is limited in the Western Indo-Pacific region [2, 3].

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The halfbeaks can be divided into two group based on its classification. The first is Hemirhamphidae that inhabit of marine (Arrhamhus, Chriodorus, Euleptorhamphus, Hemiramphus, Hyperhamphus, Melapedalation, Oxyporhamphusi, Reporhamphus, Rhynchorhamphus). The second is Zenarchopteriidae which inhabits of freshwater and brackish ecosystems (Dermogenys, Hemirhamphodon, Nomorhamphus, Tondanichtys and Zenarchopterus).

In previous studies, some of various species of Zenarchopteriidae were grouped together with marine species in the Hemirhamphidae family [4,5]. However, there is some distinguishing way to distinguished between those two families, including synapomorphies [6], internal fertilization behavior and morphological characteristics of sperm [7], pharyngeal jaw apparatus [8] and anatomical evidence [9]. Status of Zenarchopteriidae family began to accepted after it reported phylogenetic relationships between Beloniformes fish based on molecular data [2,10].

Morphometric is designation to describes the body shape of a fish [11]. The study of fish morphometric is important because it can be used to provide information about taxonomic unit differentiation and as a differentiator between fish populations [12]. Unlike the morphometric which emphasizes the measurement of fish body parts, the meristic character is related to the calculation of the number of fish body parts. In a dichotomous key, morphometric measurements and meristic calculations can help identify certain fish species. Before the DNA (modern genetic) methods, the morphometric and meristic were the main basis in fish taxonomy and systematics.

Distribution of genus Nomorhamphus is limited in Sulawesi and some islands in Philippines. The genus Nomorhamphus in particular known as endemic to Sulawesi and recently 4 species have been described from Southeast Sulawesi including Nomorhamphus ebrardti, N. hageni, N. lanceolatus and N. sagitarius [1,3,13]. Zenarchopteriidae occupies various characteristics of freshwater and brackish water habitats, including rivers (mud, sand and rock), creeks with swift streams, swamps, lakes, irrigation flow, ponds, and estuarine areas [1,5]. However, the distribution map of Nomorhamphus sp. in Southeastern Sulawesi, Indonesia still lack of information. Here, we show the existence location of halfbeak (Nomorhamphus spp.) in Southeastern Sulawesi. We also examine the morphometric and meristic characteristic of Nomorhamphus sp. from Loea river, east Kolaka regency, Southeast Sulawesi.

2. Materials and methods
2.1. Materials
Individuals were caught by a beach seine (see Figure 1) on August 2019 in Loea river about 4 km from Penanggo village. Each individual was preserved into formalin 4%. The morphometric measurements using digital calipers by 0.01 mm accuracy and body weight was measured by digital scales with an accuracy of 0.01g.

Figure 1. Catching Nomorhamphus sp. used a beach seine in Loea river
2.2. Method
The distribution map of *Nomorhamphus* sp. were based on primary and secondary data. The primary coordinate data was taken in Loea river as well as sampling for meristic and morphometric analysis, while the secondary data were taken from previous studies [1,3]. Furthermore, those two datas were running in the form of a dataset and visualized using System Information Geography (SIG) through QGIS application. The morphometric measurements and meristic counting template follow methods by [1].

Twentyone characters were measured (see Figure 2) and five characters of meristic including number of dorsal fin rays, pectoral fin rays, ventral fin rays, anal fin rays and caudal fin rays. The measured of body weight is dry weight. Both measurements were conducted at the Laboratory of Fisheries and Marine Science Faculty, Halu Oleo University.

**Figure 2.** (1) Standard length, (2) Total length, (3) Lower jaw length Brembach, (4) Lower jaw length, (5) Upper jaw length, (6) Bony orbital diameter, (7) Head length, (8) Snout to base of the pectoral fin distance, (9) Snout to base of ventral fin distance, (10) Head depth, (11) Body depth, (12) Depth of caudal peduncle, (13) Pectoral fin length, (14) Basic length of pectoral fin, (15) Dorsal fin length, (16) Basic length of dorsal fin, (17) Ventral fin length, (18) Base length of ventral fin, (19) Anal fin length, (20) Basic length of anal fin, (21) Caudal fin length

2.3. Data analysis
To know the similarity of *Nomorhamphus* spp. in Southwestern Sulawesi we use a formula:

\[
PS (\%) = \frac{n_i}{N} \times 100\%
\]

where: PS, percentage of similarity; \(n_i\), number of same characters measured; N, total characters

To determine the relationship between total length and body weight of *Nomorhamphus* sp. analyzed by linear equation:

\[
W = aL^b
\]

where: W, body weight (g); L, total length (mm); a, linear regression intercept; b, regression coefficient
If the regression coefficient (b) is equal to 3 (b = 3) then the growth pattern is isometric but if the value of b is not equal to 3 then it is allometric, b < 3 is negative allometric and b > 3 is positive allometric.

3. Results and discussions

3.1. Distribution map

The distribution map of *Nomorhamphus* in Southeastern Sulawesi described see Figure 3.

![Distribution map of Nomorhamphus sp. in Southeastern Sulawesi](image)

**Figure 3.** Distribution map of *Nomorhamphus* sp. in Southeastern Sulawesi (see Table 1 for the coordinate of each locality)

| Locality                              | Coordinates               |
|---------------------------------------|---------------------------|
| Loea river (Kolaka regency)           | S04°4'52"E121°53'10"     |
| Fotuno fountain (Muna regency) [3, 15]| S05°00'43"E122°03'24"    |
| Moramo waterfall (South Konawe regency) [3, 15] | S04°13'15"E122°04'42" |
| Balano fountain (Muna regency) [3, 15]  | S05°00'24"E122°02'27"    |
| Laweau river (Muna regency) [3, 15]    | S05°00'17"E122°02'49"    |
| Moramo river (South Konawe regency) [3, 15] | S04°01'40"E122°02'00" |
| Anduna river (South Konawe regency) [3, 15] | S04°01'59"E122°02'01" |
| Asinua river (Asipako village, Konawe regency) [13,15] | S03°42'44"E121°04'75" |
| Wawolambo river (Kolaka regency) [12]  | S04°00'51"E121°04'20.8" |
| Mangolo river (Kolaka regency) [12]    | S03°58'56.6"E121°03'40.5" |
Several locations are known as the Nomorhamphus sp. habitat, namely Fotuno fountain, Moramo waterfall, Balano fountain, Laweau river, Moramo river, Anduna river, and Asinua river [3]. Furthermore, other Nomorhamphus found in Wawolambo river (N. lanceolatus) and Mangolo river (N. sagittarius) [1] (see Figure 3, Table 1).

The halfbeaks of genus Nomorhamphus in East Kolaka, Southeast Sulawesi has only knew and reported by [14] from Penanggo, while in the Loea river (see Figure 4) it was not recorded (Loea river and Penanggo river are the same regency). Unfortunately, at the same time we went to Penanggo river and did not find it. This condition is thought to be caused by the habitat of halfbeaks which are starting to be polluted by pesticides originating from the rice fields of local communities which are located right across the Penanggo river. It also feared that this will occur in the Loea river which is located about 3 km from the Penanggo river. Therefore, it is necessary to conduct periodic data collection of Nomorhamphus in east Kolaka.

![Image](image-url)

**Figure 4.** Locality of Nomorhamphus sp. from Loea river

### 3.2. Morphometric and meristic

The morphometric and meristic data of Nomorhamphus sp. in Loea river described by Table 2. This study recorded fifty three Nomorhamphus sp. caught and it is consist of twenty two males and thirty one females from Loea river (see Figure 4). Several characters of males and females of present study including total length, standard length and head length about 30.0-87.7 mm, 24.2-70.5 mm and 7.3-30.7 mm, respectively. Overall, the females have a larger size than males at the same stadia [9]. However, based on meristic measurements showed both males and females have relatively the same number of fin rays.

Furthermore, this study is the first record of halfbeak in Loea river where the male has dark to yellowish in body color. Dorsal, anal and caudal fins of male was orange to red while the pectoral fin was translucent and the ventral body was yellowish. The fundamental difference between male (see Figure 5) and female (see Figure 6) of Nomorhamphus sp. is the anal fin as the character of the reproductive organ (sexual dimorphism). Morphologically, the female anal fin is rounder than the male. This is due to a modification of the anal fin rays called andropodium [9].
Table 2. Morphometric and meristic of *Nomorhamphus* sp. in Loea river

| No. | Characteristics                              | Male (mm)     | Female (mm)   |
|-----|---------------------------------------------|---------------|---------------|
|     | Morphometric                                | Standard length | 25.4 – 47.4 | 24.2 - 70.5 |
| 1   |                                             | Total length   | 31.5 – 60.7 | 30.0 - 87.7 |
| 2   |                                             | Lower jaw length | 0.28 - 0.04 | 0.39 - 0.09 |
| 3   |                                             | Lower jaw length | 4.0 – 9.8 | 3.3 - 13.9 |
| 4   |                                             | Upper jaw length | 3.6 – 7.4 | 2.4 - 10.0 |
| 5   |                                             | Bony orbital diameter | 1.7 - 33.0 | 0.7 - 3.9 |
| 6   |                                             | Head length     | 8.0 – 16.1 | 7.3 - 20.7 |
| 7   |                                             | Snout to base of the pectoral fin distance | 8.6 - 17.4 | 2.8 - 23.2 |
| 8   |                                             | Snout to base of ventral fin distance | 14.4 – 26.8 | 6.6 - 41.3 |
| 9   |                                             | Head depth       | 4.0 - 10.6 | 1.3 - 9.6 |
| 10  |                                             | Body depth       | 4.3 – 8.1 | 2.9 - 13.9 |
| 11  |                                             | Depth of caudal peduncle | 2.0 - 3.9 | 1.9 - 5.8 |
| 12  |                                             | Pectoral fin length | 3.1 – 9.6 | 3.5 - 11.9 |
| 13  |                                             | Basic length of pectoral fin | 1.5 - 3.0 | 1.3 - 3.9 |
| 14  |                                             | Dorsal fin length | 4.2 – 8.8 | 3.9 - 16.0 |
| 15  |                                             | Basic length of dorsal fin | 3.2 – 6.6 | 3.1 - 7.6 |
| 16  |                                             | Ventral fin length | 1.3 – 4.9 | 1.8 - 6.0 |
| 17  |                                             | Base length of ventral fin | 0.9 – 2.5 | 0.5 - 5.6 |
| 18  |                                             | Anal fin length | 1.9 – 8.2 | 1.9 – 11.8 |
| 19  |                                             | Basic length of anal fin | 3.8 – 6.0 | 3.7 - 9.4 |
| 20  |                                             | Caudal fin length | 4.6 – 10.3 | 1.0 – 13.2 |
|     | Meristic                                     | Number of anal fin rays | 13 - 16 | 14 - 16 |
| 1   |                                             | Number of dorsal fin rays | 12 - 14 | 11 - 14 |
| 2   |                                             | Number of pectoral fin rays | 11 - 12 | 11 - 14 |
| 3   |                                             | Number of ventral fin rays | 6 - 7 | 6 - 7 |
| 4   |                                             | Number of caudal fin rays | 22 - 24 | 20 - 25 |

Based on the formula, we received the similarity of *Nomorhamphus* spp. in Southeastern Sulawesi (see Figure 7).

Based on percentage of similarity that *Nomorhamphus* in Loea river has similarities with *N. lanceolatus* about 94.737% (see Figure 7). *Nomorhamphus lanceolatus* found at Wawolambo river in Kolaka regency Southeast Sulawesi [1]. Although Loea and Wawolambo are in the same regency but they are in different watersheds. To know they are the same species can be accurate if further DNA testing is done.

This study can be used as a basic reference for management endemic fish in Sulawesi. In addition, IUCN can be used as a guideline for determining its conservation status. However, several *Nomorhamphus* including *N. weberi* and *N. celebensis* are categorized as Near Threatened (NT),
Endangered (EN) respectively [16, 17], while for *Nomorhampus ebrardtii* [18] and *N. brembanchi* are categorized as Data Deficient (DD) [18,19].

![Graph showing similarity in percentages between Nomorhampus spp. in Southeastern Sulawesi](image)

**Figure 7.** Similarity in percentages between *Nomorhampus* spp. in Southeastern Sulawesi [1, 9,13]

### 3.3. Total length and body weight relationship

The relationship between total length and body weight of male and female of *Nomorhampus* sp. in this research describe (see Figure 8 and 9).

![Graph showing total length and body weight relationship of male Nomorhampus sp.](image)

**Figure 8.** Total length and body weight relationship of male *Nomorhampus* sp.

![Graph showing total length and body weight relationship of female Nomorhampus sp.](image)

**Figure 9.** Total length and body weight relationship of female *Nomorhampus* sp.

Based on the linear equation analysis of relationship between total length and body weight of *Nomorhampus* in Loea river showed $W = 0.0385L^{1.1355}$ ($r = 0.90664$) and $W = 0.0647L^{2.2221}$ ($r = 0.87756$), respectively. The value of regression coefficient (b) in each equation describes the growth pattern of the fish which is negative allometric ($b < 3$). This means that the increase in the total length of the fish is not proportional to the increase in body weight. The value of the relation coefficient (r) for each equation shows a strong value close to one. This means that the total length of the fish greatly affects its body weight. If the value of relation coefficient (r) close to one, the total length of the fish will increase with increasing its body weight until it reaches the asymptote length ($L_\infty$).

### 4. Conclusion

The findings showed that several locations are known as the *Nomorhampus* sp. habitat, namely Fotuno fountain, Moramo waterfall, Balano fountain, Laweau river, Moramo river, Anduna river and Asinua river. Furthermore, other *Nomorhampus* found in Wawolambo river (*N. lanceolatus*) and Mangolo river (*N. sagittarius*). Based on the percentage similarity, *Nomorhampus* sp. in this study
thought to have similarities with the *Nomorhamphus* from Wawolambo river (*N. lanceolatus*). Both areas still in the same Kolaka region but came from different river flows.

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