Sex ratio and first maturity size of matano ricefish (*Oryzias matanensis* Aurich, 1935) at Lake Towuti, South Sulawesi, Indonesia

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Abstract. Matano Ricefish (*Oryzias matanensis* Aurich, 1935) is an endemic freshwater fish with economic value. This study aims at determining the sex ratio and first maturity size of Matano ricefish. The study was conducted from November 2017 to October 2018 in Lake Towuti, South Sulawesi. Sample was held analysis the Fisheries Biology Laboratory, Department of Fisheries, Hasanuddin University. Total number of fish obtained during the study was 880 individu, consist of 410 male fish and 470 female fish. Sex ratio was analyzed with the chi-square test, while the average size at first gonad maturity was estimated using the Spearman-Karber method. The results showed that the sex ratio of male and female medaka ricefish was 1.00: 1.15, while size at first maturity of male gonad was 36.46 mm, and the female was 34.37 mm.

1. Introduction

Endemism is a symptom experienced by the organisms to be unique in a specific geographical location [1]. The richness and endemicity of the species are two essential components in biodiversity. Sulawesi, one of the islands in the Wallacea Region, has high level of fish diversity and endemicity [2].

Several studies on endemic fishes of Sulawesi found that several species of fish are increasingly threatened due to several factors and could lead to extinction after certain period. This situation could worsened by the absence of detailed quantitative ecological studies on the endemic fish communities, both in the rivers and in the lakes of Sulawesi [3].

One of the largest lakes complex in Sulawesi with a high endemic fish diversity is Malili Lake Complex consisted of five lakes of Matano, Towuti, Mahalona, Wawantoa, and Masapi, eighteen endemic fish species have been found in Lake Towuti [4] and 12 species found in Lake Matano which consisting of several types such as seven types of genus Telmatherina, one type of Dermogenys Genus, one type of Glossogobius, one type of Mugilogobius, one type of Oryzias and one type of Synbranchus [5].

However, for sometimes the Malili Lake complex experiences a decline of its endemic fish caused by domestic waste, mining waste, as well as introduction of foreign species, and the uncontrolled fishnet farming [6].
Among those Malili Lake Complex, Towuti has been designated as the conservation and tourism park area. Towuti is located inside the Nickel Industry (PT. INCO Company), and the endemic fishes of Towuti Lake has been affected by the mining activities, together with increasing fishing activities on endemic fish of the lake. Those two activities are causing population decline of several fishes species [7].

![Figure 1. Map of sampling locations of Matano ricefish at Lake Towuti.](image)

*Oryzias matanensis* is one of the endemic fish of genus *Oryzias* lives in Malili Lake Complex, especially in Lake Towuti and Matano [8]. The common name of *O. matanensis* is ricefish Matano or Matano medaka and locally called as *kabumbu*. The according to Kottelat et al (1993), this fish is now categorized as vulnerable species. At present, the presence of *O. matanensis* is rarely found in Matano Lake, but is found in Towuti Lake [9].

*O. matanensis* is a bioindicator species, as well as an ornamental fish and consume by the people. Unlike other endemic species of Towuti such as butini (*Glossogobius matanensis*) and opudi (*Telmatherina celebensis*), *O. matanensis* has not received attention from researchers nor the local government. The issue also supported by evidenced by no efforts to preserve this species, both in biological research as well as in ecological studies of natural habitats.

Although research on Matano ricefish (*O. matanensis*), has been done by Kottelat et al (1996), but is still limited to systematic and general description on the fish only. Therefore, this research on the sex ratio and first maturity size of Matano ricefish is still needed. The benefit of this study in publication is necessary as information for futher protect on conservation efforts the Matano ricefish species in Towuti Lake.

2. Material and Methods

The study was conducted in the Towuti Lake, South Sulawesi (figure 1), for 12 months from November 2017 to October 2018, with sampling taken once in a month. Sample sites were chosen based on local fishers. Information on the location, Matano ricefish even sighted and found in Towuti Lake.
Sampling site divided at:

Station 1: The GPS coordinates are S = 020. 40 '. 48 "and E = 1210. 25". 55 ". Tanjung Bakara, is in an area affected by sawmill and has a high population’s activity in the field of fisheries and households. At this station, water depth is 1–10 m, substrate composed of sand, mud, stone and water plants are also found.

Station 2: The GPS coordinates are S = 020. 39 '. 55 "and E = 1210. 31". 42 ". Is an Inlet to Towuti Lake from Tominanga river, this station has no influenced by fishers or other housing area. The depth is 1–20 m, the substrate is in the form of sand, rocks, gravel and no water plants are found.

The sample fishs were collected using rectangular nets, of a modified model of a fishing net measuring 10 m long, 1 m wide and of 0.5 inch mesh size, made of multifilament material, the net then stretched at the bottom of the water and hold by two fishermen, each at the end of the net. The third other fisherman lead the fish into the net. The net then raised at the same time to the surface.

Sample was analysis at the Fisheries Biology Laboratory, Department of Fisheries, Faculty of Marine Sciences and Fisheries, Hasanuddin University. Measurement of the fish length used 0.01 mm calipers, and the weight was done using 0.001 g digital scales. The fish samples then dissected using surgical scissors, and the gonad or the sex glands were done using a 0.0001 g digital scale.

Sex ratios were analyzed by comparing individual number of the male and female fish, and calculated through formula.

To check the uniformity distribution of the sex ratio chi-square test was done [10]:

\[ \chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \]

Note: \( O_i \) = random variable value; \( X^2 \) whose distribution is for example approaching Chi-square; \( O_i = \) Frequency of the observed male and female fish number i; \( E_i = \) The frequency of the observed male and female fish number i.

The first measure of gonad ripening was analyzed using the formula from the Spearman-Karber method as proposed by Udupa (1986) with the following formula:

\[ m = xk + \frac{X}{2} \sum \pi_i \]

If: \( \alpha = 0.05 \) then the 95% confidence limits of \( m \) are:

\[ \text{antilog}[m \pm 1.96] = \sqrt{\frac{x^2 \sum (\pi_i - q_i)}{n_i - 1}} \]

Note: \( m = \) logarithm of fish length when gonad is first ripe, \( x_k = \) logarithm of middle class when all fish (100%) have gonad, \( X = \) logarithm difference of median value, \( \pi_i = \) proportion of mature gonad fish in first class i (\( \pi_i = r_i / n_i \)), \( r_i = \) number of mature gonad fish in the i class, \( n_i = \) number of fish in the i class, \( q_i = 1 - \pi_i \). Thus, the length of the fish when it reaches the first gonad maturity (M) is equal to antilog \( m \).

3. Results and discussion

3.1. Results

3.1.1. Sex ratio. Total number of \( O. matanensis \) caught during the study was 880 individu, consisted of 410 male fish (46.59%) and 470 female fish (53.41%). Hence, the sex ratio of male and female 1.00:1.15. The sex ratio of Matano ricefish based on sampling time are listed in table 1.
Table 1. The Sex ratio of medaka ricefish O. matanensis Aurich, (1935) in Towuti Lake during the monthly period.

| Month        | Male Individu | Female Individu | Sex Ratio |
|--------------|---------------|-----------------|-----------|
| November 2017| 38            | 32              | 1.19 : 1.00 |
| December 2017| 36            | 34              | 1.06 : 1.00 |
| January 2018 | 24            | 41              | 1.00 : 1.71 |
| February 2018| 33            | 47              | 1.00 : 1.42 |
| March 2018   | 32            | 38              | 1.00 : 1.19 |
| April 2018   | 36            | 44              | 1.00 : 1.22 |
| May 2018     | 37            | 48              | 1.00 : 1.30 |
| June 2018    | 46            | 44              | 1.10 : 1.00 |
| July 2018    | 33            | 42              | 1.00 : 1.27 |
| August 2018  | 30            | 30              | 1.00 : 1.00 |
| September 2018| 33        | 37              | 1.00 : 1.12 |
| October 2018 | 32            | 33              | 1.00 : 1.03 |
| Total        | 410           | 470             |           |

Table 1 shows that during from November 2017 to October 2018, the numbers of male fish caught were less than the female. The most number of male fish caught was in June, while the least was in January, while, the number of most caught for female fish was in May and the least was in August. Comparing the sex ratio of Matano ricefish based on stations can be seen in table 2.

Table 2. The sex ratio of Matano ricefish based on observation stations

| Station | Male | Female | Sex Ratio |
|---------|------|--------|-----------|
| 1       | 254  | 270    | 1.00 : 1.06 |
| 2       | 156  | 200    | 1.00 : 1.28 |

Table 2 explained that the value of the sex ratio proportion between male and female fish at each observation station has no significant differences. Furthermore, the chi-square test of Table 2 showed that $X^2$ value of 4.09 indicate that the sex ratio of O. matanensis are not significantly different.

3.1.2. Size at First Maturity. The average of first maturity size of male O. matanensis is 36.46 mm with length range of 36.00–38.00 mm, while the female is 34.37 mm with a length range of 33.00-35.00 mm.

3.2. Discussion

3.2.1. Sex Ratio. It is essential to know the fish sex ratio since the information is useful to determine the stability of the fish populations in their habitat. According to Nasution et al. (2007), sex ratio can be used as an indicator for fish populations in a location whether the conditions are ideal or not. Furthermore, the balance of the composition of male and female in a population protect the fish populations from its extinction [11].

In Table 1, the sex ratio between males and females of O. matanensis is not significantly different, meaning there is a balance of male and female fish numbers in Lake Towuti. According to
Senen et al. (2011), the balanced sex ratio indicates that one male fish will fertilize one female fish. The difference in the number of male and female fish being caught is closely related to the patterns of fish migration behavior, both for spawning and foraging [12].

Sulistiono (2012), stated that males and females of lunjar fish (O. marmoratus) in Lake Towuti has sex ratio of 1: 1.15 where male fish was 46.5%, and female fish were 53.5%. Furthermore, Nasution et al. (2010) also found that the sex ratio of bonti-bonti fish (Paratherina striata Aurich, 1935) in Lake Towuti was fair with a ratio of 1.00: 0.90, it could be assumed that the number for both male and female fish is the similar [13]. Moreover, Sulistiono et al also found that the ratio of male and female of butini fish (G. matanensis) in Towuti Lake has the values of 1.00: 1.00. A balance between the individual numbers of male and female fish will provide the maximum possibility of fertilization during the breeding season [14].

On the other hand, Andy Omar et al. (2011) found that sex ratio of P. striata male: females in Towuti Lake was 1.00: 3.15, explaining that numbers of male and female fish is not balance. Changes in the proportion of fish sex ratio could be caused by high intensity of capture, environmental factors, and selectivity of the fishing gear [15].

3.2.2. Size at first maturity. Estimation of the fish first maturity size is one important parameters in determining the smallest size can be caught reflecting the population development. According to Siby et al. (2009), observing the first time maturity size of the gonad periodically could indicate the pressure on the population [15].

The first maturity size of the fish gonad is related to the growth, the environment, and reproductive strategies. The size will never be the same in every fish species. Lagler et al. (1977) state that several factors that influence the fish at first mature the gonads include species differences, age, size, differences of physiological characteristics, sex, and also the appropriate spawning site [16].

The size of O. matanensis male at the first maturity is larger than the female fish. This means that female fish gonad reached maturity at a smaller size than the male fish. Similar finding by Nasution (2010) on female lunjar fish (O. marmoratus) in Towuti Lake which reached gonads maturity at a smaller size (48 mm) than male fish (49 mm) [17]. Nasution et al. (2007) [11] also found that females bonti bonti fish (P. striata) in Towuti Lake mature at a smaller length (146.1 mm) than its male (167.8 mm). Andy Omar et al. (2011) [7] also explained that the female endemic bonti fish (P. striata) in Towuti Lake had relatively small lengths and body weights compared to the male fish at the first size of gonad reached the maturity. This condition allegedly related to the fish’s environmental influences, growth, and reproduction tactics. Furthermore, Mamangkey & Nasution (2012) also explained that butini fish (G. matanensis) in Towuti Lake had a pattern where the size of the first gonad maturity for female fish is faster than male fish with the size at 31.43 cm, while the male fish at the size of 37.3 cm [18].

Endemic fishes in Towuti Lake shown a pattern that the male reached its maturity at a smaller size than the female. One of them is dui-dui endemic fish (Dermogenys megarrhampus) where the male fish reached the first gonads maturity at 47 mm, while the females at 66 mm [19]. Furthermore, opudi fish (T. celebensis) where the gonads reached the first maturity at the size of 37.3 mm and the female fish at 36.4 mm [20].

Moresco and de Bemvenuti (2006) [21] states that the size of the first gonad ripening in fish varies. In general, fish that have a small maximum size and short reproductive periods will reach maturity at a younger age than the fish that have a larger maximum size [22].

4. Conclusion
The sex ratio of the Matano ricefish (O. matanensis Aurich, 1935) in Towuti Lake between male and female is in balanced. The size of gonad maturity for female fish are smaller than the male fish. The size of first maturity of this endemic fish seems to follow other endemic species in Towuti Lake previously studied.
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