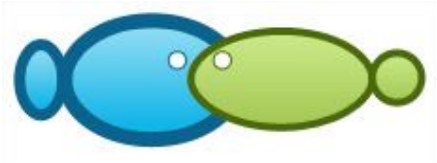

Length-weight relationship and condition factor of flying fish *Hirundichthys oxycephalus* in Majene waters, West Sulawesi Province

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Abstract. The present study aimed to determine the length-weight relationship and condition factor of flying fish *Hirundichthys oxycephalus*. This study was carried out monthly from October 2021 to March 2022 in Majene waters, West Sulawesi, Indonesia. A total 407 of samples were used during study period which consisted of 236 male fish and 171 female fish. Samples were analyzed in the Integrated Laboratory of Fisheries Department, West Sulawesi University. A digital caliper with 0.1 mm accuracy was used for the total length measurement and weight was measured using a digital balance with an accuracy of 0.01 g. A linear allometric model (LAM) was applied for length-weight relationships and the condition factor (K) analysis was performed to evaluate the fish condition. The length- weight relationship of male and female fish had a strong correlation with the equations $W = 0.0024L^{2.0153}$, $W = 0.0021L^{2.0468}$, $W = 0.0023L^{2.0258}$ consecutively. The growth pattern of *H. oxycephalus* was allometric negative for both male and female fish. The condition factor of fish is in a good condition and the value of K of male fish was lower than female fish. These findings suggest that the data from this study can be used as a reference for fisheries biologists in future studies for assessment of the flying fish.
Key Words: allometric negative, good condition, growth pattern, *Hirundicthys oxycephalus*.

Introduction. Flying fish *Hirundichthys oxycephalus* belongs to the family Exocoetidae, which is the main component of small pelagic fisheries in Indonesia, especially in West Sulawesi. *H. oxycephalus* is distributed from tropical to subtropical waters around the world (Dalzell 1993; Monteiro et al 1998). This fish can be found across Indonesia waters such as Makassar Strait, Flores Sea, Lawu Sea, Jawa Sea, Nusa Tenggara, Papua and Maluku waters (Syahailatua 2006; Febyanty & Syahailatua 2008).

Majene waters represent one of the prominent hotspots for the flying fish (Palo et al 2019). This species is familiar to the local coastal communities as one of protein sources and for its highly valued eggs for export (Indriyani et al 2021). Over the last few decades the flying fish sources have been exploited intensely especially for the eggs (Tuapetel 2020). Consequently, this has been threatening the sustainability of wild flying fish populations (Tuapetel et al 2015; Ali 2019). In order to preserve the species, the conservation efforts must be carried out.

Several studies on *H. oxycephalus* have been well documented such as concerning the growth of flying fish in Binuangeun water, Banten (Harahap & Djamali 2005), food habit (Febyanty & Syahailatua 2008), maturity and spawning in Makassar Strait (Ali 2019), and distribution in the central Makassar Strait (Palo et al 2019). However, fundamental biological information has never been reported, as no study currently exists on the length-weight relationship and condition factor of flying fish *H. oxycephalus* from Majene waters.

The length-weight relationships (LWRs) and condition factor (*K*) have a fundamental role in biometric studies. The analyzing length-weight relationships and condition factor is a critical measurement in describing the key biological aspects of fish

stocks to evaluate conditions of fish, estimation of biomass, stock assessment, age, and growth pattern (Jisr et al 2018; Batubara et al 2019; Mehanna & Farouk 2021). Therefore, the present study was intended to determine the length-weight relationship and condition factor of *H. oxycephalus* in Majene waters, West Sulawesi. This will provide information related to management and conservation, and allow comparisons between populations of the same species in near future.

Material and Method

Description of the study sites. The present study was carried out from October 2021 to March 2022 in Majene waters, West Sulawesi, Indonesia (Figure 1). The research on biological aspects of flying fish was carried out in Mosso Village, Majene District, West Sulawesi. Samples were analyzed in the Integrated Laboratory of Fisheries Department, West Sulawesi University.

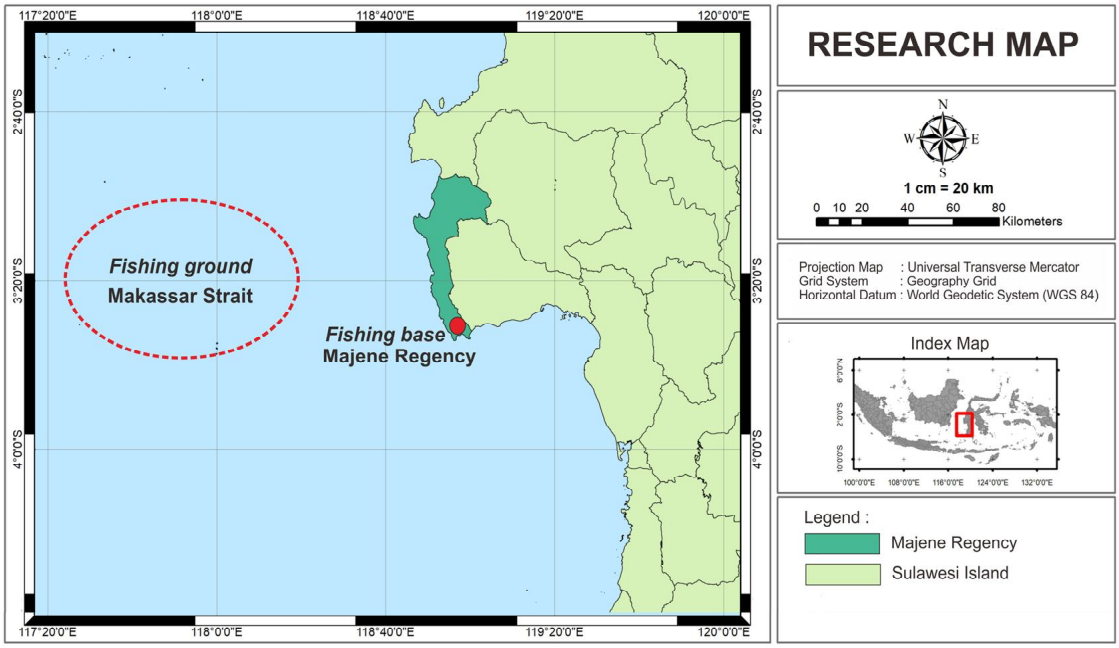

Figure 1. Study sites.

Data collection. A total of 407 fish samples consisting of 236 males and 171 females were used during the study period. A digital caliper with 0.1 mm accuracy was used for the total length measurement and a digital balance with an accuracy of 0.01 g was used for measuring the body weight. The fish samples were dissected with scissors to identify the sex and morphological stages of gonad development. The shape, length, color, and development stage of gonads were observed for morphological determination.

Data analysis. The length-weight relationship of fish was calculated by using Linear Allometric Model (LAM), using the formula:

$$W = (aL^b);$$

where: W = the weight of fish (g);
L = the length of fish (mm);
a = linear regression intercept;
b = coefficient regression.

If $b = 3$ then the growth pattern is isometric and if $b \neq 3$ the growth pattern is allometric. The two types of allometric patterns are positive allometric and negative allometric. A negative allometric ($b < 3$) means that length increases proportionately faster than weight, and a positive allometric ($b > 3$) means that weight increases proportionately faster than length.

The condition factor (K) on isometric growth was calculated by formula of Effendie (2002), $K = 10^5 W/L^3$, and in allometric condition, it was calculated using the formula of Le Cren (1951), $K = W/W^*$; where W represents the body weight (g), L represents the total length of fish (mm), and W* represents the weight calculated from length-weight relationship.

Results and Discussion. The information concerning the length-weight relationship and condition factor are useful for further population studies and stock assessment for sustainable management measures of the pelagic fish species (Mehanna & Farouk 2021). As mentioned before, in this study, the total samples were 407 individuals consisting in 236 males and 171 females. The total length of males ranged from 155 to 240 mm and of females from 160 to 235 mm. The body weight of males ranged from 61.3 to 156.0 g and of females from 61.3 to 172.0 g. These sizes were lower than the size of *H. oxycephalus* found in Binuangeun waters, Banten where the total length was 214.5-278.5 mm (Harahap & Djamali 2005). However, the total length in our study is no smaller than the total length found in Makassar with the range of 161-215 mm (Febyanty & Syahalatua 2008).

The equations for the length-weight relationship for males, females, and combined sexes were $W = 0.0024L^{2.0153}$, $W = 0.0021L^{2.0468}$ and $W = 0.0023L^{2.0258}$ respectively (Table 1). In the present study, the exponential b value of male and female fish found in Majene waters is less than 3.0. Similarly, b value of combined sexes shows negative allometric (b > 3). The determination coefficient (r) varied between male and female fish, but all of the values suggest a strong correlation and association between length and weight. However, the results of the combined sexes analysis of the monthly length-weight relationship from October 2021 to March 2022 showed that the growth pattern was negative allometric indicating the increase in weight of *H. oxycephalus* was not proportional to the increase in length (Figure 2).

Table 1

Statistical description of length-weight relationship of flying fish *Hirundichthys oxycephalus* in Majene waters, West Sulawesi

Gender	*n*	*Length (mm)*	*Weight (g)*	*Length-weight relationship*	*r*	*Growth pattern*
Male	236	155-240	61.3-156.0	$W = 0.0024L^{2.0153}$	0.9147	NA
Female	171	160-235	61.3-172.0	$W = 0.0021L^{2.0468}$	0.9142	NA
Combination	407	155-240	61.3-172.0	$W = 0.0023L^{2.0258}$	0.9147	NA

Descriptions: n = total individual; *r* = correlation coefficient; NA = negative allometric.

The LWRs equations of *H. oxycephalus* from October, November, December, January, February, and March were $W = 0.0011L^{2.1765}$, $W = 0.001L^{2.1753}$, $W = 0.0265L^{1.5646}$, $W = 0.0004L^{2.3450}$, $W = 0.0002L^{2.4819}$, $W = 0.2092L^{1.1677}$, respectively. The correlation coefficient (r) for combined sexes monthly from October 2021 to March 2022 were 0.9279, 0.9252, 0.7995, 0.9384, 0.8652, 0.7819, respectively. This finding indicates that a strong correlation between length and weight of *H. oxycephalus*. Length-weight relationship can be used as biological indicator of ecosystem condition and wild fish stock(Courtney et al 2014).

In the present study, the growth pattern of *H. oxycephalus* was negative allometric. Negative allometric growth implies the fish becomes slimmer as it becomes longer. Similarly, Harahap & Djamali (2005) reported that male and female fish of *H. oxycephalus* show negative allometric growth in Binuangen waters, Banten. Conversely, the growth pattern of *H. coromandalensis* in the Bay of Bengal near Pulicat Coast (Vinoth & Prabu 2014) and *Cypselurus poecilopterus* in the Western Coast of Surigao del Norte, Philippines (Gomez 2020) showed positive allometric growth. It indicates that the same species in open water areas may show different growth patterns when fish are caught in different months and seasons. The biological and ecological conditions of the waters are very dynamic. The variation of growth can also be affected by genetic or environmental

factors (Vinoth & Prabu 2014), gonad maturity (Harahap & Djamali 2005), feeding intensity, and stomach fullness (Hashim et al 2017).

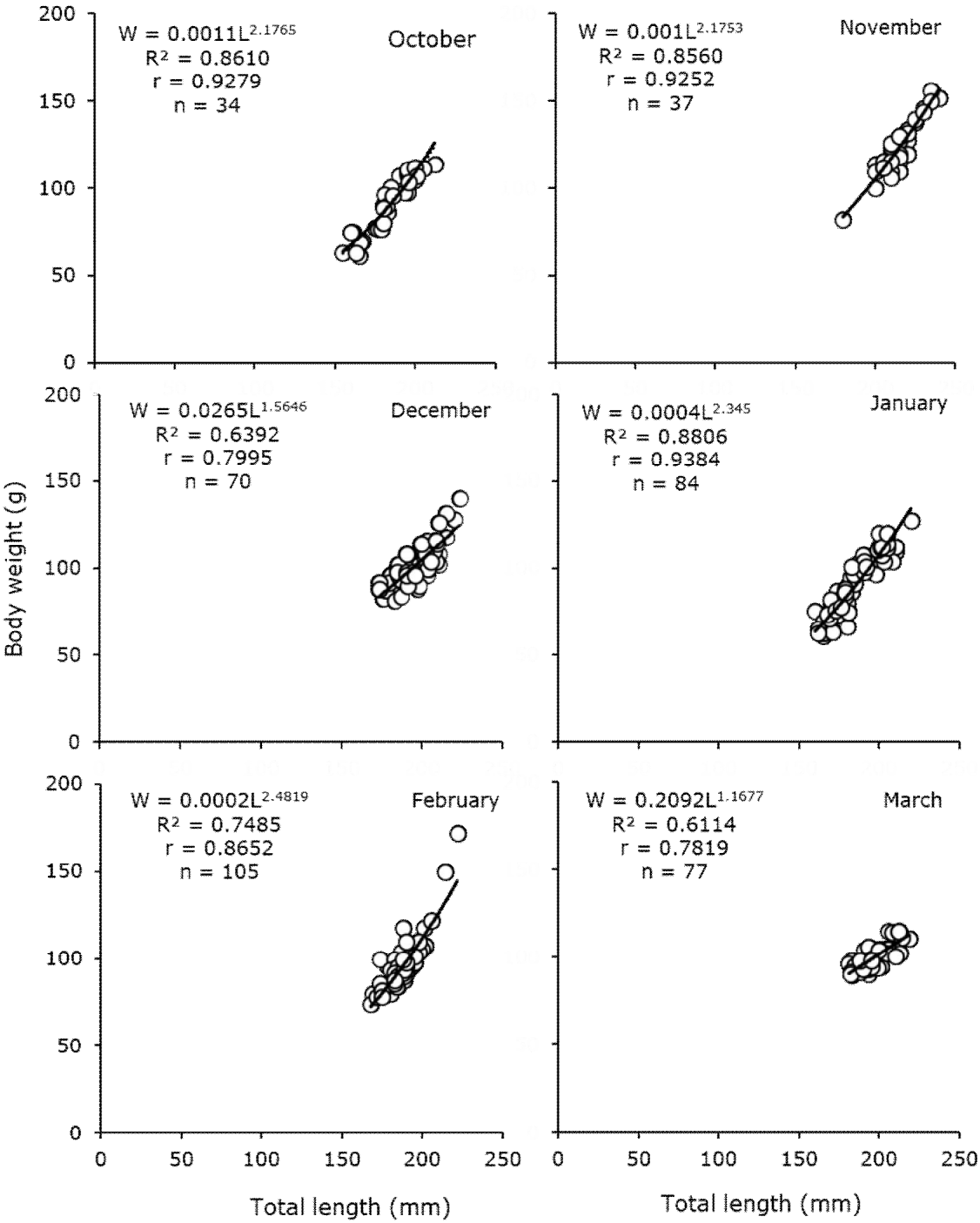

Figure 2. Length-weight curves and equations for *Hirundichthys oxycephalus* in Majene waters, West Sulawesi from October 2021 to March 2022.

In the present study, the condition factor *H. oxycephalus* in Majene Waters ranged from 0.7875 to 1.2840 for male fish and 0.8155 to 1.2906 for female fish. This indicates that the condition factor of female fish is greater than male fish. It suggests that the fish is in a good condition. This leads to better conditions for female fish to survive during the reproductive process. As said by Le Cren (1951), if the condition factor (K) is greater

than 1, the fish is in good condition. Furthermore, Kasimoglu (2014) added that the condition factor is used as an indicator to assess environmental changes. In the present study, the fish condition factor was still proportional (K > 1) where the growth co-efficient (b) was slightly negative allometric. Several factors can affect the condition factor such as seasonal factor (Akhter et al 2020; Nur et al 2020), water quality (Zuh et al 2019), gonad development stage (Phan et al 2021), food availability (Litvinenko et al 2021; Nasyrah et al 2021). Therefore, the condition factor is often used as a quantitative value to indicate the general health status of fish, physiological condition, and reproduction.

Conclusions. The growth pattern of *H. oxycephalus* was negative allometric for both male and female fish. However, further investigations are required on fish age or water quality parameters. The condition factor showed that fish in Majene waters was in a good condition. Moreover, the value of K for female fish was higher than male fish. These findings will be useful references for fisheries biologists in future studies on the population assessment of the flying fish *H. oxycephalus* in Majene waters, West Sulawesi.

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Conflict of interest. The authors declare that there is no conflict of interest.

References

Akhter F., Islam M. A., Islam M. M., Zahangir M. M., 2020 Seasonal variations in some biological parameters (length-weight relationship, condition factor, hepatosomatic and gonadosomatic index) of silver and black pomfret (*Pampus argenteus* and *Parastromateus niger*) from the Bay of Bengal. Journal of Fisheries and Aquaculture Reserach 5(1):043-053.

Ali S. A., 2019 Maturity and spawning of flying fish (*Hirundichthys oxycephalus* Bleeker, 1852) in Makassar Strait, South Sulawesi. IOP Conference Series: Earth and Environmental Science 253:012012.

Batubara A. S., Muchlisin Z. A., Efizon D., Elvyra R., Irham M., 2019 Length-weight relationship and condition factors of the naleh fish, *Barbonymus gonionotus* (Pisces, Cyprinidae) harvested from Nagan Raya waters, Indonesia. Vestnik Zoologii 53(1):75-82.

Courtney Y., Courtney J., Courtney M., 2014 Improving weight-length relationship in fish to provide more accurate bioindicators of ecosystem condition. Aquatic Science and Technology 2(2):41-51.

Dalzell P., 1993 The fisheries biology of flying fishes (Families: Exocoetidae and Hemiramphidae) from the Camotes Sea, Central Philippines. Journal of Fish Biology 43(1):19-32.

Effendie M. I., 2002 [Fisheries biology]. Yayasan Pustaka Nusatama, Yogyakarta, 162 pp. [in Indonesian]

Febyanty F., Syahailatua A., 2008 [Food habit of flying fish, *Hirundicthys oxycephalus* and *Cheilopogon cynopterus,* in Makassar Strait]. Jurnal Penelitian Perikanan Indonesia 14(1):123-131. [in Indonesian]

Gomez B. C., 2020 Lenght-weight relationship of yellow-wing flyingfish, *Cypselurus poecilopterus* (Valenciennes) in the western coast of Surigao del Norte, Philippines. International Journal of Bioscience 17(3):7-12.

Harahap T. S. R., Djamali A., 2005 [Growth of flying fish (*Hirundicthys oxycephalus*) in Binuangeun waters, Banten]. Jurnal Iktiologi Indonesia 5(2):49-54. [in Indonesian]
Hashim M., Abidin D. A. Z., Das S. K., Mazlan A. G., 2017 Length weight relationship, condition factor and TROPH of *Scatophagus argus* in Malaysian coastal waters. AACL Bioflux 10(2):297-307.
Indriyani I., Findra M. N., Jufri A., Hidayat H., Pariakan A., 2021 Genetic variation of *Cheilopogon nigricans* in the Makassar Strait, Indonesia. Indo Pacific Journal of Ocean Life 5(1): 22-28.
Jisr N., Younes G., Sukhn C., El-Dakdouki M. H., 2018 Length-weight relationships and relative condition factor of fish inhabiting the marine area of the eastern Mediterranean city, Tripoli-Lebanon. The Egyptian Journal of Aquatic Research 44(4):299-305.
Kasimoglu C., 2014 The effect of fish size, age and condition factor on the contents of seven essential elements in *Anguilla anguilla* from Tersakan Stream Mugla (Turkey). Journal of Pollution Effects and Control 2:2.
LE Cren E. D., 1951 The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis)*. Journal of Animal Ecology 20(2):201-219.
Litvinenko V., Kotovska G., Buzevitch O., Khrystenko D., 2021 Length-weight relationship and condition factors of white bream (*Blicca bjoerkna* (Linnaeus, 1758)) from the Kyiv Reservoir. AACL Bioflux 14(6):3283-3290.
Mehanna S. F., Farouk A. E., 2021 Length-weight relationship of 60 fish species from the eastern Mediterranean Sea, Egypt (GFMC-GSA 26). Frontiers in Marine Science 8: 625422.
Monteiro A., Vaske Jr. T., Lessa R. P., El-Deir A. C. A., 1998 Exocoetidae (Beloniformes) off North-Eastern Brazil. Cybium 22(4):395-403.
Nasyrah A. F. A., Rahardjo M. F., Simanjuntak C. P. H., Nur M., 2021 The length-weight relationships and condition factor of an endemic *Marosatherina ladigesi* Ahl, 1936 in Walanae Cenranae River watershed, South Sulawesi, Indonesia. E3S Web of Conferences 322:01002.
Nur M., Rahardjo M. F., Simanjuntak C. P. H., Djumanto, Krismono, 2020 Length-weight relationship and condition factor of an endemic *Lagusia micracanthus* Bleeker, 1860 in rivers of the Maros watershed. Jurnal Iktiologi Indonesia 20(3):263-270.
Palo M., Najamuddin, Zainuddin M., Farhum S. A., 2019 Hotspots of bony flying fish (*H. oxycephalus*) distribution constrained by physical oceanographic condition in the central of Makassar Strait during boreal winter. International Journal of Environment, Agriculture and Biotechnology 4(4):989-994.
Phan G. H., Linh L. T. T., Dinh Q. M., Truong N. T., Nguyen T. H. D., 2021 Length-weight relationship, growth pattern and condition factor of *Glossogobius giuris* caught from coastal areas in the Mekong Delta. AACL Bioflux 14(3):1478-1485.
Syahailatua A., 2006 [Flying fish fisheries in Indonesia: research towards management]. Oseana 31(3):21-31. [in Indonesian]
Tuapetel F., 2020 [Flying fish, potential in Maluku waters that missed]. Warta Iktiologi 4(3):11-18. [in Indonesian]
Tuapetel F., Nessa N., Ali S. A., Sudirman, 2015 Distribution, species composition and size of flying fish (Exocoetidae) in the Ceram Sea. International Journal of Scientific and Technology Research 4(3):75-76.
Vinoth A., Prabu R. S., 2014 Length weight relationship and condition factor of *Hirundichthys coromandelensis* (flying fish) in Bay of Bengal near Pulicat Coast. International Journal of Information and Review 1(11):162-164.
Zuh A. K., Abobi S. M., Campion B. B., 2019 Comparative assessment of age, growth and food habit of the black-chinned tilapia, *Sarotherodon melanotheron* (Ruppel, 1852), from a closed and open lagoon, Ghana. Fisheries and Aquatic Science 22:31.

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