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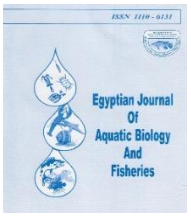


# Reproduction potential of the Medaka fish (*Oryzias profundicola*) as an endemic fish in Lake Towuti

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## ABSTRACT

This research aims to determine the reproductive potential of medaka fish (*Oryzias profundicola*) including fecundity, egg diameter, gonado somatic index (GSI). This research was carried out from January to June 2022. The sampling location was Lake Towuti, 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 with 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 TKG III and 65-175 eggs (104 ± 21 eggs) for TKG IV, as well as total fecundity (15,157 eggs). Station 2 (Tanjung Lengkobutangan) fecundity for TKG III ranged from 31-84 eggs (47 ± 11 eggs) and TKG IV ranged from 97-182 eggs (153 ± 20 eggs), and total fecundity (11,369 eggs). The diameter of medaka fish eggs in Lake Towuti at all stations was found to range between 0.03-1.19 mm with the highest frequency for TKG III in the range 0.03-1.08 mm, while for TKG IV in the range 0.15-1. 19 mm. 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 is 15,157 eggs, station 2 is 11,369 eggs, station 3 is 10,723 eggs, station 4 is 14,842 eggs and station 5 is 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 is 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 by **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; so their existence needs to be preserved. To preserve the medaka fish, it is necessary to study its reproductive potential. Data on the reproductive potential of trees but can be used 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. 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, but 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 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 is 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 at Lake Towuti, South Sulawesi, Indonesia. Fish sampling locations were: 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 with 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, then the net is lifted simultaneously to the surface and the entire catch is

used as a sample. The location position of sampling the medaka fish was determined using Global positioning system (GPS).

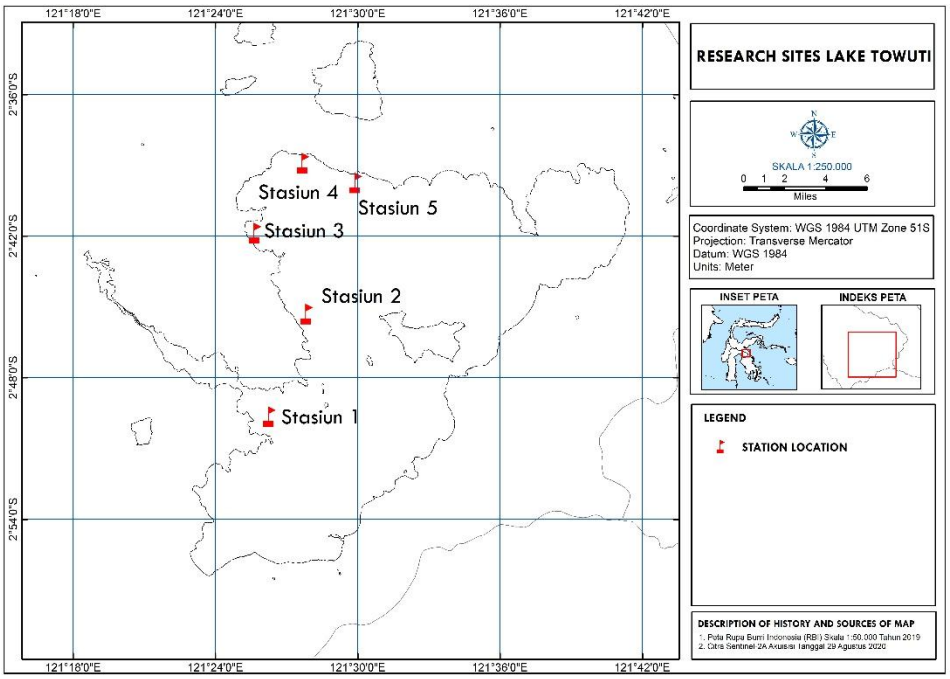


**Fig. (1). Map of research locations (Source: Nursyahran *et al.*, 2022)**

**Fish measurements**

The catches obtained from each station were separated according to 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. Then the caught fish is coded on a label stating the location where it was found.

**Fecundity**

Total fecundity was calculated using the direct calculation method, namely all eggs (of gonad maturity levels III & VI: TKG III and TKG IV) in the females gonads were used as samples **(**according to **Andy Omar *et al*., 2012).**

**Egg diameter**

The results of each egg diameter measurement were displayed with a histogram on TKG III and TKG IV. Egg diameter is calculated as follows **(Andy Omar *et al*., 2012):**

$$Ds = \sqrt{Dh \; x \; dv}$$

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 **Johnson** formula **(1971):**

$$GSI = \frac{Wg}{W} \; x \; 100\%$$

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

### Reproductive potential

Reproductive potential is calculated based on the percentage of the number of individuals and average total fecundity (FT) in each age group or mode. Reproductive potential is calculated based on **Conand (1987),** namely:

$$PR = N \times FT$$

Where: PR= Reproductive potential, N= number of individuals, 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 TKG III ranged from 31 to 84 eggs (47 ± 11 eggs) and TKG 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), and 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 and gonad maturity level IV ranged from 81 to 146 (99 ± 13 eggs), and total fecundity was 14,842 eggs and at station 5 (Tanjung Tominanga), fecundity ranged from 43 to 105 (73 ± 17 eggs) for gonad maturity level III and 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 TKG III eggs and 46,184 TKG IV eggs.

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

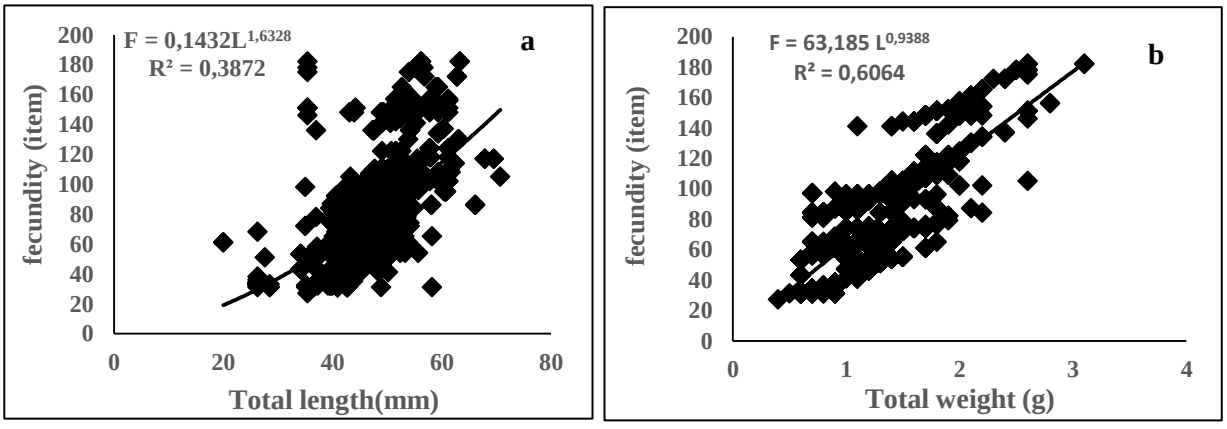


**Fig. (2). Relationship between fecundity and total length (a) and weight (b) at all stations**

### Egg diameter

The egg diameter of medaka fish in Lake Towuti at all stations was found to be between 0.03-1.19 mm with the highest frequency for gonad maturity level III in the range

0.03-1.08 mm, while for gonad maturity level IV in the range 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 0.03-0.17 mm for gonad maturity level III, while for gonad maturity level IV it was found in the size range of 0.93 -1.07 mm **(Fig. 3)**.

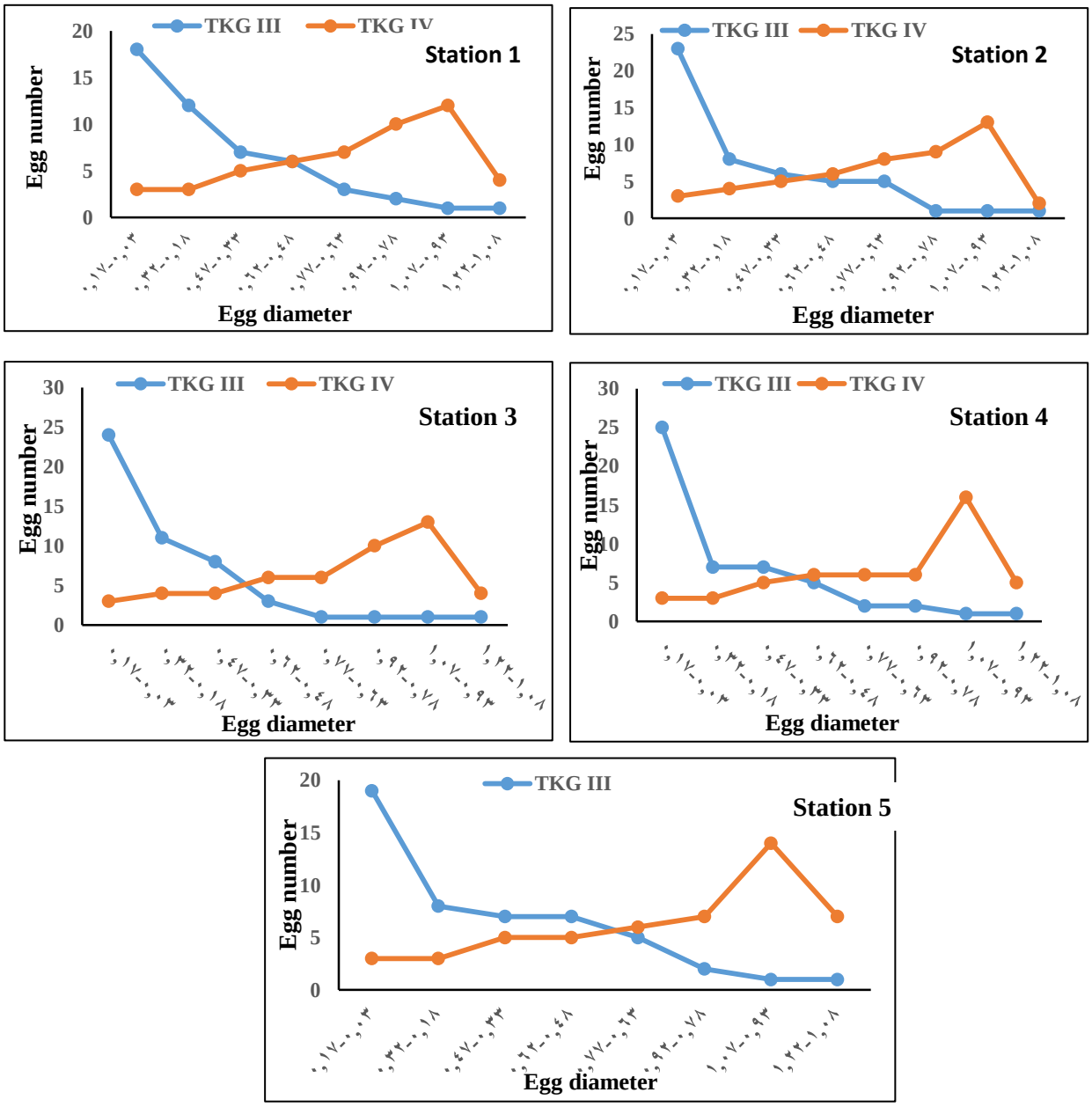


**Fig. (3). Egg diameter of medaka fish for TKG III and IV at all studied stations**

**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 can be seen in **Fig. (4)**. Figure 5 showed that the average GSI of male fish at Station 1 during the research ranged from 0.77 to 1.56% and female fish from 1.52 to 1.66%. Female GSI is greater than male GSI every month. The average GSI of male fish at station 2 was 1.13-1.50% and female fish was 0.59-1.67%. Female GSI was greater than male GSI in each month. 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 from 1.37 to 1.65% **(Fig. 4)**.

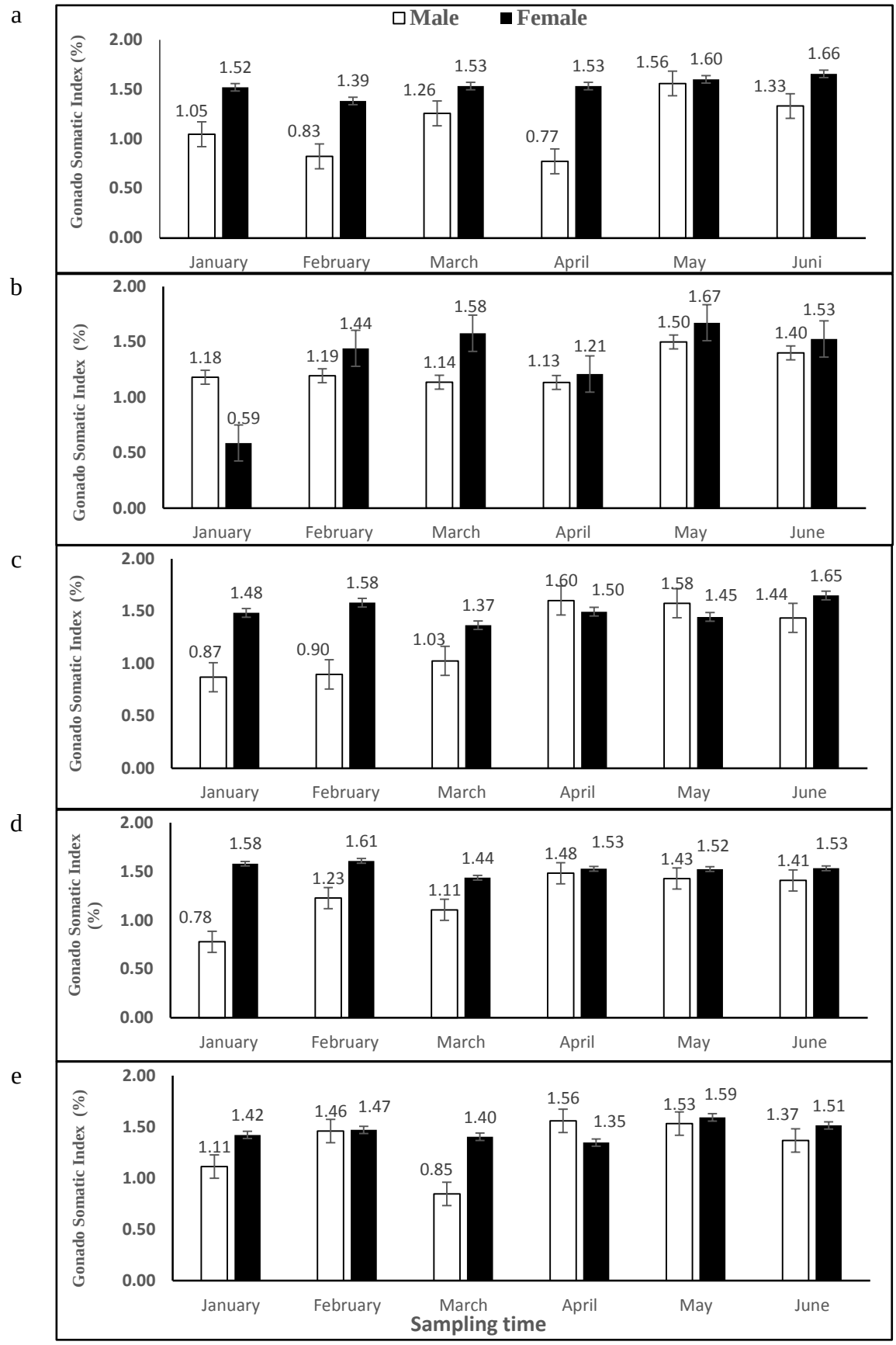


**Fig. (4). The average value of Gonado Somatic Index (%) of male and female medaka fish based on sampling time at station 1 Tanjung Timbala (a), station 2 Tanjung Lengkobutanga (b), station 3 Tanjung Bakara (c), station 4 Tanjung Saone (d) and station 5 Tanjung Tominanga (e).**

Female GSI is larger than male GSI in January, February, March and June. 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 1.44-1.61% **(Fig. 4)**. The female GSI is larger than the male GSI at the time of sampling. Also, 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 1.40-1.59%. Female GSI is larger than 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**

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)**.

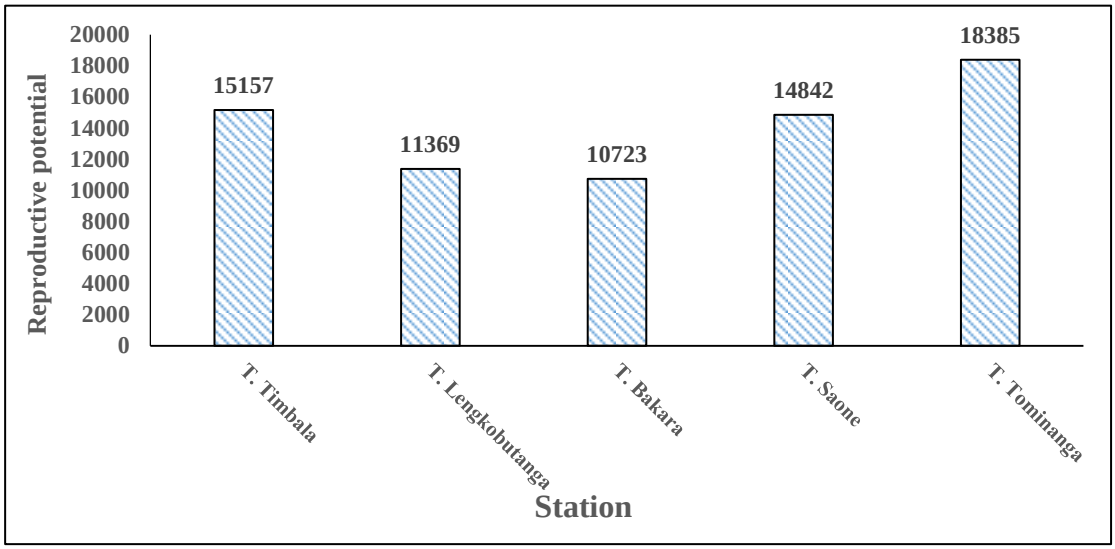


**Fig. (5). Reproductive potential of medaka fish in Lake Towuti**

## 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 because 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 eggs to 182 eggs. The fecundity of this fish is smaller than several endemic fish of the same species, including lunjar fish (*O. marmoratus*) ranging from 20-760 eggs **(Sulistiono, 2012a),** *O. nigrimas* fish ranging from 143-243 eggs **(Serdiati, 2019).** Matano medaka fish (*O. matanensis*) found greater fecundity than medaka fish (*O. profundicola*), namely 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. 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 TKG III was found in the size range of 0.03-0.15 mm, while for TKG IV it was found in the size range of 0.93-0.1.07 mm 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 TKG III and TKG IV. The distribution of egg diameters varies at each station. The frequency of egg diameter in TKG III decreased with increasing egg diameter but in TKG 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 TKG. 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 are found to have various sizes of eggs in the ovaries so 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, so 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 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. woworae* **(Firmansyah *et al.*, 2021),** *O. marmoratus* **(Said & Mayasari, 2020).** Gradual or partial spawning is found in endemic fish viz. *T. ladigesi* **(Andriani, 2000; Jayadi et al., 2016; Kariyanti *et al.*, 2014; Nasution *et al.*, 2006).** *T. celebensis* **(Jayadi *et al.*, 2010; Nasution *et al.*, 2007).** *Glossolepis incisus* **(Siby *et al.*, 2009),** *T. bonti* **(Nursyahran *et al.*, 2021).**

The diameter of lunjar fish (*O. marmoratus*) eggs in Lake Towuti is 0.01-1.10 mm **(Sulistiono, 2012b),** O. nigrimas fish is 266-1166 microns **(Serdiati 2019),** medaka fish (*O. matanensis*) in Lake Matano is 0 .05-1.15 mm **(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 (*Telmatherina bonti*) which has an egg diameter range of 0.33-1.85 mm **(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 Indeks from time to time, you can know the size at which fish start 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). The IKG value from the results of this study is in accordance with the statement **(Effendie, 2002**) that the IKG in male fish is generally smaller than in females. The IKG value of the endemic bonti-bonti fish in Lake Towuti is relatively small for male fish compared to female fish **(Andy Omar *et al.*, 2012; Nasution *et al.*, 2010).** 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)** that female Matano medaka fish have 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. The highest IKG value of male medaka fish at station 2 Tanjung Lengkobutanga was found in March 2022 and female fish in May 2022. 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. The highest IKG value of male medaka fish at station 4 Tanjung Saone was found in April 2022 and females in February 2022, but 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 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 because 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 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).** The peak spawning of *O. nigrimas* fish occurs in June and August **(Serdiati, 2019).** The peak spawning of *O. matanensis* fish occurs from August to September **(Eragradhini, 2020).** 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 as an endemic fish is very good for protecting its population from extinction based on fecundity values, egg diameter, gonado somatic indeks (GSI) and the results of calculations of reproductive potential.

## REFERENCES

**Andriani. (2000).** Bioekologi, morfologi, kariotip dan reproduksi ikan hias rainbow Sulawesi (Telmatherina ladigesi) di Sungai Maros, Sulawesi Selatan. IPB.

**Andy Omar, S. Bin**. **(2010).** Aspek reproduksi ikan nilem, *Osteochilus vittatus* (Valenciennes 1842) di Danau Sidenreng, Sulawesi Selatan. Jurnal Iktiologi Indonesia **10**(2): 111-122.

**Andy Omar, S.; Salam, R.; Umar, M.T.** and **Kune, S. (2012).** Biologi reproduksi ikan endemik bonti-bonti , Paratherina striata Aurich , 1935 di Danau Towuti. Seminar Nasional Tahunan IX Hasil Penelitian Perikanan Dan Kelautan, July 2012, BP-03.

**Conand, F. (1987).** Biologie et Ecologie des Poissons Pelagiques du Lagon de Nouvelle – Caledonie Utilisable Comme Appat Thonier. These de Doctorat d'Etat, Univ. Bretagne Occidentale, Brest. 235 pp.

**Effendie.M.I. (2002).** Biologi perikanan. Yayasan pustaka nusatama.

**Elfidasari, D., Puspaningtias, F.C.** and **Fahmi, M.R. (2022).** Reproductive Biology Pleco (Pterygoplichthys pardalis Castelnau 1855) in Ciliwung River. Jurnal Pembelajaran Dan Biologi Nukleus, **8**(2): 247–262.

**Eragradhini, A. R. (2020).** Ekobiologi dan Reproduksi Ikan Matano Medaka, *Oryzias matanensis* (Aurich , 1935) di Danau Towuti Sulawesi Selatan. Universitas Hasanuddin Makassar.

**Firmansyah, M. A.; Mustahal, M.; Syamsunarno, M. B. and Herjayanto, M. (2021).** Optimization of reproduction of ricefish endemic to Southeast Sulawesi *Oryzias woworae* Parenti & Hadiaty, 2010 through different sex ratios in spawning. Jurnal Iktiologi Indonesia, **21**(3), 235–251.

**Gomiero, L.M.; Garuana, L.** and **Braga, F.M.S. (2008).** Reproduction of *Oligosarcus hepsetus* (Cuvier, 1829) Characiformes in the Serra do Mar State Park, São Paulo, Brazil. Brazilian Journal of Biology, **68**(1): 187–192.

**Hadiaty, R. K. (2018).** Status taksonomi iktiofauna endemik perairan tawar Sulawesi. Jurnal Iktiologi Indonesia, **18**(2): 175-190.

**Hunter, J.R. (1980).** The Feeding Behavior and Ecology of Marine Fish Larvae. Fish Behavior and Its Use in the Olpture and Culture of Fishes, 287–327.

**Husnah, S.** and **Makmur, S. (2006).** Riset keanekaragaman hayati dan bahan perumusan pengelolaan jenis ik an endemik perairan pedalaman di Sulawesi. Laporan Teknis. PusatRiset Perikanan Tangkap.

**Hussain, M.A.; Khatun, M.R.** and **Hossain, M.A. (2007).** On the fecundity and sex-ratio of Botia Dario (Hamilton) (Cypriniformes : Cobitidae). University Journal of Zoology, Rajshahi University, **26**: 27–29.

**Jayadi, J.; Hadijah, S.; Tang, B.** and **Husma, A. (2016).** Biologi reproduksi ikan beseng-beseng (Marosatherina ladigesi Ahl, 1936) di beebrapa sungai di Sulawesi Selatan. Jurnal Iktiologi Indonesia, **16**(2): 185–198.

**Jayadi, J.; Hamal, R.** and **Arifuddin, (2010).** Reproduksi ikan endemik rainbow Sulawesi Telmatherina celebensis di Danau Matano Sulawesi Selatan. Torani (Jurnal Ilmu Kelautan Dan Perikanan), **20**(1): 44–48.

**Johnson, J.E. (1971).** Maturity and fecundity of threadfin shad, Dorosoma petenense (*Gunther*), in Central Arizona reservoirs. Transaction of the American Fisheries Society, **100**(1): 74-85

**Juliana, Koro, Y., and Lamadi, A. (2018).** Domestikasi dan Apalikasinya Terhadap Ikan Manggabai (1st ed.)

**Kara, A.** and **Bayhan, B. (2008).** Length-weight and length-length relationship of the bogue, *Boops boops* (Linneaus, 1758) in Izmir Bay (Aegean Sea of Turkey). Belgian Journal of Zoology, **138**(2): 154–157.

**Kariyanti, Omar, S.B.A.** and **Tresnati, J. (2014).** Analisis Fekunditas dan Diameter Telur Ikan Beseng-Beseng (*Marosatherina ladigesi* Ahl, 1936) Sungai Pattunuang Asue dan Sungai Bantimurung, Kabupaten Maros, Sulawesi Selatan. Simposium Nasional I Kelautan Dan Perikanan, November, 1–10.

**Katiandagho, B.** and **Marasabessy, F. (2017).** Potensi Reproduksi, Pola Pemijahan Serta Alternatif Pengelolaan Ikan Kembung Laki-Laki (Rastrelliger kanagurta) Di Sekitar PesisirTimur Perairan Biak. Agrikan: Jurnal Agribisnis Perikanan, **10**(2): 51.

**Mostafa, Z.; Haque, M.R.; Afsana, D.** and **Tareque, A.M.H. (2008).** Fecundity of *Liza parsia* (Hamilton) and relationship between length-weight and fecundity. Fisheries (Bethesda), **16**(Salojarvi 1987): 65–70.

**Muchlisin, Z.A. (2014).** A General overview on some aspects of fish reproduction. Aceh International Journal of Science and Technology, **3**(1): 43–52.

**Nasution, S.H.; Muschsin, I.** and **Sulistiono, S. (2010).** Potensi rekrut Ikan Bonti-Bonti (*Paratherina striata* Aurich) Di Danau Towuti, Sulawesi Selatan. BAWAL Widya Riset Perikanan Tangkap, **3**(1): 45. https://doi.org/10.15578/bawal.3.1.2010.45-55

**Nasution, S.H.; Lukman, S.S D.** and **Fauzi, T.H. (2006).** Aspek Reproduksi Ikan Beseng Beseng (*Telmatherina ladigesi* Ahl) darl beberapa sungai dl sulawesi selatan. Prosiding Seminar Nasional Ikan I V, Jatiluhur, 29-30 Agustus (2006), pp.: 83-93

**Nasution, S.H.; Sulistiono, S.; Sjafei, D.S.** and **Haryani, G.S. (2007).** Distribusi Spasial dan Temporal Ikan Endemik (Telmatherina celebensis Boulenger) di Danau Towuti Sulawesi Selatan. Jurnal Penelitian Perikanan Indonesia, **13**(2): 95.

**Nursyahran, N.; Jayadi, J.; Tamsil, A.** and **Harlina. (2023).** Domestication of yellow-finned medaka fish (*Oryzias profundicola*). AACL Bioflux, **16**(1): 524–533.

**Nursyahran, N.; Kariyanti, K.; Ilmiah, Jayadi, J.** and **Yusuf, A. (2021).** Fecundity and egg diameter of endemic fish ( Telmatherina bonti Weber and De Beaufort , 1922 ) from Towuti Lake , South Sulawesi , Indonesia. International Journal of Fisheries and Aquatic Studies, 9(3), 378–382.

**Said, D. S**. and **Hidayat.** (2015). 101 Ikan Hias Air Tawar. LIPI Press

**Said, D.S.** and **Mayasari, N. (2020).** *Oryzias mamoratus*, Si Marmer dari Danau Towuti, Sulawesi Selatan. WARTA IKTIOLOGI, **4**(3): 19–23.

**Serdiati, N. (2019).** Karakterisasi ikan padi oryzias nigrimas (kottelat, 1990) sebagai upaya pengelolaan ikan endemik di danau poso sulawesi tengah. Universitas Brawijaya.

**Siby, L. S., Rahardjo, M. F. and Sjafei, D. S. (2009).** Biologi Reproduksi Ikan Pelangi Merah (*Glossolepis incisus*, Weber 1907) di Danau Sentani. Jurnal Iktiologi Indonesia, **9**(1), 49–61

**Suhendra, C.; Utami, E.** and **Umroh, U. (2017).** Reproductive Biology Of fish Keperas (Cyclocheilichthys apogon) in Menduk River, Bangka Regency. Akuatik Jurnal Sumberdaya Perairan, **11**(1): 1–11.

**Sulistiono, S. (2012a).** Reproduction of tank goby (*Glossogobius giuris*) in Ujung Pangkah waters, East Java. Jurnal Akuakultur Indonesia, **11**(1): 64-75.

**Sulistiono, S. (2012b).** Reproduksi Ikan Lunjar (*Oryzias marmoratus*) di Danau Towuti Sulawesi Selatan. Agrisains, **13**(1): 55–65.

**Usman, B.I.; Amin, S.M.N.; Arshad, A.** and **Aminur Rahman, M. (2013).** Fecundity and egg size of grey-eel catfish, *Plotosus canius* (Hamilton, 1822) from the coastal waters of Kampong Telok, Negeri Sembilan Peninsular Malaysia. Asian Journal of Animal and Veterinary Advances, **8**(2): 348–354.

**Villéger, S.; Brosse, S.; Mouchet, M.; Mouillot, D.** and **Vanni, M.J. (2017).** Functional ecology of fish: current approaches and future challenges. Aquatic Sciences, **79**(4): 783–801.

**Whitten, A.J.; Bishop, K.D.; Nash, S.V.** and **Clayton, L. (1987).** One or more extinctions born Sulawesi, Indonesia? Conservation Biology, **1**(1): 42–48.