

Length-weight relationship and condition factors of Matano medaka (*Oryzias matanensis* Aurich, 1935) in Towuti Lake, South Sulawesi, Indonesia

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Abstract. Matano medaka (*Oryzias matanensis*) is an endemic fish in Towuti Lake, South Sulawesi. This study was aimed to determine the growth pattern and condition factors of Matano medaka. Samples were collected from November 2017 to October 2018. During the study 880 fish samples were obtained containing 410 males and 470 females. The total body length ranged 25-54 mm and weight ranged 1.04-3.73 g. The result showed that the growth pattern for male and female were negative allometric with the condition factor ranging from 0.56-1.80.

Key Words: allometry, condition factors, *Oryzias matanensis*, Matano medaka, Lake Towuti.

Introduction. Indonesian waters are the home of the genus *Oryzias*, where you can find half of the species in the genus (Parenti 2008). However, high diversity in Indonesia has not been accompanied by the proper knowledge regarding these species (Fahmi et al 2018). Matano medaka *Oryzias matanensis* (Aurich 1935) is one of the several endemic fish in Matano Lake (Makmur et al 2007). The population is quite scarce in Matano Lake, but quite abundant in Towuti Lake. Lake Matano and Towuti Lake form a unified lake system, connected by Petea and Tominanga River (Nomosatriyo et al 2013). Fish in the genus *Oryzias* are usually found near the water surface, where they usually feed. The male fish has brighter colors and filaments on the dorsal and anal fin than female fish (Kottelat & Whitten 1996).

Matano medaka is an ornamental fish, but it is also a fish consumed and exploited by local people. Information obtained from the community indicates that there is a decreased population of medaka, caused by various factors, including unenvironmental friendly fishing activities, habitat degradation, and foreign species introduction (Kinoshita et al 2009).

The declining population raises the extinction concern for Matano medaka (*Oryzias matanensis*) inhabiting the Towuti Lake. For example, Bonti-bonti fish (*Paratherina striata* Aurich, 1935) is an endemic fish in Towuti Lake, suspected to decrease in population due to ecosystem changes and high exploitation level. Nasution (2007) found that the exploitation rate of Bonti-bonti fish was 0.56 per year, then Umar et al (2012) added that the exploitation rate of Bonti-bonti fish increased to 0.85 per year. The data proves that the Bonti-bonti fish have reached overexploitation. The same outcome can happen for Matano medaka (*Oryzias matanensis*), in Towuti Lake, if preventive measures are not taken immediately. Therefore, extinction prevention and habitat conservation efforts can be performed, and information based on the growth pattern analyzed from the length-weight relationship and condition factor are important.

Length-weight relationship is an important tool in fisheries management (Lawson et al 2013), with wide application in fish biology (Ahmadi 2018). The length-weight

relationship offers necessary information regarding stock evaluation and the status of the fish population (Patel et al 2014).

The study of length-weight relationship and condition factor of *Oryzias matanensis* in Towuti Lake has never been conducted. This is evidenced by the unavailability of such information for researchers and the public. Published researches on the endemic fish in Towuti Lake are about Butini fish (*Glossogobuis matanensis*) by Sulistiono et al (2014), Bonti-bonti fish (*Paratherina striata*) by Nasution et al (2007), rainbow selebensis fish (*Telmatherina celebensis*) by Nasution (2007) and lunjar fish (*Oryzias marmoratus*) by Sulistiono (2012). Therefore, this study results on the length-weight relationship and condition factor of Matano medaka are important, as they add to the information available for the public and researchers, that study *Oryzias matanensis* sustainable management.

Material and Method

Period and location. This study was conducted in Towuti Lake, South Sulawesi (Figure 1) for 12 months from November 2017 to October 2018 with 1 month sampling interval.

We established two monitoring stations in Towuti Lake. Station selection was based on differences in substrate, the presence of water plants, and the presence of fish.

Site 1: Tanjung Bakara, with GPS coordinates S = 02° 40' 48" and E = 121° 25' 55", located in an area affected by sawmill production (wood cutting into planks), high human activity in fisheries and households, with water plants at 1-10 m water depth, and a substrate made of sand, mud, and stone.

Site 2: Towuti Lake, where Tominanga River drains, with GPS coordinates S = 02° 39' 55" and E = 121° 31' 42", a location unaffected by human activities and households, with no water plants at 1-20 m water depth, with a substrate made of sand, stone, and gravel.



Figure 1. The map location of Matano medaka sampling in Towuti Lake.

Sampling and sample handling. Fish were collected using rectangular nets, a modified fishing net measuring 10 m in length, 1 m width, and 12.7 mm mesh size, made of multifilament material. The net was stretched at the bottom of the water and held by two fishermen at the end of the net. The third fisherman leads the fish into the net. The net is then raised from both sides, at the same time, to the surface, and all captured fish were taken as samples.

The length-weight relationship of Matano medaka was analyzed in the Fish Biology Laboratory, Department of Fisheries, Faculty of Marine Sciences and Fisheries, Hasanuddin

University, Makassar. Fish were measured for their total length, from the tip of the snout to the tip of the longer lobe of the caudal fin, using a vernier caliper with 0.01 mm accuracy and weighted using a digital scale with 0.001 g accuracy. Fish were separated based on their sexes. Morphologically, these fish have secondary sexual characteristics of dimorphism, where male fish have a more attractive color than female fish. However, this only applies if the fish are still alive. When in a state of death, this fish is morphologically indistinguishable. The fish will change color quickly so that it cannot be distinguished between male and female fish anymore. Therefore, sex is determined by dissecting the abdomen and observing the gonads to differentiate between male and female fish.

Data analysis. The formula used to determine the relationship of length and weight was

$$W = aL^b$$

whereas W is the body weight (g), L is body length (mm), while a and b are constants (Ayoade & Ikulala 2007). T-test ($p < 0.05$) was performed to determine whether $b = 3$ or not, as $b = 3$ means that fish has isometric growth, while $b \neq 3$ means that fish has allometric growth (Effendie 2002). The condition factor was calculated using the equation:

$$K = \frac{W_b}{W^*}$$

whereas K is the condition factor, W_b is the observed fish weight (g) and W^* is the predicted fish weight (g) (Anibeze 2000).

Results

Length and weight relationship. The total of Matano medaka captured during the study was 880 fish, containing 410 male and 470 female fish. The analysis result of the length-weight relationship can be seen on Table 1.

Table 1

The length-weight relationship of Matano medaka (*Oryzias matanensis*) in Towuti Lake

Parameter	Male	Female
Total sample (individuals)	410	470
Total length range (mm)	25 - 48	24 - 54
Total weight range (g)	1.05 - 3.25	1.04 - 3.73
Regression coefficient (b)	2.0367	2.2444
Growth type	Hipoallometric	Hipoallometric

Table 1 shows that male Matano medaka (*Oryzias matanensis*) have the length and weight range of 25 – 48 mm and 1.05 – 3.25 g respectively, while female fish have the length and weight range of 24 – 54 mm and 1.04 – 3.73 g respectively. The average length and weight of male Matano medaka were 34 mm and 2.03 gr respectively, while the average length and weight of female Matano medaka were 34 mm and 2.06 g respectively.

The regression coefficient (b) between male and female Matano medaka fish was less than 3 ($b < 3$), where the value of b in male fish is 2.0367, and in female fish is 2.2444. It indicates that the growth type of male and female Matano medaka is hipoallometric growth (negative allometric), which means that the body length accelerates faster than the bodyweight (Omar et al 2015).

Based on morphological characters, fish at station 1 Tanjung Bakara are the same population as the one found at station 2 Towuti Lake Inlet. The total capture result length-weight range of Matano medaka based on the observatonal stations can be seen on Table 2.

Table 2

The total capture, length and weight range of Matano medaka (*Oryzias matanensis*) based on the observational station results

Station	Male			Female		
	Length range (mm)	Weight range (g)	N (fish)	Length range (mm)	Weight range (g)	N (fish)
Tanjung Bakara	25 – 48	1.05 – 3.23	254	24 – 52	1.08 – 3.73	270
Towuti Lake Inlet	25 – 48	1.07 – 3.25	156	24 – 54	1.04 – 3.66	200

Table 2 presents the total of captured fish from Tanjung Bakara station, with 524 fish (59.55%), comprising 254 male fish and 270 female fish. Station Towuti Lake Inlet obtained 356 fish (40.45%), comprising 156 male fish and 200 female fish.

The body length and weight both on male and female fish at station Tanjung Bakara and station Towuti Lake Inlet was relatively identical. The male body length and weight range from station Tanjung Bakara were 25 - 48 mm and 1.05 - 3.23 g respectively, while female fish had body length and weight range of 24 - 52 mm and 1.08 - 3.73 g respectively. The body length and weight range from station Towuti Lake Inlet were 25 - 48 mm and 1.07 - 3.25 g respectively, while the female fish had body length and weight of 24-54 mm and 1.04-3.66 g, respectively.

The analysis result of length- weight relationship showed strong correlation value (r) between length and weight of Matano medaka (*Oryzias matanensis*) in Towuti Lake. The correlation coefficient (r) value on length-weight relationship obtained for male Matano medaka was 0.8695 and for female fish was 0.8523 (Figure 2).

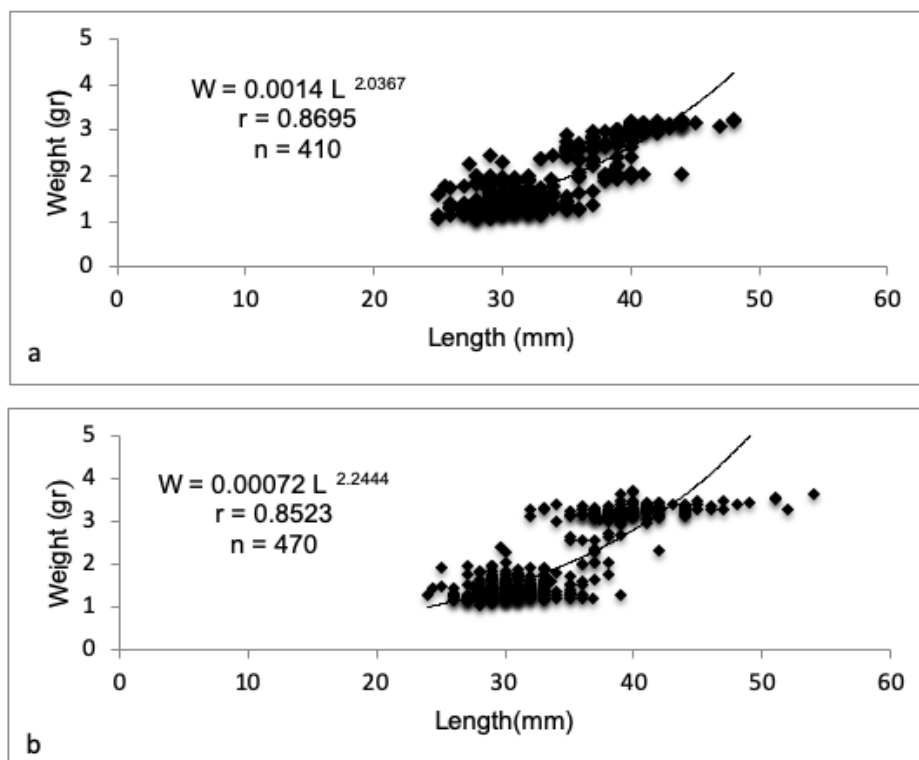


Figure 2. Length-weight relationship of Matano medaka (*Oryzias matanensis*) at both stations in Towuti Lake: a) male fish and b) female fish.

Condition factor. The monthly condition factor value of Matano medaka in a year fluctuated. The male fish condition factor was relatively smaller than the female fish. The

average condition factor value in a year on Matano medaka ranged from 0.61 to 1.80 for males and from 0.47 to 1.98 for females. The highest condition factor of male fish was found in September, while the lowest one was found in March. The highest condition factor of female fish was found in October, while the lowest one was found in April (Figure 3).

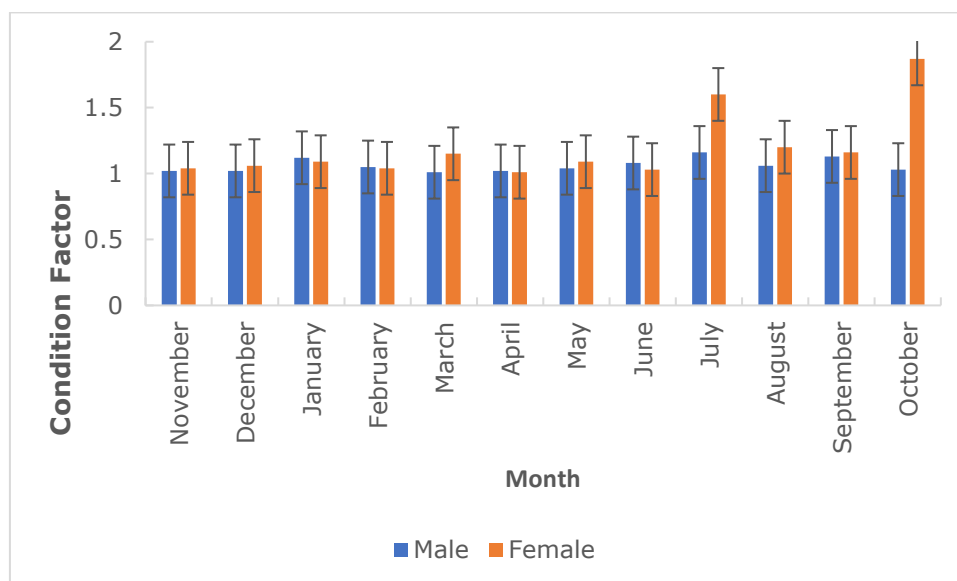


Figure 3. Average condition factor of Matano medaka (*Oryzias matanensis*) in Towuti Lake.

In addition to the gender, the condition factor of Matano medaka was also analysed based on the observation stations. The value factor of the condition of Matano fish on each station can be seen in Table 3.

Table 3

The condition factor of Matano medaka (*Oryzias matanensis*) in Towuti Lake at the observation stations

Station	Male				Female			
	N	Range	Average	SD	N	Range	Average	SD
Tanjung Bakara	254	0.67 – 1.76	1.02	0.18	270	0.49 – 1.98	1.02	0.18
Towuti Lake Inlet	156	0.61 – 1.58	1.01	0.16	200	0.62 – 1.83	1.01	0.17

Table 3 shows the range of condition factors (with SD being the standard deviation) between male and female Matano medaka fish is not very different, so it can be said that the male and female Matano medaka fish have the same ability to adapt to their environment.

Based on the station, the range of condition factors at Tanjung Bakara station is higher than the Towuti Lake Inlet station. It shows that there is enhanced physical capacity of male and female Matano medaka fish for survival and reproduction at Tanjung Bakara station.

Discussion

Length-weight relationship. The growth patterns of fish determine the relationship between the length and weight of fish, the selectivity of fishing gear, the environmental conditions, and it could also measure the Index of Plumpness which aims to distinguish the fish populations relative health (Barrata et al 2019).

Growth is physically expressed as the total cells and size of cells alteration formed as body tissue in a certain period, which is then calculated in length or weight units (Rahardjo et al 2011). The fish growth is influenced by different factors, such as temperature, salinity, acidity level (pH), geographical position (Jennings et al 2001); seasons, habitat, feed movement, fish health (Zhu et al 2008); feed availability, gonad development, and spawning period (Dewi et al 2018).

Based on the statistical analysis, the correlation coefficient (b) obtained in both male and female fish is less than 3 ($b < 3$). This indicates that the growth type of male and female Matano medaka is hipoallometric growth (negative allometric) which means that the grows faster in length than in body weight (Omar et al 2015).

Additionally, Froese (2006) also states that the value of b is in the normal range if it is in the ranges between 2.5 - 3.5. Therefore, the relationship between total length and body weight of male and female Matano medaka fish means that the length is increasing faster than the gain in body weight, but within the normal range. According to Froese (2006), this type of negative allometric growth pattern causes fish body shape to tend to be fusiform, which reduces lateral oscillations in water and that makes it easier to move up and down in the water column (Webb 1984). Matano medaka fish has a fusiform body shape based on its morphological characters. Thus, it is assumed that Matano medaka fish have an excellent ability to move actively in the water.

The pattern of hipoallometric growth (negative allometric) is also found for the endemic fish Rono Lindu (*Oryzias sarasinorum* Popta, 1905) in Lindu lake, Central Sulawesi (Gani et al 2015) as well for the endemic opudi fish (*Telmatherina prognatha*) at Matano lake (Chadijah et al 2019). Umar et al (2012), defines the growth patterns of Bonti-bonti male and female fish (*Paratherina striata*), in Towuti Lake as positive allometric which means a more accelerated expansion in body weight than the rise in body length. Besides positive and negative allometric growth patterns, endemic fishes in Towuti lake also have isometric growth patterns such as the opudi fish (*Telmatherina prognatha*), studied by Nasution (2007). The growth patterns of organisms, especially fish, can change and differ in the same population, depending on the environmental conditions, availability of food, variations in the number and size of fish observed, and the responses to habitat differentiation (Kharat et al 2008; Patimar et al 2009; Aisyah et al 2014).

Correlation coefficient (r) values obtained for the length-weight relationship of male Matano medaka fish are 0.8189 and 0.8640 for the female fish. It means a strong correlation (r) is present between the length and the weight of the Matano medaka (*Oryzias mattanensis*) fish in Towuti Lake.

Based on the number and size of caught fish, the male and female Matano medaka fish found at Tanjung Bakara station, indicates that the characteristics of this station are optimal for Matano medaka fish. This area is a space that has a diversity of water plants and rocks which help the fish to hide from predators quickly. Risnawati et al (2015), argued that medaka fish (*Oryzias* sp.) generally like muddy substrates and aquatic vegetation due to the function of protection and the presence of optimal spawning ground.

Condition factor. Condition factor is an important part of growth for fish population analysis to provide the fish body shape (Salim et al 2019). The value of fish condition factor is influenced by age, sex, food, and maturity level of gonads (Fafioye & Oluajo, 2005).

The condition factor of the Matano medaka fish during the study showed a smaller range in males (0.61 - 1.80) than in females (0.47 - 1.98).

Nasution (2007), stated that the condition factor value of male opudi endemic fish (*Telmatherina prognatha*) in Towuti Lake, had smaller value than female fish. The range of condition factor value in males was 0.93 - 1.21, while for females was 1.09 - 1.26. The same pattern is also found in opudi fish (*Telmatherina prognatha*) endemic fish in Matano lake, which had a smaller range of relative condition factors in male fish (0.9864 ± 0.2084) than in female fish (1.0121 ± 0.1571) (Chadijah et al 2019).

Gani et al (2015) found that the condition factor value of Rono Lindu endemic fish (*Oryzias sarasinorum*) in Lindu Lake, Central Sulawesi, had relatively larger condition factor value in male than female fish. The range value of the male Rono Lindu fish condition factor was 0.601 - 1.634, while for the female fish was 0.649 - 1.549.

The difference in the value of the condition factors can show an indication of various biological traits of the fish, such as obesity, environment adaptability, gonad development, gonad maturation level, and spawning season (Saranga et al 2018). The value of condition factor will increase towards the peak of the spawning period and decrease after the spawning process is complete, due to the fact that the primary energy source is used by fish for gonad development and spawning processes (Rahardjo & Simanjuntak 2008).

Overall, the range of condition factors for Matano medaka fish caught at Tanjung Bakara station is more extensive than those caught at Towuti Lake Inlet station. This situation represents that Tanjung Bakara Station has a more qualified physical capacity for survival and reproduction of male and female Matano medaka fish. This happens because Tanjung Bakara station has aquatic plants functioning as a sheltered place for the Matano medaka fish, while station Towuti Lake Inlet has no aquatic plants, which is the reason why Matano medaka fish are hardly found in that area. Emre et al (2010) emphasized that the value of the condition factor depends on various circumstances such as ecology, season, quality of food, and the quality of water, where the fish live (Özdemir & Erk'akan 2012).

Conclusions. The study results conclude that:

1. The growth pattern of male and female Matano medaka is hipoallometric (negative allometric), which means that the body length accelerates faster than the bodyweight.
2. The condition factor of Matano medaka male fish is smaller than female fish. Based on the condition factor, we conclude that fish have better environmental conditions, including for spawning, in Tanjung Bakara station area, because this station has aquatic plants functioning as a shelter and feeding ground for the Matano medaka fish.

References

- Ahmadi, 2018 Length-weight relationship and condition factor of the *Mystus nigriceps* from Sungai Batang River, Indonesia. *International Journal of Innovative Studies in Aquatic Biology and Fisheries* 4(3):26-35.
- Aisyah S., Darma B., Desrita D., 2014 [Biological reproduction aspect of Lemeduk fish (*Barbodes schwanenfeldii*) in Belumai River, Deli Serdang Regency, North Sumatera Province]. *Jurnal Aquacoastmarine* 6(1):21-31 [in Indonesian].
- Anibeze C. I. P., 2000 Length-weight relationship and relative conditions of *Heterobranchus longifilis* (Valenciennes) from Idodo River, Nigeria. *Naga, the ICLARM Quarterly* 23 (2):34-35.
- Aurich, 1935 *Oryzias matanensis* in GBIF Secretariat (2017). GBOF Backbone Taxonomy checklist dataset.
- Ayoade A. A., Ikulala A. O. O., 2007 Length-weight relationship, condition factor and stomach contents of *Hemichromis bimaculatus*, *Sarotherodon melanotheron* and *Chromidotilapia guentheri* (Perciformes: Cichlidae) in Eleiyele Lake, Southwestern Nigeria. *Rev. Biol. Trop. (Int. J. trop. Biol.)* 55(3-4):969-977.
- Barrata, Yanti A. H., Setyawati T. R., 2019 [Growth pattern of Peam fish (*Leptobarbus melanopterus*) in Sentarum Lake National Park, Kapuas Hulu Regency]. *Protobiont* (2019) Vol. 8 (1):1-5 [in Indonesian].
- Chadijah A., Sulistiono, Haryani G. S., Affandi R., Mashar A., 2019 [Size distribution, growth pattern, and condition factor of endemic Opudi fish (*Telmatherina prognatha*) in Lake Matano, South Sulawesi]. *Jurnal Ilmu Pertanian Indonesia (JIPI)* Vol. 24 (4):295-303 [in Indonesian].
- Dewi I. A., Halili, Arami H., 2018 [Length-weight relationship and condition factor of Silver biddy fish (*Gerres filamentosus*) caught in Sero at Tondonggeu Waters Abeli district Kendari City]. *Jurnal Manajemen Sumberdaya Perairan* 3(4):263-271 [in Indonesian].
- Effendie M. I., 2002 [Fisheries Biology]. Yayasan Pustaka Nusantara. Yogyakarta [in Indonesian].

- Emre Y., Balik I. C., Sumer D. A., Oskay H. O., Yesilcimen, 2010 Age, growth, length-weight relationship and reproduction of the striped seabream (*Lithognathus mormyrus* L., 1758) (Sparidae) in the Beymelek Lagoon (Antalya, Turkey). *Turk J Zool*, 34:93-100.
- Fafioye O. O., Oluajo O. A., 2005 Length-weight relationships of five fish species in Epe lagoon, Nigeria. *African Journal of Biotechnology* 4(7): 749-75.
- Fahmi M. R., Prasetyo A. B., Vidiakusuma R., 2018 [Potential medaka fish (*Oryzias woworae*, *Oryzias javanicus* and *Oryzias profundicola*) as ornamental fish and model fish]. *Prosiding Seminar Nasional Ikan ke 8. Masyarakat Ikhtologi Indonesia* [in Indonesian].
- Froese R., 2006 Cube law, condition factor and weight-length relationships: metanalysis and recommendations, *Journal of Applied Ichthyology*, vol. 22, no. 4, hal. 241-253.
- Gani A., Nilawati J., Rizal A., 2015 [Study of habitat and feeding habits (food habit) of rono lindu fish (*Oryzias sarasinorum* Popta, 1905) in Lake Lindu, Central Sulawesi]. *Jurnal Sains dan Teknologi Tadulako* 4(3):9-18 [in Indonesian].
- Jennings S., Kaiser M. J., Reynolds J. D., 2001. *Marine Fishery Ecology*. Blackwell Publishing, Oxford. 417 p.
- Kharat S. S., Khillare Y. K., Dahanukar N., 2008 Allometric scalling in growth and reproduction of a freshwater loach *Nemacheilus mooreh* (Sykes 1839). *Electronic Journal of Ichthyology*. 1:8-17.
- Kinoshita M., Kenji M., Kiyoshi N., Minoru T., 2009 *Medaka. Biology Management and Experimental Protocols*. Wiley-Blackwell Publishing. Iowa USA.
- Kottelat M., Whitten A. J., 1996 *Freshwater Fishes of Western Indonesia and Sulawesi: Additions and Corrections*. Periplus Edition. Hongkong.
- Lawson E. O., Akintola S. L., Awe F. A., 2013 Length-weight relationships and morphometry for eleven fish species from Ogudu Creek, Lagos, Nigeria. *Advances in Biological Research* 7(4):122-128.
- Makmur S., Asaad A. I. J., Mustapia I., Burhanuddin A. I., Slamet S., Suryaningrat S., Irawan B., 2007 [Endemic fish biotechnology research in Lake Matano, South Sulawesi]. *Balai Riset Perikanan Perairan Umum. Laporan Teknis*. 50 hal [in Indonesian].
- Nasution S. H., 2007 Growth and condition factor of rainbow selebensis (*Telmatherina celebensis* Boulenger) in Lake Towuti, South Celebes. *Indonesian Fisheries Research Journal* 13(2):117-123.
- Nasution S. H., Sulistiono, Sjafei D. S., Haryani G. S., 2007 [Spatial and temporal distribution of endemic rainbow selebensis (*Telmatherina celebensis* Boulenger) in Lake Towuti, South Sulawesi]. *Jurnal Penelitian Perikanan Indonesia*. 12(2) [in Indonesian].
- Nomosatryo S., Henny C., Jones C. A., Michiels C., Crowe S. A., 2013 [Tropic characteristics and classification in Lake Matano and Lake Towuti, South Sulawesi]. *Prosiding Pertemuan Ilmiah Tahunan MLI I. Cibinong* [in Indonesian].
- Omar S. B. A., Fitrawati R., Sitepu F. G., Umar M. T., Nur M., 2015 [Growth pattern of White-Spotted Spinefoot (*Siganus canaliculatus* Park, 1797) in the waters of the North Coast of the Selayar Islands Regency]. *Torani* 25(3): 169-177 [in Indonesian].
- Özdemir F., Erk'akan F., 2012 Growth and reproductive properties of an Endemic Species, *Gobio hettitorum* Ladiges, 1960, in Yeşildere Stream, Karaman, Turkey. *Journal Biological & Chemical*. 40 (4), 457-468.
- Parenti L. R., 2008 A phylogenetic analysis and taxonomic revision of medaka, *Oryzias* and relatives (Beloniformes, Adrianichthyidae). *Zoological Journal of the Linnean Society* 154(3):494-610.
- Patel V., Shukla S. N., Patel S., 2014 Studies on length-weight relationship and ponderal index of *Cyprinus carpio* in Govindgarh Lake, Rewa (M.P). *Journal of Chemical Biological and Physical Sciences* 4(2):1183-1187.
- Patimar R., Yousefi M., Hosieni S. M., 2009 Age, growth and reproductive of the sand smelt *Atherina boyeri* Risso, 1810 in the Gomisha wetland-southeast Caspian Sea. *Journal Estuarine, Coastal, and Shelf Science*. 81:457-462.

- Popta, 1905 *Oryzias sarasinorum* in GBIF Secretariat (2019). GBOF Backbone Taxonomy checklist dataset.
- Rahardjo M. F., dan Simanjuntak C. P. H., 2008 [Length-weight relationship and condition factors of Tetet fish *Johnius belangerii* Cuvier (Pisces: Sciaenidae) in Mayangan Beach, West Java]. *Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia*, 15(2):135–140 [in Indonesian].
- Rahardjo M. F., Sjafei D. S., Affandi R., Sulistiono, Hutabarat J., 2011 [Ichthyology]. Penerbit Lubuk Agung. Bandung. 395 [in Indonesian].
- Risnawati M. R., Umar, Andriani I., 2015 [Population distribution and ecology of medaka fish *Oryzias* spp. in the waters of Maros River, Maros Regency, South Sulawesi]. *Hasanuddin University Repository* 2015: 1–9 [in Indonesian].
- Salim G., Firdaus M., Heriyana 2019. [Analysis of the relationship between length, weight, and condition factors of tempakul fish (*Periophthalmus barbarus*) in the Mangrove and Bekantan Conservation Area, Tarakan City]. *Jurnal Harpodon Borneo* 12(1):20–32 [in Indonesian].
- Saranga R., Manengkey J. I., Asia, Arifin M. Z., 2018 [Growth, sex ratio, condition factors, and size structure of Selar fish (*Crumenophthalmus*) from waters around Bitung]. *Jurnal Sains dan Teknologi Frontiers* 1 (3):257–271 [in Indonesian].
- Sulistiono, 2012 [Reproduction of Lunjar fish (*Oryzias marmoratus*) in Lake Towuti]. *Jurnal Agrisains* 13 (1):55–65 [in Indonesian].
- Sulistiono, Firmansyah A., Sofiah S., Brojo M., Affandi R., dan Mamangkey J. J., 2014 [Biological aspect of Butini fish (*Glossogobius matanensis*) in Lake Towuti, South Sulawesi]. *Jurnal Ilmu Perairan dan Perikanan*, Vol 14 (1):12–22 [in Indonesian].
- Umar M. T., Omar S. B. A., Suwarni, Salam R., 2012 [Growth study of Bonti-bonti fish (*Paratherina striata* Aurich, 1935) in Lake Towuti, South Sulawesi]. *Prosiding Seminar Nasional Ikan 2012*. Yogyakarta [in Indonesian].
- Webb P. W., 1984 Form and function in fish swimming. *Scientific American* Vol. 251 (1): 56-68.
- Zhu G., Xu L., Zhou Y., Dai X., 2008 Length-frequency compositions and weight-length relations for big eye tuna, yellowfin tuna. (Perciformes: Scombrinae) in the Atlantic, Indian, and Eastern Pacific Oceans. *Acta Ichthyologica Et Piscatoria* 38(2):157-161.

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