Length-Weight Ratio and Condition Factor of Endemic Fish *Oryzias nigrimas* (Kottelat, 1990) in Poso Lake, Central Sulawesi

N Serdiati¹, D Arfiati², M S Widodo³, T D Lelono³, A Masyahoro¹, N Hasanah¹ and A Gani³

¹Faculty of Animal Husbandry and Fisheries, Tadulako University, Palu, Indonesia
²Faculty of Fisheries and Marine Science, Brawijaya University, Malang, Indonesia
³Faculty of Fisheries, Muhammadiyah University, Luwuk Banggai, Indonesia

E-mail: novalinaserdiati@untad.ac.id

**Abstract.** This research aimed to evaluate the length-weight relationship (LWR) and condition factor of the endemic fish *Oryzias nigrimas* in Lake Poso and took place from May 2017 until April 2018. A total of 645 *O. nigrimas* samples were analysed (137 males and 508 females). The length-weight equation was \( W = 3.95 \times 10^6 L^{2.346} \) for males and \( W = 3.95 \times 10^6 L^{2.107} \) for females. The LWR coefficient \( b \) was \( b = 2.346 \) for males and \( b = 2.107 \) for females (combined value 2.155) which means that \( b < 3 \), indicating *O. nigrimas* is a fish with an allometric negative growth pattern. The condition factor ranged from 0.945-1.091 for males and 0.940-1.107 for females. Overall, the condition factor (Kn) ranged from 0.940 - 1.091, indicating that the sampled fish could be considered in a normal condition. Kn appeared to be related to reproduction with the average Kn value of both male and female fish, being highest in September and February during peak spawning seasons.

1. **Introduction**

Poso Lake is in Central Sulawesi Province, Poso Regency, with a geographical position of Latitude 144°02’04” South and Longitude 120°32’-120°43’ East, approximately 50 km south of Poso City. Poso Lake is an ancient lake whose formation is the result of tectonic activity in this region, located at an altitude of 500 asl (above sea level) [1]. Poso Lake is an oligotrophic lake that has little organic material content and has a high productivity, with a maximum depth of 450 m and an area of 32,320 ha. It is the second deepest and the third largest lake in Indonesia [2]. The environmental conditions are still natural so that this lake retains a unique biodiversity with a variety of endemic organisms.

Endemic fish species that inhabit Poso Lake include: *Adrianichthys kruyti, A. roseni, Xenopoecilus poptae, X. oophorus, Mugilogobius amadi, Nomorhamphus celebensis, Oryzias nigrimas, O. orthognathus*, and *O. nebulosus* [3-5]. Three fish species, *A. kruyti, X. poptae* and *M. amadi* are thought to be extinct.

*Oryzias nigrimas* is a fish that only inhabits fresh, shallow waters with many aquatic plants [3,6]. *O. nigrimas* is one of the species whose populations are still commonly found in Poso Lake, and has a local name of *ikan rono*; because of its bitter taste, the people around the lake call it bitter rono (*rono pahit*) [7]. *O. nigrimas* is small, beautiful coloured and has an elongated body shape. Until now, no one has reported on aspects of the relationship between the length of the weight and the condition of this fish. However, this information is important because it is one of the basic considerations in studying *O. nigrimas* fisheries resources in Poso Lake.

Quantitative aspects of information such as the length and weight relationships are important in the study of fish biology; among other uses, they are used to compare life cycles [8], compare and describe characteristics of fish populations between sexes and between seasons [9] and to describe the...
morphological aspects of fish populations inhabiting different areas [10]. Condition factors can be used as indicators of the health of fish populations [11] and indicators of individual energy levels and overall quality during reproduction [12]. Studying condition factors is important for understanding the life cycle of fish species, and can contribute to the management of a given species of fish [13]. This study aimed to examine the length-weight relationship and the condition factors of the fish *O. nigrimas* in Poso Lake.

2. Material and Method

This study was conducted in the waters of Poso Lake, Central Sulawesi, from May 2017 to April 2018. The collection of sample fishes (specimens) was conducted monthly at three observation stations selected based on surveys identifying the habitat of *O. nigrimas* [7]. Station one: Watudilana waters, in the northern part of Poso Lake; station two: in the waters of Tolambo Village, in the eastern part of Poso Lake; and station three: in the waters of Taipa Village, located in southwest Lake Poso.

Fish sampling was done randomly at each fishing station by using a fishing net with a mesh size of 1 mm. The fish caught at each location were counted. The total length of the fish was measured using digital callipers with 0.01 mm precision and body weight was determined using digital scales with a precision of 0.01 g. Gender was determined by observing body shape and colour [3-5].

Analysis of the fish length-weight relationship used the equation [14]:

\[ W = aL^b \]  

(1)

where: *W* = body weight (g), *L* = total length (mm), *a* is the coefficient of body shape, and *b* is an exponent which is an indication of the relationship between weight and length growth dimensions [15]. The *W=aL^b* relationship was then converted into logarithmic form to give a straight-line relationship with the equation:

\[ \log W = \log a + b \log L \]  

(2)

The value of *b* obtained is used to determine the growth pattern: *b* = 3 indicates isometric growth i.e. the length increase is directly proportional to the weight gain; a value of *b* > 3 indicates positive allometric growth, i.e. weight gain is faster than length increase; *b* <3 indicates allometric negative growth, i.e. a slower weight gain compared to length increase.

The value of the condition factor (K) in fish with slightly flattened or compressed bodies ranges from 2.0 to 4.0 while in fish that were less flat or fusiform it is generally in the range 1.0 - 3.0 [16]. The value of the condition factor is calculated based on the length-weight relationship using the relative condition factor (Kn), defined as:

\[ Kn = \frac{W}{W_{est}} \]  

(3)

where: Kn = relative condition factor, *W* = sampled fish weight (g), *W* _est_ = estimated sampled fish weight based on the length of the fish.

3. Results and Discussion

A total of 645 *Oryzias nigrimas* were caught during the study, consisting of 508 female fish and 137 male fish. Overall, the maximum fish length was 58.83 mm and the minimum length was 42.00 mm with an average of 50.57 mm. The maximum weight was 2.21 g and the minimum was 0.68 g with an average of 1.56 g.

The length weight relationship for *O. nigrimas* males (Figure 1a) produced the equation \[ W = 1.55 \times 10^6 L^{2.346} \] (n = 137), with \[ R^2 = 0.706 \] which means that 70.6% of the variations in fish weight can be explained by variation in fish length. The length-weight relationship equation for female fish (Figure 1b) was \[ W = 3.95 \times 10^6 L^{1.07} \] (n = 508) with \[ R^2 = 0.614 \] which means that 61.4% of the variation in fish weight can be explained by variations in fish length. The length-weight relationship for all *O. nigrimas* specimens (males and females) during the study (Figure 1c) produced the equation \[ W = 3.28 \]
x $10^6 L^{2.155}$ (N = 645), with $R^2 = 0.634$ which means that 80% of the variation in fish weight can be explained by variations in fish length. The value of $b$ was $b = 2.346$ for males, $b = 2.107$ for females, and $b = 2.155$ for both sexes combined.

**Figure 1.** *Oryzias nigrimas* specimens: male (above) and female (below).

The results of the analysis of the length-weight relationship (Figure 2) for *O. Nigrimas* males and females in Poso Lake gave a value of $b < 3$. Therefore Poso Lake *O. nigrimas* in this study had an allometric negative growth pattern, which means that the increase in length is faster than the weight gain for this fish.

**Figure 2.** Length-weight relationship of *Oryzias nigrimas*: (a) Males; (b) Females; and (c) Males and Females combined.
In general, fish with a negative allometric growth pattern tend to have faster growth rates, although the coefficient b can be influenced by environmental factors, differences in fish stocks within the same species, gonad maturity, fish development stage, sex, seasonal factors and even differences in capture time due to differences in stomach contents [17-20]. According to [16], variations in b can be influenced by the length and weight of the fish, and indirectly the factors that influence the size of individual fishes bodies will affect the growth pattern and hence the value of b. According to [21], the value of b depends on physiological and environmental conditions such as pH, salinity, temperature, site characteristics and geographical location. If the rate of growth in length is more dominant than the rate of weight gain, then the fish will have an allometric negative growth pattern [22]. According to [23], the coefficient b can also be influenced by fish behaviour, for example actively swimming fish tend to have a lower value of b compared to more sedentary or passively swimming fish.

The condition factor (Kn) can reflect the state of an individual fish in terms of physical capacity for survival and reproduction and is determined based on fish length data. The calculation of the condition factor (Kn) aims to determine the general health of the fish, the level of productivity and the physiological state of the fish population. The overall average condition factor values (Table 1) covered a range from 0.940 to 1.091. The Kn values of male fish ranged from 0.951-1.061 and Kn values of female fish ranged from 0.940-1.107. From these data, the Kn data value is around the lower limit or just outside the relative normal condition factor range which is between 1 and 3 [16]. The Kn value of a in a given water body varies depending on the type of food, age, sex and gonad maturity level and seasonal factors [18-23]. Condition factors can be used as indicators that illustrate the interaction between biotic and abiotic factors on the physiological state of fish with the assumption that, at a given length, a higher fish body weight value indicates a superior physiological state or a healthier fish [24].

| Month | Kn female | Kn male | Kn combined |
|-------|-----------|---------|-------------|
| May-17 | 0.940 | 0.975 | 0.945 |
| Jun-17 | 0.981 | 1.061 | 0.994 |
| Jul-17 | 1.005 | 1.003 | 1.005 |
| Aug-17 | 1.042 | 0.951 | 1.018 |
| Sep-17 | 1.107 | 1.046 | 1.091 |
| Oct-17 | 1.029 | 0.992 | 1.022 |
| Nov-17 | 1.019 | 1.032 | 1.021 |
| Dec-17 | 0.941 | 1.001 | 0.956 |
| Jan-18 | 0.959 | 1.027 | 0.989 |
| Feb-18 | 1.051 | 0.999 | 1.041 |
| Mar-18 | 1.020 | 1.022 | 1.021 |

The mean condition factor (Kn) value of *O. nigrimas* fish (Table 1) shows that the average value fluctuates every month. In male fish, the highest Kn values were in June, September, November, December and March (1.061, 1.046, 1.032, 1.027, and 1.022). High Kn values can be influenced by *O. nigrimas* spawning season in these months; in addition, the variation in the length range of fish affected the weight of individual *O. nigrimas* and the number of samples observed can also have an affect. The highest condition for female fish was only found in September and February (1.107 and 1.051). The average Kn value of male and female fish was highest in September and February with Kn values of (1.091 and 1.041). Female fish tended to have a higher Kn value compared to male fish, this shows the condition of female fish tends to be better in terms of survival and reproductive processes.
The increase in the average condition factor values in September and February is presumably due to the spawning season occurring in that month [25], where the main energy source of fish is used for gonad development and spawning [13]. From the overall results, varying values can be influenced by fish size, where fish that have a large body size will have a relatively high condition factor value and will decrease as the fish body size gets smaller. Fluctuations in the value of the condition factor can be influenced by at least 3 factors, namely: (1) Changes in fish food types; (2) Changes in living habits; and (3) Gonadal development, especially if it occurs rapidly before spawning, besides which the spawning season can also affect the value of Kn in fish.

The lowest condition factor value in male fish occurred in August with a mean Kn value 0.951, while in female fish it occurred in May and December with mean Kn values of 0.940 and 0.941, and the lowest average Kn value of male and female fish combined occurred in May and December with Kn values of 0.945 and 0.956. The low Kn value in those months indicates that the physiological condition of the fish caught was less good, thus a small Kn value was obtained. Low Kn values can indicate very extreme conditions affecting the fish and conversely high Kn in sampled fish indicate excellent fish condition from.

4. Conclusion
The length-weight relationship of Oryzias nigrimas in Poso Lake shows that this fish can be classified as having an allometric negative growth pattern, with faster growth in length than in weight. Condition Factor of O. nigrimas ranged from 0.945 to 1.091 which is in a relatively normal range indicating that the length and development of this fish living in the waters of Poso Lake are quite good.

References
[1] Lukman and Ridwansyah I 2009 Telaah kondisi fisik Danau Poso dan prediksi ciri ekosistem perairannya. J. Limnoltek 16 (2): 64 -73
[2] Whitten A J, Mustafa M and Henderson G S 1987 The ecology of Sulawesi. Gajah Mada University Press, Yogyakarta. 777 pp.
[3] Kottelat M 1990 Synopsis of the endangered buntingi (Osteichthyes; Adrianichthyidae) of Lake Poso Central Sulawesi Indonesia with a new reproductive guide and description of three new species. Ichthyol. Expl. Freshwater 1(1): 49 – 67
[4] Parenti L R and Soeroto B 2004 Adrianichthys roseni and Oryzias nebulosus, two new ricefishes (Atherinomorpha: Beloniformes: Adrianichthyidae) from Lake Poso, Sulawesi, Indonesia. Ichthyol. Res. 51(1): 10-19
[5] Parenti L R 2008 A phylogenetic analysis and taxonomic revision of ricefishes, Oryzias and relatives (Beloniformes: Adrianichthyidae). Zoological J. Linn. Soc. 154 (3): 494 – 610
[6] Miesen F M, Fabian D, Hullen S, Hadiyat R K and Herder F 2016 An annotated checklist of the inland fishes of Sulawesi. Bonn Zoological Bull. 64(2): 77-106
[7] Serdiati N, Arfiati D, Widodo M S, Lelono T D, Ndobe S, Mansyur K and Moore A M 2021 Perspectives on sustainable management of the Poso Lake (Indonesia) endemic ricefish, Oryzias nigrimas (Actinopterygii: Adrianichthyidae) Rev. Biol. Trop. 69 139–52
[8] Wu-Shan C, Yi-You H, Yih-Tsong U and Jiang-Ping W 2012 Correlation between the length and weight of Ariusmaculatus of the southwestern coast of Taiwan. Brazilian Arch. Biol. Technol. 55(5): 705-708
[9] Gomiero L M, Souza U P and Braga F M S 2012 Condition factor of Astyanax intermedius Eigenmann. 1908 (Osteichthyes, Characidae) parasitised by Paracymothoa astyanaxii Lemos de Castro, 1955 (Crustacea, Cymothoidae) in the Grande River, Serra do Mar State Park-Santa Virginia Unit, São Paulo, Brazil. Brazilian J. Biol. 72(2): 379-388.
[10] Goncalves J M S, Bentes L, Lino P, Ribeiro J, Canario A V M and Erzini K 1997 Weight-length relationships for selected fish species of the small-scale demersal fisheries of the south and south-west coast of Portugal. Fisheries Res., 30(3): 253-256
[11] Moyle P B and Cech J J Jr. 2004 *Fishes an introduction to ichthyology*. Engelwood Cliffs. New Jersey, USA. 726 pp.
[12] Neff B D and Cargnelli L M 2004 Relationships between condition factors, parasite load and paternity in bluegill sunfish, *Lepomis macrochirus*. *Env. Biol. Fish.* 71(3): 297-304
[13] Lizama M D L A P and Ambrósio A M 2002 Condition factor in nine species of fish of the Characidae family in the upper Paraná River Floodplain, Brazil. *Brazilian J. Biol.* 62(1): 113-124
[14] Froese R 2006 Cube law, condition factor and weight-length relationships: history, metaanalysis and recommendations. *J. Appl. Ichthyology* 22(4): 241-253
[15] Kishakudan S J and Reddy P S 2012 Length-weight relationship in three species of silver bellies from Chennai coast. *Indian J. Fish* 59(3): 65-68
[16] Effendie M I 2002 *Biologi Perikanan*. Yayasan Pustaka Nusantara, Yogyakarta. 163 pp.
[17] Tarigan A, Bakti D and Desrita 2017 Catch and gonadal maturity level of yellow stripe trevally (*Selaroides leptolepis*) in the Strait of Malacca. *Acta Aquatica* 4(2): 44-52
[18] Indarjo A, Salim G, Zein M, Susiyanti S, Soejarwo P A, Nugraeni C D, Bija S and Pham Y T H 2020 Characteristics of Von Bertalanfy Growth, Allometric, Condition Index and Mortality of *Periophthalmus barbarus* in Mangrove and Probiotics Conservation Area (KKMB), Tarakan, North Kalimantan *Ilmu Kelaut. Indones. J. Mar. Sci.* 25: 31–8
[19] Indarjo A, Salim G, Amir F, Soejarwo P A, Nugraeni C D, Prakoso L Y, Ambariyanto A, Firdaus M and Ransangan J 2020 Growth characteristics layur fish *Lepturacanthus savala* in Juata Waters, Tarakan, Indonesia *Ilmu Kelaut. Indones. J. Mar. Sci.* 25 127–34
[20] Olopade O A, Dienye H E and Okonkwo C C 2020 Biometric Indices and Condition factors of *Pomadasys jubelini* (Cuvier, 1830) from Obuama Creek, Nigeria *Ilmu Kelaut. Indones. J. Mar. Sci.* 25 45–52
[21] Muchlisin Z A, Musman M and Siti-Azizah M N 2010 Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. *J. Appl. Ichthyology* 26: 949-953
[22] Ibrahim P S, Setyobudiandi I. and Sulistiono 2017 Hubungan panjang bobot dan faktor kondisi ikan selar kuning *Selaroides leptolepis* di Perairan Selat Sunda. *Jurnal Ilmu dan Teknologi Kel. Tropis* 9 (2): 577-584
[23] Muchlisin Z A, Musman M and Siti-Azizah M N 2010 Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. *J. Appl. Ichthyology* 26: 949-953
[24] Lemma B, Tessema T and Fessehaie R 2015 Distribution, abundance and socio-economic impacts of invasive plant species (IPS) in Borana and Guji Zones of Oromia National Regional State, Ethiopia. *J. Agric. Sci. Rev.* 4(9): 271-279
[25] Rahardjo M F and Simanjuntak C P H 2008 Hubungan panjang bobot dan faktor kondisi ikan tetet, *Johnius belangerii* Cuvier Pisces: Sciaenidae di Perairan Pantai Mayangan, Jawa Barat. *J. Ilmu-ilmu Perairan dan Perikanan Indonesia* 15(2):135-140