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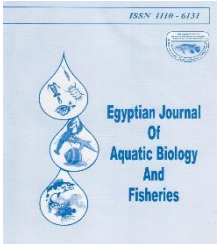

Reproduction Potential of Medaka Fish (*Oryzias profundicola*) as an Endemic Fish in Lake Towuti

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ABSTRACT

The aim of this research was to determine the reproductive potential of medaka fish (*Oryzias profundicola*), including fecundity, egg diameter, and gonado somatic index (GSI). This research was carried out from January to June 2022. The sampling location was Lake Towuti in South Sulawesi. Medaka fish sample collection was carried out at each research station using a modified bag seser net with a mesh size of ¾ inch, a total length of one fishing gear unit of 15 meters, a height of 1.50 meters, and a bag length of 3 meters.

The fecundity of medaka fish at station 1 (Tanjung Timbala) ranged from 27- 87 eggs (56± 15 eggs) for GML III and 65- 175 eggs (104± 21 eggs) for GML IV, while the total fecundity recorded 15,157 eggs. Station 2 (Tanjung Lengkobutangan) fecundity for GML III ranged from 31- 84 eggs (47± 11 eggs) and GML IV ranged from 97- 182 eggs (153 ± 20 eggs), and total fecundity was 11,369 eggs. The diameter of medaka fish eggs in Lake Towuti at all stations was found to range between 0.03 & 1.19mm, with the highest frequency for GML III in the range of 0.03- 1.08mm, while for GML IV, it was in the range of 0.15- 1. 19mm. The IKG tendency for female fish is relatively greater than that of male fish, except in April and May at station 3 (Tanjung Bakara) and in April at station 5 (Tanjung Tominanga). Reproductive potential is the product of the number of fish and the average fecundity. The reproductive potential of medaka fish at station 1 was 15,157 eggs, station 2 was 11,369 eggs, station 3 was 10,723 eggs, station 4 was 14,842 eggs, and station 5 was 18,385 eggs.

INTRODUCTION

Sulawesi is one of Indonesia's large islands with high biota richness. This island is included in the Wallacea region, together with the Philippines and Nusa Tenggara, which is a transitional area between Oriental and Australian zoogeography **(Whitten *et al.*, 1987)**. Therefore, there are many endemic types of flora and fauna that attract the attention of biological researchers.

Lake Towuti stores a variety of biodiversity and reprsents a multifunctional lake, including having the potential for freshwater fisheries resources with food fish and ornamental fish commodities, which have economic value and contribute to the main ecological processes in the aquatic environmental system, controlling the food web as consumers and prey for other

organisms, contributing on nutrient cycles, and shaping biophysical habitats through ecological engineering **(Villéger *et al.*, 2017)**.

Based on information in the study of **Hadiaty (2018)**, 17 types of endemic fish were found in Lake Towuti. Meanwhile, **Husnah *et al.*, (2006)** reported that the endemic fish species found included those from the genera *Oryzias*, *Glossogobius*, *Telmatherina*, *Paratherina*, and *Dermogenys*.

Medaka fish (*Oryzias profundicola*) is one of the species of the *Oryzias* genus in Lake Towuti. In the international language, it is called yellow-finned medaka or ricefish, while in the local language, it is called pangkilang fish **(Said *et al.*, 2015)**. Medaka fish have important economic and ecological value; therefore, their existence needs to be preserved. To preserve the medaka fish, it is necessary to study its reproductive potential. The data on the reproductive potential of trees can serve as a reference for maintaining its sustainability through domestication. This has been domesticated with different natural feeds on medaka fish (*O. profundicola*) **(Nursyahran *et al.*, 2023)**.

Basic information regarding the reproductive potential of fish can be obtained by reviewing the phenomena of gonad development. This phenomenon is used to predict the fish reproductive process, starting from gonad development until the fish spawn and produce seeds. The reproductive potential of each type of fish is different and can be influenced by human intervention, feed quality, and environmental factors. The fish reproductive potential includes spawning patterns, gonado somatic index, fecundity, egg diameter, and maturation time. Some freshwater fish such as *O. kalabu*, a relative of *O. vittatus* (nilem fish), have mature gonads every month, however peak spawning occurs in certain months at the end of the year **(Nasution *et al*., 2006)**.

The distribution of mature egg diameters in the ovary can be used to estimate the frequency of spawning, namely by looking at the mode that is formed. The length of time for spawning can be predicted from the diameter of the eggs. If the fish specimen has a short spawning time, then all the eggs that mature in the ovaries will be the same size. However, if the spawning time of the fish is long or continues over a long period of time, the eggs in the ovaries will have different sizes **(Omar, 2010)**.

The aim of the present research was to determine the reproductive potential of freshwater medaka fish (*Oryzias profundicola*), including fecundity, egg diameter and gonado-somatic index (GSI).

MATERIALS AND METHODS

Study area

The research was conducted for 6 months from January to June 2022 in Lake Towuti, South Sulawesi, Indonesia. The fish sampling locations were at Tanjung Timbala, Lengkobutanga Cape, Tanjung Bakara, Tanjung Saone, and Tanjung Tominanga (Fig. 1).

Sample collection

Medaka fish sample collection was carried out at each research station using a modified bag seser net with a mesh size of ¾ inch, a total length of one fishing gear unit of 15 meters, a height of 1.50 meters, and a bag length of 3 meters. The net is stretched at the bottom of the water, and each end is held by a fisherman, then another fisherman guides the fish into the net, and the net is simultaneously lifted to the surface and the entire catch is used as a sample. The location for sampling the medaka fish was determined using the global positioning system (GPS).

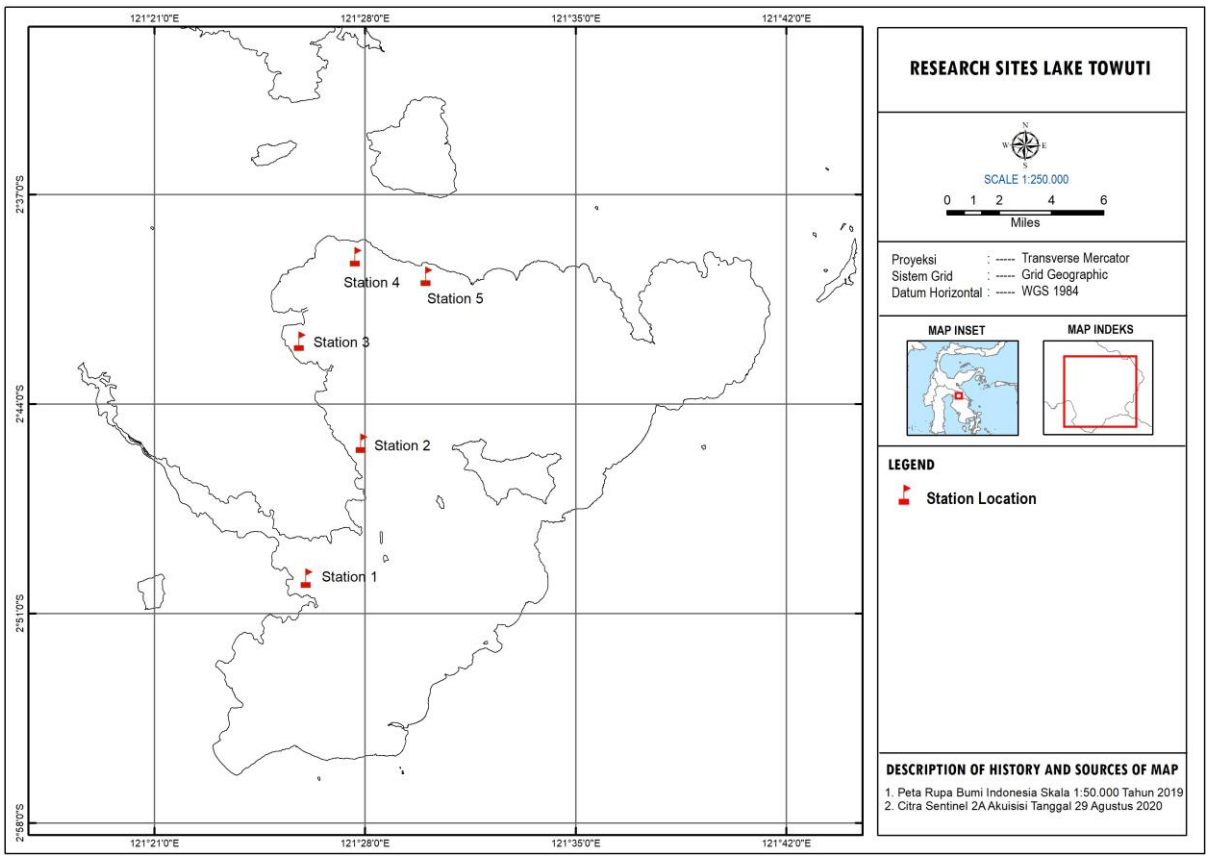


Fig. 1. Map of research locations **(Nursyahran *et al.*, 2022)**

Fish measurements

The catches obtained from each station were separated by gender and counted. The fish samples were preserved in 4% formalin for ±1 hour, and then the fish samples were rinsed using clean water and fixed with 70% alcohol. Subsequently, the caught fish were coded on a label stating the location where it was found.

Fecundity

The total fecundity was calculated using the direct calculation method, namely all eggs (of gonad maturity levels III & VI: GML III and GML IV) in the female's gonads used as samples **(Andy Omar *et al.*, 2012)**.

Egg diameter

The results of each egg diameter measurement were displayed with a histogram on GML III and GML IV. The egg diameter was calculated using the method of **Andy Omar *et al*. (2012)**, as follows:

$$Ds = \sqrt{Dh \times dv}$$

Where, Ds= Actual egg diameter (mm), Dh= Horizontal egg diameter (mm), dv= Vertical egg diameter (mm)

Gonado somatic index

The gonado-somatic index (GSI) was calculated using the formula of **Johnson (1971)**, as follows:

$$GSI = \frac{Wg}{W} \times 100\%$$

Where, GSI= Gonado somatic index (%), Wg= Gonad weight (g), W= Total weight (g).

Reproductive potential

The reproductive potential was calculated based on the percentage of the number of individuals and average total fecundity (FT) in each age group or mode. The reproductive potential was calculated based on **Conand (1987)** method, as follows:

$$PR = N \times FT$$

Where, PR= Reproductive potential; N= Number of individuals, and FT= Average total fecundity.

RESULTS

Fecundity

The fecundity of medaka fish at station 1 (Tanjung Timbala) ranged from 27 to 87 eggs (56± 15 eggs) for gonad maturity level III and from 65 to 175 eggs (104± 21 eggs) for gonad maturity level IV, as well as total fecundity was 15,157 eggs. At station 2 (Tanjung Lengkobutangan), fecundity for gonad maturity level GML III ranged from 31 to 84 eggs (47 ± 11 eggs) and GML IV ranged from 97 to 182 eggs (153± 20 eggs), and total fecundity was 11,369 eggs. At station 3 (Tanjung Bakara), fecundity ranged from 32 to 82 eggs (48± 15 eggs), gonad maturity level IV ranged from 58 to 182 eggs (105± 37 eggs), and total fecundity was 10,723 eggs. At station 4 (Tanjung Saone), fecundity ranged from 53 to 87 eggs (67± 10 eggs) for gonad maturity level III, gonad maturity level IV ranged from 81 to 146 (99± 13 eggs), and total fecundity was 14,842 eggs. Additionally, at station 5 (Tanjung Tominanga), fecundity ranged from 43 to 105 (73± 17 eggs) for gonad maturity level III, gonad maturity level IV ranged from 84 to 156 eggs (103± 84 eggs), as well as total fecundity was 18,385 eggs. Overall, the fecundity of medaka fish in Lake Towuti was 70,467 eggs, consisting of 24,292 GML III eggs, and 46,184 GML IV eggs.

The relationship between fecundity and total length of medaka fish is at a value of R^2= 0.3872, meaning that 38.72% of fecundity is influenced by total length, while the relationship between fecundity and total weight is at a value of **R^2= 0.6064**, meaning that 60.64% of fecundity is influenced by total weight (Fig. 2). The graph show that the heavier the fish, the higher the fecundity. Fish weight correlates with fecundity.

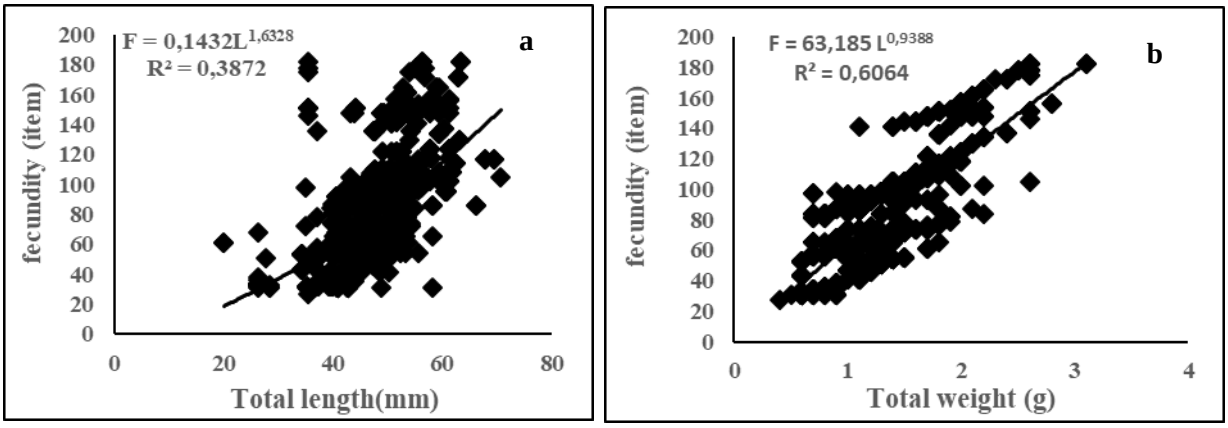
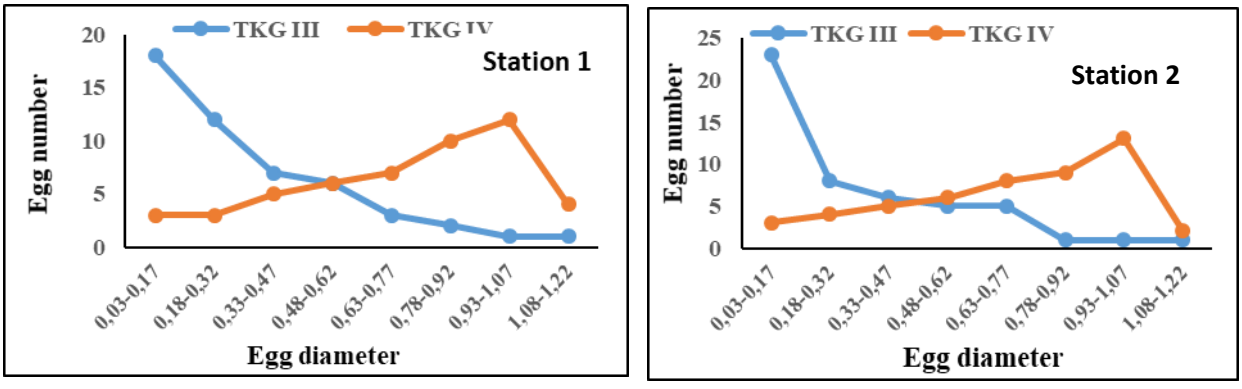


Fig. 2. Relationship between fecundity and total length: **(a)** Weight **(b)** At all stations

Egg diameter

The egg diameter of medaka fish in Lake Towuti at all stations was found to be between 0.03- 1.19mm with the highest frequency for gonad maturity level III in the range 0.03-1.08mm, while for gonad maturity level IV, it was in the range of 0.15- 1.19mm. Based on the analysis of the distribution of egg diameters at all stations, both gonad maturity levels (III and IV) found one peak mode. For all stations (1– 5), the peak mode egg diameter was found in the size range of 0.03- 0.17mm for gonad maturity level III, while for gonad maturity level IV, it was found in the size range of 0.93- 1.07mm (Fig. 3).



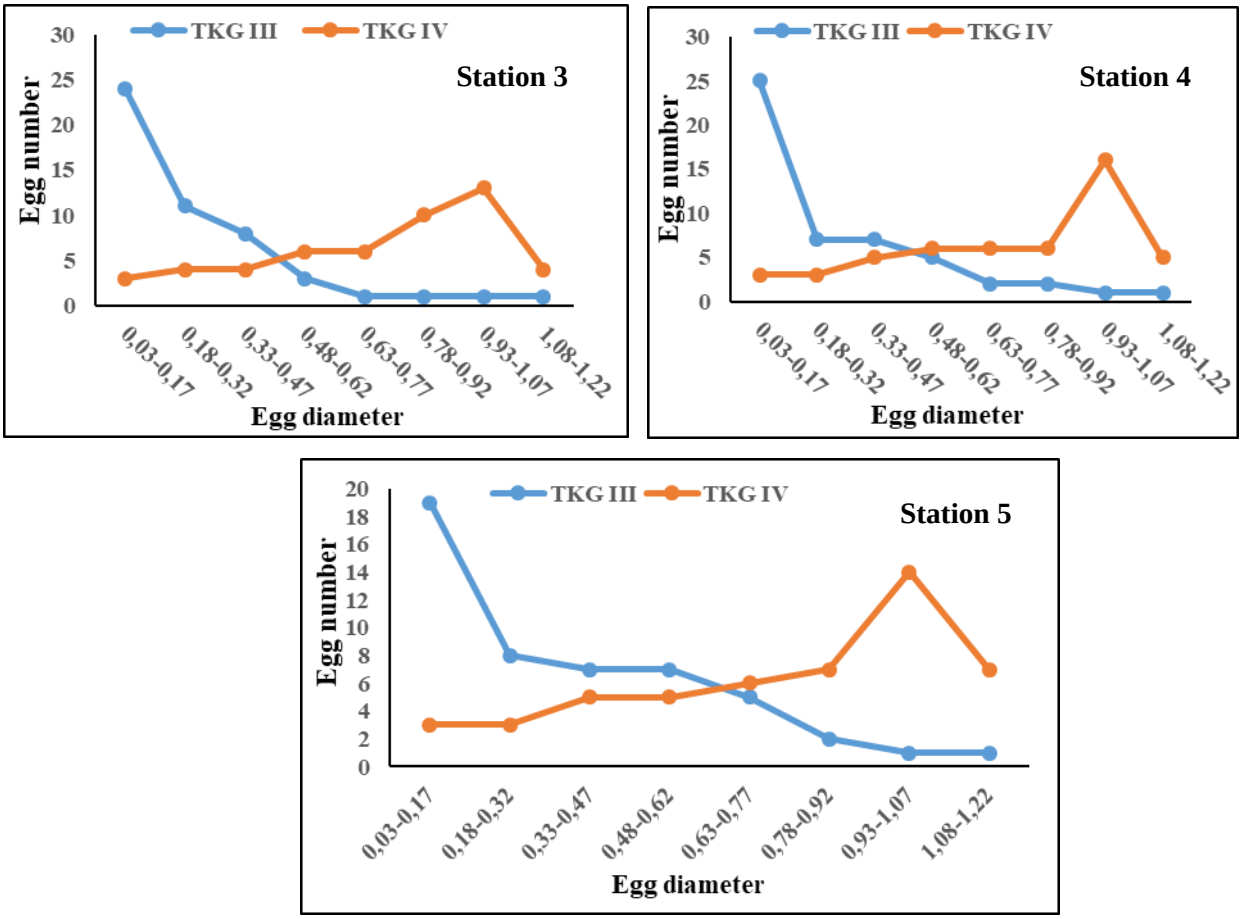


Fig. 3. The egg diameter of medaka fish for GML III and IV at all studied stations

Gonado-somatic index (GSI)

The results of the analysis of the average GSI values for male and female fish at each station based on sampling time are displayed in Fig. (4). Fig. (5) shows that the average GSI of male fish at station 1 during the research ranged from 0.77 to 1.56% and female fish ranged from 1.52 to 1.66%. The female GSI recorded every month was greater than the male GSI. The average GSI of male fish at station 2 was 1.13- 1.50% and female fish was 0.59- 1.67%. The female GSI was greater than the male GSI in each month. The results showed that the average GSI of male fish at station 3 during the research ranged from 0.87 to 1.60%, and female fish ranged from 1.37 to 1.65% (Fig. 4).

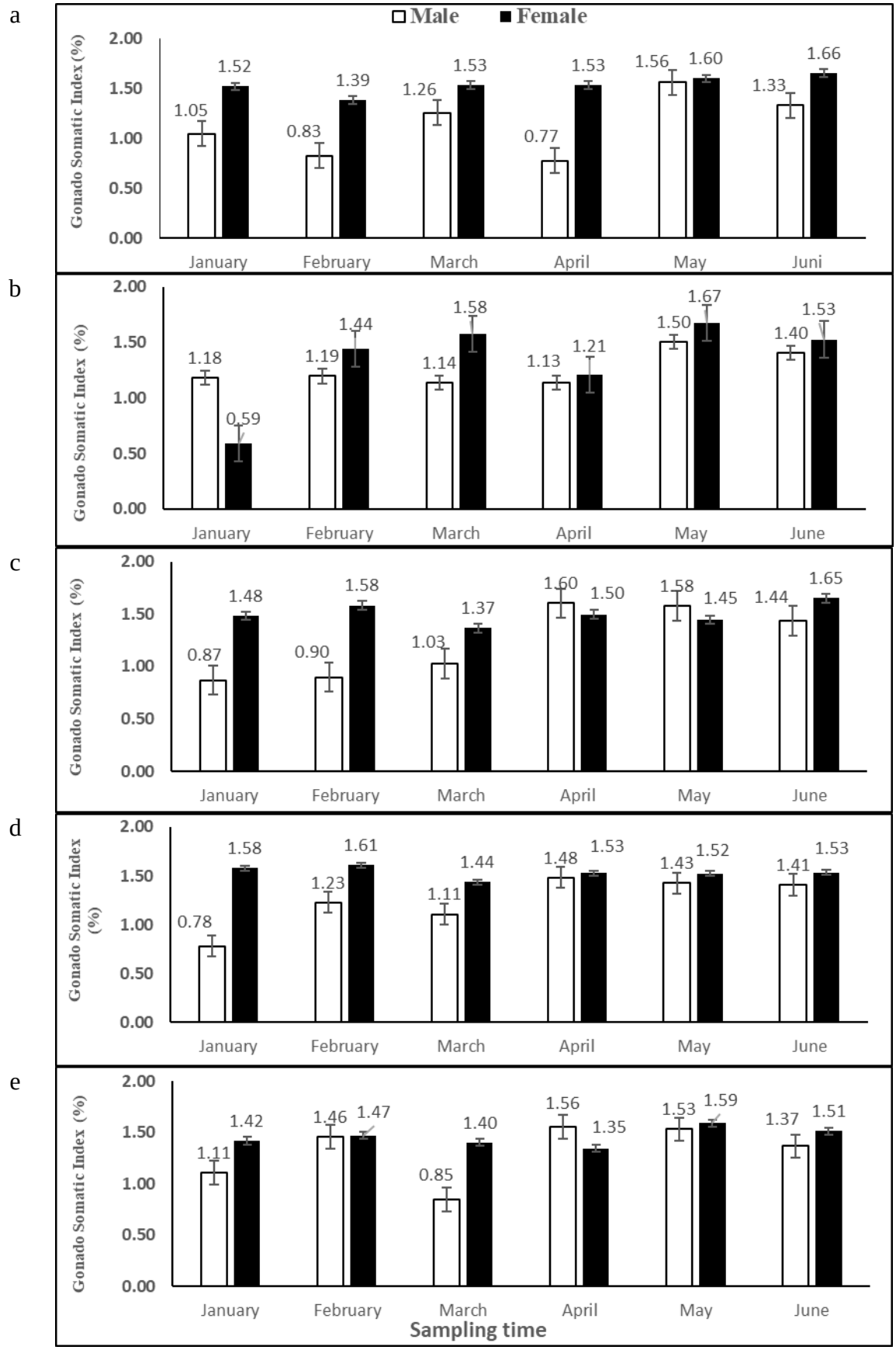


Fig. 4. The average value of gonado somatic index (%) of male and female medaka fish based on sampling time at station 1 **(a)** Tanjung Timbala, station 2 **(b)** Tanjung Lengkobutanga, station 3 **(c)** Tanjung Bakara, station 4 **(d)** Tanjung Saone, and station 5 **(e)** Tanjung Tominanga

The female GSI was larger than the male GSI in January, February, March and June. The data showed that the average GSI of male fish at station 4 during the study ranged from 0.78 to 1.48%, and female fish was at 1.44- 1.61% (Fig. 4). The female GSI was larger than the male GSI at the time of sampling. Furthermore, the results showed that the average GSI of male fish at station 5 during the study ranged from 0.85 to 1.56% and female fish was at 1.40- 1.59%. The female GSI was larger than the male GSI in every month except April (Fig. 4).

Based on the present data, different GSI fluctuations were shown in each month and at each station. The tendency for gonado-somatic index (GSI) of female fish was relatively greater than that of male fish, except in April and May at station 3 and April at station 5 (Fig. 4).

Reproductive potential

The reproductive potential is the product of the number of fish and the average fecundity. The reproductive potential of medaka fish at station 1 was 15,157 eggs, station 2 was 11,369 eggs, station 3 was 10,723 eggs, station 4 was 14,842 eggs, and station 5 was 18,385 eggs (Fig. 5).

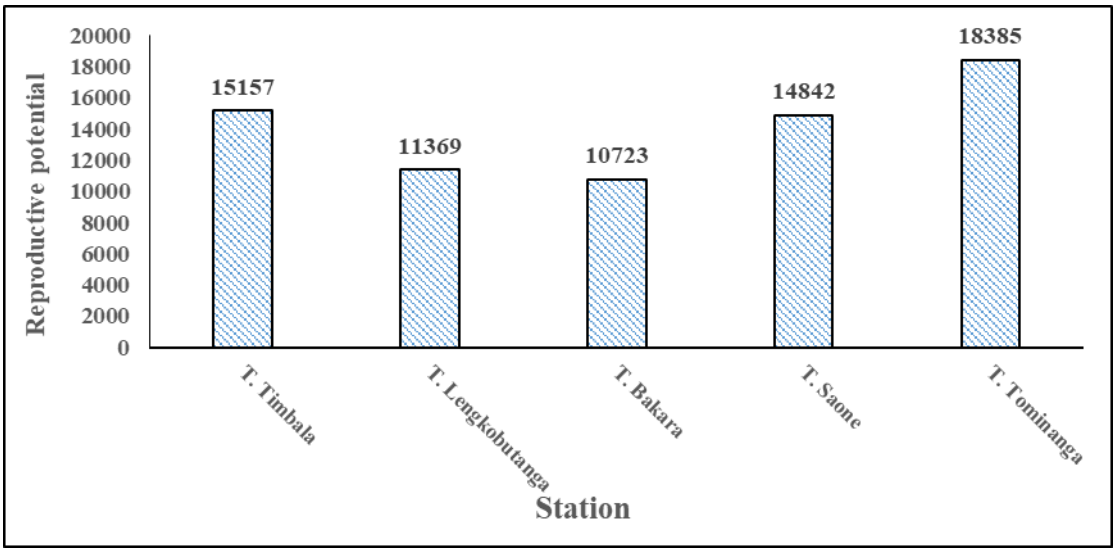


Fig. 5. The Reproductive potential of medaka fish in Lake Towuti

DISCUSSION

Fecundity is a variable of reproductive strategy in fish, in addition to sex ratio, size of first mature gonads, period and type of spawning, and oocyte development **(Gomiero *et al.*, 2008)**. Knowledge about the fecundity of a fish is very important since it can be used to evaluate the stock potential, life cycle, cultivation, and management of the species itself **(Hussain *et al.*, 2007)**. Fecundity is the number of eggs previously released by female fish during spawning **(Nursyahran *et al.*, 2021)**.

The fecundity of medaka fish in Lake Towuti based on location and time of research ranged from 27 to 182 eggs. The fecundity of this fish species is smaller than several endemic

fish of the same species, including lunjar fish (*O. marmoratus*) ranging from 20- 760 eggs **(Sulistiono, 2012a)**, and *O. nigrimas* fish ranging from 143- 243 eggs **(Serdiati, 2019)**. In Matano medaka fish (*O. matanensis*) a greater fecundity was recorded compared to the medaka fish (*O. profundicola*), with 22- 180 eggs **(Eragradhini, 2020)**. The occurrence of low fecundity in a fish species is thought to be related to its small body shape, as is the case with the beseng-beseng fish in the Maros River **(Jayadi *et al.*, 2016)**.

The amount of fecundity in the same species can be influenced by body size, age, environment, and egg diameter. The fish fecundity tends to increase with increasing body size, which is influenced by the amount of food and other environmental factors, such as temperature and season **(Kara & Bayhan, 2008)**.

The length of spawning time can be predicted from the frequency of egg diameter measurements. Egg diameter analysis was carried out to determine fish spawning patterns. There are two types of spawning patterns, namely total spawning and partial spawning. Fish ovaries that contain all the same or uniform-sized cooked eggs indicate a short spawning time. On the other hand, a long and continuous spawning time is indicated by the number of fish eggs of different sizes in the ovary **(Katiandagho & Marasabessy, 2017)**. Variations in average egg diameter and increase in egg diameter along with increasing total length, total weight, and ovary weight are caused by environmental factors and the level of fish gonad maturity **(Mostafa *et al.*, 2008)**.

The peak mode diameter of medaka fish eggs for GML III was found in the size range of 0.03- 0.15mm, while for GML IV it was found in the size range of 0.93- 0.1.07mm at all stations. Thus, the results of this study show that the distribution of egg diameter at all stations has only one highest peak mode at GML III and GML IV. The distribution of egg diameters varies at each station. The frequency of egg diameter in GML III decreased with increasing egg diameter, however in GML IV the frequency of egg diameter increased with increasing egg diameter. The distribution of egg diameter at the level of gonad maturity shows the fish spawning pattern. The frequency distribution of the diameter of medaka fish eggs varies in size at different GML. Fish with asynchronous ovulators are known as multiple spawners or partial spawning **(Muchlisin, 2014)**. Therefore, medaka fish are included in gradual spawning or partial spawning or long spawning. Fish that partially lay eggs have various sizes of eggs in their ovaries, indicating that all the eggs are not ready to be spawned **(Hunter, 1980)**. The length of egg-laying time is indicated by the number of differences in egg size in the ovary; therefore it can be said that, the egg diameter at each level of gonad maturity will reflect the spawning pattern **(Nursyahran *et al.*, 2021)**. The polymodal nature of the egg size frequency distribution over almost the entire length range predicts that the species may spawn one or more times over a long seasonal period **(Usman *et al.*, 2013)**.

The frequency distribution of the diameter of medaka fish in the ovaries did not reveal large differences between the levels of gonad maturity. From these results, it is known that the medaka fish is a partial spawning type that can spawn several times in one spawning season. This is found in other types of medaka fish, such as *O.matanensis* **(Eragradhini,**

2020), *O. marmoratus* **(Said & Mayasari, 2020)**, and *O. woworae* **(Firmansyah *et al.*, 2021)**. Gradual or partial spawning is found in endemic fish, viz. *T. ladigesi* **(Andriani, 2000; Nasution *et al.*, 2006; Kariyanti *et al.*, 2014; Jayadi *et al.*, 2016)**, *T. celebensis* **(Nasution *et al.*, 2007; Jayadi *et al.*, 2010)**, *Glossolepis incisus* **(Siby *et al.*, 2009)**, and *T. bonti* **(Nursyahran *et al.*, 2021)**.

The diameter of lunjar fish (*O. marmoratus*) eggs in Lake Towuti is 0.01- 1.10mm **(Sulistiono, 2012b)**, *O. nigrimas* fish individual is 266- 1166 microns **(Serdiati 2019)**, and medaka fish (*O. matanensis*) in Lake Matano is 0.05- 1.15mm **(Eragradhini, 2020)**. In research on *O. marmoratus* fish, *O. nigrimas* and *O. matanensis*, the egg diameter range is slightly smaller than that of *O. profundicola* fish. Several endemic fish in Lake Towuti that are reported to have a larger egg diameter range than medaka fish include the bonti-bonti fish specimen (*Telmatherina bonti*), which has an egg diameter range of 0.33- 1.85mm **(Nursyahran *et al.*, 2021)**.

Quantitative changes in the gonads can be identified as an index of gonadal maturity. By monitoring changes in the gonado somatic index from time to time, you can know the size at which fish individual starts to spawn. The IKG value of female medaka fish was higher than that of male medaka fish at all stations (Tanjung Timbala, Tanjung Lengkobutanga, Tanjung Bakara, Tanjung Saone and Tanjung Tominanga). Moreover, the IKG value from the results of this study is in accordance with the statement of **Effendie (2002)** that the IKG in male fish is generally smaller than in females. Furthermore, the IKG value of the endemic bonti-bonti fish in Lake Towuti is relatively small for male fish compared to female fish **(Nasution *et al.*, 2010; Andy Omar *et al.*, 2012)**. In addition, the IKG value of female beseng-beseng fish is greater than the IKG value of males **(Jayadi *et al.*, 2016)**. The IKG value of female *Glossogobius giuris* fish is higher than that of males in Lake Limboto **(Juliana *et al.*, 2018)**. The IKG value from the results of this research is in accordance with research by **Eragradini (2020)** who elucidated that female Matano medaka fish individual has a higher IKG value than male fish.

The highest IKG value of male and female medaka fish at station 1 Tanjung Timbala was found in March 2022. Moreover, the highest IKG value of male medaka fish at station 2 Tanjung Lengkobutanga was found in March 2022 and female fish in May 2022. Furthermore, the highest IKG value of male medaka fish was in station 3 Tanjung Bakara was found in March 2022 and females in February and May 2022. In addition, the highest IKG value of male medaka fish at station 4 Tanjung Saone was found in April 2022 and females in February 2022, while the highest IKG value of male medaka fish was recorded at station 5 Tanjung Tominanga during February 2022 and females during March 2022. Thus, the spawning peak of male and female medaka fish in Lake Towuti ranged from February to March 2022.

The gonado somatic index value of medaka fish is quite high in both male and female fish. This shows that this fish species can spawn in almost all stations. However, station 3 Tanjung Bakara and station 5 Tanjung Tominanga are thought to be the spawning places for medaka fish in Lake Towuti since fish were found with the highest gonado somatic index

values for both male and female fish, and it is possible that the microhabitat at each station is different.

Several endemic fish species are reported to have different spawning peaks. The peak of bonti-bonti fish spawning in Lake Towuti is in May and November **(Nasution *et al.*, 2010)**. The peak of the spawning of *O. marmoratus* fish is in July **(Sulistiono, 2012b)**. The peak of peras fish spawning in the Menduk River occurs from May to August **(Suhendra *et al.*, 2017)**. Moreover, the peak spawning of *O. nigrimas* fish occurs in June and August **(Serdiati, 2019)**. Furthermore, the peak spawning of *O. matanensis* fish occurs from August to September **(Eragradhini, 2020)**. Additionally, the peak spawning of Pleco fish, *Pterygoplichthys pardalis* in the Ciliwung River is in February and May **(Elfidasari *et al.*, 2022)**.

CONCLUSION

Based on the research results, it can be concluded that the reproductive potential of the medaka fish (*O. profundicola*) in Lake Towuti, an endemic species, is robust. This conclusion is based on the fecundity values, egg diameter, gonado somatic index (GSI), and the results of calculations of reproductive potential. These findings indicate that the population is well-protected from extinction.

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