RESEARCH ARTICLE

Length-weight relationships and condition factors of mullets *Liza macrolepis* and *Moolgarda engeli* (Pisces: Mugilidae) harvested from Lambada Lhok waters in Aceh Besar, Indonesia [version 1; peer review: 2 approved with reservations]

Derita Yulianto ¹, Indra Indra², Agung Setia Batubara^{3,4}, Deni Efizon⁵, Firman M. Nur ¹, Syamsul Rizal^{3,4}, Roza Elvyra ⁶, Zainal A. Muchlisin ^{3,4}

¹Doctorate Program in Mathematics and Applied Sciences,, Universitas Syiah Kuala, Banda Aceh, Aceh province, 23111, Indonesia

²Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Aceh province, 23111, Indonesia

³Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh, Aceh Province, 23111, Indonesia

⁴Marine and Fisheries Research Center, Universitas Syiah Kuala, Banda Aceh, Aceh Province, 23111, Indonesia

⁵Faculty of Fisheries and Marine Sciences, Universitas Riau, Pekanbaru, Riau Province, Indonesia

⁶Faculty of Mathematics and Natural Sciences, Universitas Riau, Pekanbaru, Riau Province, Indonesia

V1 First published: 14 Apr 2020, 9:259
<https://doi.org/10.12688/f1000research.22562.1>
 Latest published: 10 Jun 2020, 9:259
<https://doi.org/10.12688/f1000research.22562.2>

Abstract

Background: The mullets fish *Liza macrolepis* and *Moolgarda engeli* are predominant in the Lambada Lhok waters in Aceh province. At present, no scientific report on this species in Aceh waters is available. Therefore, the objective of the present study is to examine the growth pattern and condition factor of the species of mullets *L. macrolepis* and *M. engeli* harvested from the aforementioned coastal waters.

Methods: The sampling was done in three locations in the Lambada Lhok waters from July to November 2018. The fish were captured using gillnets from 6:00 AM to 3:00 PM four times a month for five months. A total of 242 *L. macrolepis* and 109 *M. engeli* were used for the analysis. The growth pattern was analyzed using linear allometric model; then, two condition factors, Fulton's and relative weight, were calculated.

Results: The study revealed a *b* value of 2.49 for the male *L. macrolepis* and 1.81 for the female. The *b* value was 3.22 for the male *M. engeli* and 3.41 for the female. The *b* value of the fish was higher during the dry season. The Fulton's condition factor of the male *L. macrolepis* was 1.19, and that of the female was 1.19. The relative condition factor of this species was 100.11 and 100.01 for males and females, respectively. The Fulton condition factor of male *M. engeli* was 1.05 and that of the female was 1.06. The relative weight condition factors

Open Peer Review

Approval Status

	1	2
version 2		
(revision)
10 Jun 2020	view	view

version 1		
14 Apr 2020	view	view

1. **Esti Handayani Hardi** , Mulawarman University, Samarinda, Indonesia

2. **Rudy Agung Nugroho** , Mulawarman University, Samarinda, Indonesia

Any reports and responses or comments on the article can be found at the end of the article.

were 101.08 and 100.61 for the male and female, respectively.

Conclusions: The growth pattern of *M. engeli* tends to be isometric, whereas that of *L. macrolepis* has a negative allometric growth pattern. The condition factors indicate that the Lambada Lhok waters are still in good condition and support the growth of the mullets, but *M. engeli* is more adaptable than *L. macrolepis*.

Keywords

Growth pattern, Relative weight condition factor, Fulton's condition factor, Linear allometric model

Corresponding author: Zainal A. Muchlisin (muchlisinza@unsyiah.ac.id)

Author roles: **Yulianto D:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – Original Draft Preparation; **Indra I:** Conceptualization, Methodology, Writing – Original Draft Preparation; **Batubara AS:** Data Curation, Formal Analysis, Investigation, Resources, Software, Visualization, Writing – Original Draft Preparation; **Efizon D:** Conceptualization, Methodology, Supervision, Writing – Original Draft Preparation; **Nur FM:** Data Curation, Formal Analysis, Investigation, Writing – Original Draft Preparation; **Rizal S:** Conceptualization, Formal Analysis, Supervision, Writing – Original Draft Preparation; **Elvyra R:** Conceptualization, Methodology, Validation, Writing – Original Draft Preparation; **Muchlisin ZA:** Conceptualization, Funding Acquisition, Supervision, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: This study was supported by the Universitas Syiah through Professorship research scheme. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Copyright: © 2020 Yulianto D *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Yulianto D, Indra I, Batubara AS *et al.* Length-weight relationships and condition factors of mullets *Liza macrolepis* and *Moolgarda engeli* (Pisces: Mugilidae) harvested from Lambada Lhok waters in Aceh Besar, Indonesia [version 1; peer review: 2 approved with reservations] F1000Research 2020, 9:259 <https://doi.org/10.12688/f1000research.22562.1>

First published: 14 Apr 2020, 9:259 <https://doi.org/10.12688/f1000research.22562.1>

Introduction

Mulletts (Mugilidae) represent a family of euryhaline fish that can tolerate a wide range of salinity^{1,2}. This fish is frequently found in marine environments, brackish and fresh water²⁻⁷. To date, a total of 30 genus belonging to 78 species of mullets have been described worldwide^{8,9}. A total of 21 species of mullets have been reported in Indonesian waters, and among them, four species have been recorded in the waters of Aceh province; these are *Liza melinoptera*, *Mugil chepalus*, *Valamugil cunne-sius*, and *V. speigleri*^{4,10,11}. Our previous study recorded three additional mullets from Aceh waters, namely, *L. macrolepis*, *Crenimugil crenilapis*, and *Moolgarda engeli* (Yulianto, thesis in preparation), which accounted for a total of seven species of mullets in the Aceh region. These additional species are commonly found in Lambada Lhok, Aceh Besar district close to Banda Aceh City, the capital of Aceh province, Indonesia. Moreover, our field observation showed that *L. macrolepis* and *M. engeli* were the predominant species among other mullets in this area.

The coastal area of Lambada Lhok has a mangrove forest; however, the forest area has been significantly decreased due to tsunami disaster in 2004, land conversion for settlement and aquaculture ponds. The other potential threats are pollution from domestic waste, fishing port, and tourism activities^{12,13}. Mulletts are a species of shoaling and schooling fish commonly found in river mouths for feeding^{14,15}, which then subsequently migrate to deep waters for spawning¹⁶. Therefore, these fish are highly susceptible to exposure to pollution from coastal areas; for instance, *Chelon subviridis* from Donan River estuary, Central Java, have been contaminated by cadmium and copper¹⁷. A similar finding has been reported in *M. cephalus* from the Ligurian Sea in Italy¹⁸. In addition, *L. macrolepis* and *M. engeli* have been harvested intensively by local fishermen, thereby increasing the pressure on these fish. Thus, research related to bioecology as basic information is crucial in planning an effective conservation strategy. The two important pieces of information are length–weight relationships (LWRs) and growth pattern and condition factors.

The study of the LWRs and condition factors has become popular and is therefore commonly conducted by fish biologists¹⁹. The objectives of LWRs study are to determine the specific weight and length variations of fish individually or the population a whole to determine the age, obesity status, health, productivity, and physiological conditions, including gonadal development^{20,21}. LWRs analysis is also useful to estimate the fish condition or plumpness index, which is an important variable in the evaluation of the health conditions of fish populations or individuals²²⁻²⁴. The condition factor indicates the biological and physical conditions of fish and its fluctuations by interaction among feeding condition, food reserves, and parasite infestation²⁵⁻²⁷.

Several studies on LWRs and condition factor of mullets have been conducted, such as, that on *M. dussumieri* in Ujung Pangkah, East Jawa, Indonesia¹⁴; on LWRs in *L. macrolepis* from Indian waters^{28,29}, and on *L. macrolepis* from Taiwanese waters³⁰. In addition, the study of LWRs in several species of mullets

in Aceh waters, Indonesia has been reported by Mulfizar *et al.*³¹ in *M. chepalus* from the waters of Kuala Gigieng, Aceh Besar, and by Muttaqin *et al.*³² in the same species from Madat waters in East Aceh. However, no study has been published on *L. macrolepis* and *M. engeli*. Thus, the objectives of the present study are to analyze LWRs and condition factor of these two types of mullet harvested from Lambada Lhok waters.

Methods

Time, site, and sampling

The sampling was conducted from July to November 2018 in the Lambada Lhok estuary, Aceh Besar regency in Aceh province, Indonesia (Figure 1). The location is a small river mouth and deforested mangrove areas and fishing port (5°36'57.6" N, 95° 23'25.6" E). The sampling was done purposively at these locations as they were easy to access and fish were reported to be present. Sampling was conducted four times a month for five months. The target species in this study were determined based on preliminary survey and observations on the composition of local fishermen catches, where *Liza macrolepis* and *Moolgarda engeli* were the dominant species caught.

The fish was caught using gillnets with a mesh size of 2.0 inch. The gillnets were set up in the waters for 4 h (06.00 AM –03.00 PM) and were monitored in 30 min intervals. The sampled fish was washed, euthanized with cold water 4 °C for 5 min. This euthanize method was chosen as it is easy to apply, non-toxic and inexpensive. Then the fish was preserved temporarily in crushed ice in a styrofoam box, and then transported to a laboratory for further analysis. Other species of fish caught were separated from the mullets, and released back to the waters if still live, but the fish taken for consumption if they died during sampling. All efforts were made to ameliorate harm to the animals by complying to the [guidelines of ethics animal use in research of Syiah Kuala University](#).

Field observations

During this process, the weather condition, tides, and water turbidity are also observed visually during the sampling.

LWRs analyses

The length-weight relationships were calculated to predict the growth pattern of the fish. A total of 242 *L. macrolepis* and 109 *M. engeli* were measured for total length to the nearest mm using a digital caliper (Mitutoyo CD-6CS, error: 0.05 mm) and for body weight to the nearest mg using a digital balance (ION EPS05, error: 0.1 mg). A linear allometric model (LAM) was used to calculate parameters *a* and *b* values based on the work of De-Robertis and Williams³³ and Muchlisin *et al.*²² as follows:

$$W=e^{0.5\sigma}.a.L^b,$$

where *W* is total body (g), *L* is total length (mm), *a* is regression intercept, *b* is regression coefficient, σ is residual variation of the LAM, and 0.5 is correction factor. The growth pattern of

Figure 1. Map of Lambada Lhok coastal area showing the sampling location (5 ° 36'57.6 "N, 95 ° 23 '25.6" E).

the fish is divided into three categories; isometric when the b value is equal to 3, negative allometric when the b value lower than 3, and positive allometric when the b value is higher than 3.

Condition factor analyses

The condition factor indicates the conditions of the fish and water, and their interactions. Two condition factors, namely, relative weight condition factor (W_r) and Fulton's condition factor (K) were analyzed in this study. The relative weight condition factor of 100 indicates a balance between prey and predator, while if the W_r higher than 100 indicates a surplus of prey, and it vice versa. Based on the work of Rypel and Richter³⁴, the relative weight condition factor was calculated as follows: $W_r = (W/W_s) \times 100$, where W_r is the relative weight condition factor, W is body weight of fish from direct measurement, W_s is the prediction weight of fish, and $W_s = aL^b$.

Based on the work of Okgerman³⁵, Fulton's condition factor was calculated as follows:

$$K = WL^{-3} \times 100,$$

where K is the Fulton's condition factor, W is the body weight of fish from direct measurement (g), and L is the total length of fish from direct measurement (mm). According to Morton and Routledge³⁶, a fish population is in good condition when the K value is higher than 1.

Data analysis

The raw data of total length and body weight were processed using a Microsoft Excel (Microsoft Office 365).

The data were presented as tables and figures, and then the data were analyzed descriptively through comparison with related reports, theories, and field observations.

Results

Length-weight relationships

The field observation of the catch composition showed that *Liza macrolepis* and *Moolgarda engeli* were predominant. A total of 242 *L. macrolepis* and 109 *M. engeli* were sampled and measured in the study. The length of male *L. macrolepis* ranged from 141.4 – 202.1 mm (164.8 ± 15.03 mm), and ranged from 129.2–185.4 mm (159.1 ± 12.66 mm) for females. The body weight of male *L. macrolepis* ranged from 34.7 g to 89.6 g (54.1 ± 13.3 g in average), and 28.8 g to 75.13 g (47.9 ± 9.52 g in average) in females. The length of the male *M. engeli* ranged from 109.9–188.5 mm (161.9 ± 20.83 mm) and 116.5–182.3 mm (154.1 ± 18.94 mm) for females. The body weight of the males was 13.6 – 108.5 gram (47.6 ± 19.3 gram), and that of the females was 14.2–75.1 gram (41.4 ± 16.43 gram). Raw data are available as underlying data³⁷.

The results of the LWRs analysis on *L. macrolepis* showed that the male fish had a b value of 2.49 with a correlation coefficient of 0.93, and the female fish had a b value of 1.81 and a correlation coefficient of 0.82 (Figure 2a and 2b). Therefore, the male and female *L. macrolepis* displayed negative growth patterns, and a moderate correlation between body weight and total length of the fish. The results of LWRs analysis of male *M. engeli* revealed that the average b value was 3.22 with a coefficient correlation of 0.89. The female *M. engeli* had an average b value of 3.41 with a coefficient correlation of 0.93 (Figure 3a and 3b). These data indicate that the male and female *M. engeli* have a positive allometric growth

Figure 2. The length-weight relationship of *Liza macrolepis* based on linear allometric model (a) male, (b) female; Comparison of observed and predicted growth for male (c), and female (d) of *Liza macrolepis*. R² - determination coefficient, r - correlation coefficient, N - number of fish sampled.

pattern, and a strong correlation between body weight and total length.

Based on sampling season, the average *b* value of *L. macrolepis* (male and female) was 2.78 during the dry season and 2.28 during the rainy season (Figure 4a). The *b* value of *M. engeli* was 3.42 during the dry season and 2.48 during the rainy season (Figure 4b). These data indicate that the *b* value is lower during the rainy season for both species. The scatter plots of predicted standard weight for respective observed length, as calculated from the composite of length-weight regression, are presented in Figure 2c and 2d and Figure 3c and d. The regression models show a difference between the observed and predicted growth patterns in both species.

Condition factors. The results showed that the male *L. macrolepis* had a Fulton's condition (K) factor of 1.19, and relative weight condition factor (Wr) of 100.11; while the females had a Fulton's condition factor of 1.19, and relative weight condition factor of 100.01. In addition, male *M. engeli* had a Fulton's condition factor of 1.05, and relative weight condition factor of 101.08; whereas the females has Fulton's condition factor of 1.06, and relative weight condition factor of 100.61 (Table 1). Based on sampling season, the Fulton's condition of *L. macrolepis* during the dry season was 1.22 and 100.49 for the relative weight; during the rainy season these were 1.19 and 101.74, respectively. In addition, the K and Wr values of *M. engeli* during the dry season were 1.03 and

102.09, respectively; during the rainy season these were 1.09 and 100.47, respectively (Table 2).

Discussion

The study revealed that male and female *L. macrolepis* had negative allometric growth patterns. However, the *b* value of the females was less than that of the male. The *b* value of the male *M. engeli* showed a positive allometric growth pattern. Based on these growth pattern data, the study indicated that *M. engeli* grows better than *L. macrolepis*, thereby indicating that *M. engeli* is more adaptable to the environmental condition of Lambada Lhok waters. Furthermore, the field observation on the catch composition of the fishermen showed that *M. engeli* was also predominant. The Fulton's condition factor showed a slight difference in K value between the male and female for both species, where the K value was higher than 1. According to Morton and Routledge³⁶, a fish population is in good condition when the K value is higher than 1. The study showed that the K value of *L. macrolepis* ranged from 1.16 to 1.22, and 1.03 to 1.09 for *M. engeli*; therefore, both populations are in good condition, in dry and rainy season, respectively. In addition, the relative weight condition factor of both species is close to 100, indicating a balance between prey and predator²⁰. These results show that these waters provide a sufficient food source for these species. The relative weight condition factor also corresponds to fish health conditions, stock estimates, and management levels^{23,35,36,38,39}. Therefore, the Lambada Lhok waters provide sufficient food sources for mullets.

Figure 3. The length-weight relationship of *Moolgarda engeli* based on linear allometric model (a) male, (b) female; Comparison of observed and predicted growth for male (c), and female (d) of *Moolgarda engeli*. R² - determination coefficient, r - correlation coefficient, N - number of fish sampled.

Figure 4. The length-weight relationship of *Liza macrolepis* (a) during dry season (b) during rainy season and *Moolgarda engeli* (c) during dry season (d) during rainy season. R² - determination coefficient, r - correlation coefficient, N - number of fish sampled.

Table 1. The *b* value, coefficient of correlation and determination, and condition factors of *Liza macrolepis* dan *Moolgarda engeli* sampled from July–November 2018 according to sex.

Species	Sex	Body weight (mean ±SD) (gram)	Total length (mean ± SD) (mm)	N	<i>b</i> value	Coefficient of correlation (r)	Coefficient of determination (R ²)	Fulton condition factor (K)	Relative weight condition factor (Wr)
<i>L. macrolepis</i>	Male	34.7 – 89.6 (54.1 ± 13.3)	141.4 – 202.1 (164.8 ± 15.03)	172	2.49	0.93	0.85	1.19 ± 0.12	100.11 ± 09.38
	Female	28.8 – 75.1 (47.9 ± 9.52)	129.2 – 185.4 (159.1 ± 12.66)	70	1.81	0.82	0.65	1.19 ± 0.19	100.01 ± 11.23
<i>M. engeli</i>	Male	13.6 – 108.5 (47.6 ± 19.3)	109.9 – 188.5 (161.9 ± 20.83)	68	3.22	0.89	0.90	1.05 ± 0.15	101.08 ± 14.74
	Female	14.2 – 75.1 (41.4 ± 16.43)	116.5 – 182.3 (154.1 ± 18.94)	41	3.41	0.93	0.94	1.06 ± 0.25	100.61 ± 11.72

Table 2. The *b* value, coefficient of correlation and determination, and condition factors of *Liza macrolepis* dan *Moolgarda engeli* sampled from July–November 2018 according to sampling seasons.

Species	Season	Body weight (mean ±SD) (gram)	Total length (mean ± SD) (mm)	N	<i>b</i> value	Coefficient of correlation (r)	Coefficient of determination (R ²)	Fulton condition factor (K)	Relative weight condition factor (Wr)
<i>L. macrolepis</i>	Dry	30.4 – 80.2 (49.6 ± 11.17)	138.4 – 193.7 (158.9 ± 11.37)	92	2.78	0.90	0.82	1.22 ± 0.11	100.49 ± 59.56
	Rainy	34.7 – 85.5 (53.9 ± 13.35)	129.2 – 202.1 (159.1 ± 12.66)	150	2.28	0.89	0.79	1.19 ± 0.15	100.58 ± 10.89
<i>M. engeli</i>	Dry	13.6 – 108.5 (32.1 ± 18.42)	109.9 – 182.9 (142.4 ± 17.51)	59	3.42	0.79	0.82	1.03 ± 0.29	102.09 ± 24.18
	Rainy	41.2 – 74.5 (56.2 ± 9.31)	153.1 – 188.5 (172.1 ± 8.97)	50	2.48	0.78	0.63	1.09 ± 0.11	100.47 ± 09.81

The results also showed differences in growth patterns during the dry and rainy seasons, and that the fish grew better during the dry season. The probable reason is that the waters are clear and a maximum rate of sunlight penetrates into the waters, triggering the growth of phytoplankton and algae. Algae is a primary food item for the mullets^{40–43}. By contrast, turbidity and currents were higher during the rainy season⁴⁴, and thereby presume to inhibit the growth of phytoplankton and algae as important food item for mullets. A similar phenomenon was reported by Chu *et al.*³⁰, who found a negative growth pattern in *L. macrolepis* in Taiwan during winter, and an isometric growth pattern during summer and spring. Moreover, Sandhya and Shameem²⁹ observed a negative growth pattern in *L. macrolepis* in polluted waters, in contrast to an isometric growth pattern in unpolluted waters. According Muchlisin *et al.*²², besides being affected by the environmental factors, the growth pattern of fish is also influenced by fish behavior; for example, the fish that were active swimmer had a lower *b* value than those that were passive swimmers^{45–47}.

The average correlation coefficients of *L. macrolepis* were 0.93 and 0.89 in females and males, respectively, whereas *M. engeli* had a correlation coefficient of 0.89 for males and

0.93 for females. In general, the correlation coefficients of *L. macrolepis* and *M. engeli* tend to be similar (above 75%), indicating a strong correlation between total length and body weight. The determination coefficients of *L. macrolepis* were 0.85 and 0.65 for the male and female fish, respectively, which means that approximately 65%–85% of total variants can be explained by the model, while *M. engeli* had a value of 0.90 and 0.94 for males and females, respectively, indicating that 90%–94% of variants can be explained by the model.

Conclusion

The results of this study showed that *L. macrolepis* had a negative growth pattern, whereas *M. engeli* had a positive allometric growth pattern. These growth patterns were better during the dry season for both species. Condition factors showed that the environmental condition of Lambada Lhok remains suitable for the growth of the mullets, and the density of prey and predator is balanced.

Data availability

Underlying data

Figshare: Raw Data of *Liza macrolepis*.xlsx. <https://doi.org/10.6084/m9.figshare.12028062.v1>³⁷

This project contains the following underlying data:

- Raw Data of *Liza macrolepis*.xlsx (Raw data of sampled *Liza macrolepis*)
- Raw Data of *Moolgarda engeli*.xlsx (Raw data of *Moolgarda engeli*)

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Acknowledgments

All members of Ichthyos Research Group are acknowledged.

References

- Chang CW, Iizuka Y: **Estuarine use and movement patterns of seven sympatric Mugilidae fishes: the Tatu Creek estuary, central western Taiwan.** *Estuarine, Coastal and Shelf Science*. 2012; **106**: 121–126.
[Publisher Full Text](#)
- Minos G, Imsiridou A, Economidis PS: ***Liza haematocheilus* (Pisces, Mugilidae) in Northern Aegean Sea.** In: XII European Congress of Ichthyology in Cavtat (Dubrovnik), Croatia. 2007.
[Reference Source](#)
- Nzioka RM, Marine K: **Fish culture in brackish water.** *Post Kenya*. 1980; **5**(2): 22–25.
[Reference Source](#)
- Muchlisin ZA, Siti-Azizah MN: **Diversity and distribution of freshwater fishes in Aceh Waters, Northern Sumatera, Indonesia.** *International Journal of Zoological Research*. 2009; **5**(2): 62–79.
[Publisher Full Text](#)
- Mićković B, Nikčević M, Hegediš A, et al.: **Mullet fry (Mugilidae) in coastal waters of Montenegro, their spatial distribution and migration phenology.** *Archives of Biological Sciences*. 2010; **62**(1): 107–114.
[Publisher Full Text](#)
- Regner S, Gacic Z, Krpo-Cetkovic J: **Mullet fry (Mugilidae) in coastal waters of Montenegro, their spatial distribution and migration phenology.** *Archives of Biological Sciences*. 2010; **62**(1): 107–114.
[Publisher Full Text](#)
- Turan C, Gürlek M, Ergüden D, et al.: **Systematic status of nine mullet species (mugilidae) in the Mediterranean sea.** *Turkish Journal of Fisheries and Aquatic Sciences*. 2011; **11**(2): 315–321.
[Reference Source](#)
- Durand JD, Shen KN, Chen WJ, et al.: **Systematics of the grey mullets (Teleostei: Mugiliformes: Mugilidae): molecular phylogenetic evidence challenges two centuries of morphology-based taxonomy.** *Mol Phylogenet Evol*. 2012; **64**(1): 73–92.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Nelson JS: **Fishes of the world.** USA: John Wiley and Sons, Inc. 2007.
[Reference Source](#)
- Batubara AS, Muchlisin ZA, Thamren MY, et al.: **Check list of marine fishes from Simeulue Island waters, Aceh Province, Indonesia.** *Aceh Journal of Animal Science*. 2017; **2**(2): 77–84.
[Publisher Full Text](#)
- Batubara AS, Abdan M, Muhammad Z, et al.: **Peripheral fishes in the Estuary of Simeulue Island, Indonesia.** *IOP Conference Series: Earth and Environmental Science*. IOP Publishing. 2018; **216**: 012011.
[Publisher Full Text](#)
- Zainabun, Djuita S, Diba F: **Development of region of zoning mangrove rehabilitate land of post tsunami in District of Baitussalam sub-Province of Aceh Besar.** *Agrista*. 2011; **15**(1): 10–14.
- Liew SC, Kam SP, Chen P, et al.: **Mapping tsunami-affected coastal aquaculture areas in Northern sumatra using high resolution satellite imagery.** Asian Association on Remote Sensing - 26th Asian Conference on Remote Sensing and 2nd Asian Space Conference. *ACRS*. 2005; **1**: 116–120.
[Reference Source](#)
- Sulistiono S, Arwani M, Aziz KA: **Growth of mullet, *Mugil dussumieri* in Ujung Pangkah, East Java.** *Jurnal Iktiologi Indonesia*. 2001; **1**(2): 39–47.
[Reference Source](#)
- Guinea J, Fernandez F: **Morphological and biometrical study of the gill rakers in four species of mullet.** *Journal of Fish Biology*. 1992; **41**(3): 381–397.
[Publisher Full Text](#)
- Al-Ghiffary GA, Rahardjo MF, Zahid A, et al.: **Diet composition and niche breadth of mullet *Chelon subviridis* (Valenciennes, 1836) and *Moolgarda engeli* (Bleeker, 1858) in Pabean Bay Indramayu Subdistrict, West Java Province.** *Jurnal Iktiologi Indonesia*. 2018; **18**(1): 41–56.
[Publisher Full Text](#)
- Prastyo Y, Batu DTL, Sulistiono S: **Heavy metal contain Cu and Cd on the mullet in the estuary of Donan River, Cilacap, Central Java.** *Jurnal Pengolahan Hasil Perikanan Indonesia*. 2017; **20**(1): 18–27.
[Publisher Full Text](#)
- Squadrone S, Prearo M, Gavinelli S, et al.: **Heavy metals in *Mugil cephalus* (Mugilidae) from the Ligurian Sea (north-west Mediterranean, Italy).** *Food Addit Contam Part B Surveill*. 2013; **6**(2): 134–138.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Froese R: **Cube law condition factor and weight-length relationships: history, meta-analysis and recommendations.** *Journal of Applied Ichthyology*. 2006; **22**(4): 241–253.
[Publisher Full Text](#)
- Blackwell BG, Brown ML, Willis DW: **Relative weight (Wr) status and current use in fisheries assessment and management.** *Reviews in Fisheries Science*. 2000; **8**(1): 1–44.
[Publisher Full Text](#)
- Muchlisin ZA, Batubara AS, Azizah MNS, et al.: **Feeding habit and length weight relationship of keureling fish, *Tor tambra* Valenciennes, 1842 (Cyprinidae) from the western region of Aceh Province, Indonesia.** *Biodiversitas*. 2015; **16**(1): 89–94.
[Publisher Full Text](#)
- Muchlisin ZA, Musman M, Siti-Azizah MN: **Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia.** *Journal of Applied Ichthyology*. 2010; **26**(6): 949–953.
[Publisher Full Text](#)
- Muchlisin ZA, Fransiska V, Muhammadar AA, et al.: **Length-weight relationships and condition factors of the three dominant species of marine fishes caught by traditional beach trawl in Ulelhee Bay Banda Aceh City, Indonesia.** *Croatian Journal of Fisheries*. 2017; **75**(4): 104–12.
[Reference Source](#)
- Batubara AS, Muchlisin ZA, Efizon D, et al.: **Length-Weight Relationships and Condition Factors of the Naleh Fish, *Barbonymus gonionotus* (Pisces, Cyprinidae) Harvested from Nagan Raya Waters, Indonesia.** *Vestnik Zoologii*. 2019; **53**(1): 75–82.
[Publisher Full Text](#)
- Datta SN, Kaur VI, Dhawan A, et al.: **Estimation of length-weight relationship and condition factor of spotted snakehead *Channa punctata* (Bloch) under different feeding regimes.** *SpringerPlus*. 2013; **2**(1): 436.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Oscos J, Campos F, Escala MC: **Weight-length relationships of some fish species of the Iberian Peninsula.** *Journal of Applied Ichthyology*. 2005; **21**(1): 73–4.
[Publisher Full Text](#)
- Perdana AW, Batubara AS, Nur FM: **LWRs, condition factors and isopod parasites infection of the sumbo fish *Selar crumenophthalmus* (Pisces: Carangidae) in Lampulo fishing port, Banda Aceh, Aceh Province, Indonesia.** *IOP Conference Series: Earth and Environmental Science*. 2019; **348**(1): 012017.
[Publisher Full Text](#)
- Parida S, Karna SK, Pradhan SK, et al.: **Length weight relationship and condition factor of *Liza macrolepis* (Smith, 1946) in Chilika Lagoon, Odisha, India.** *Journal of Global Biosciences*. 2013; **2**(5): 116–120.
[Reference Source](#)
- Sandhya V, Shameem U: **Length-weight relationship and condition factor of *Liza macrolepis* (Smith) from polluted and unpolluted waters of Visakhapatnam.** *Indian Journal of Fisheries*. 2003; **50**(4): 543–546.
[Reference Source](#)
- Chu WS, Hou YY, Ueng YT, et al.: **Length-weight relationship of largescale mullet, *Liza macrolepis* (Smith, 1846), off the southwestern coast of Taiwan.** *African Journal of Biotechnology*. 2012; **11**(8): 1948–1952.
[Reference Source](#)
- Mulfizar M, Muchlisin ZA, Dewiyantri I: **Hubungan panjang berat dan faktor kondisi tiga jenis ikan yang tertangkap di perairan Kuala Gigieng, Aceh Besar, Provinsi Aceh.** *Depik*. 2012; **1**: 1–9.
[Reference Source](#)
- Muttaqin Z, Dewiyantri I, Aliza D: **Kajian hubungan panjang berat dan faktor kondisi ikan nila (*Oreochromis niloticus*) dan ikan belanak (*Mugil cephalus*) yang tertangkap di Sungai Matang Guru, Kecamatan Madat, Kabupaten Aceh**

- Timur. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah*. 2016; 1(1): 397–403.
[Reference Source](#)
33. De-Robertis A, Williams K: **Weight-length relationships in fisheries studies: the standard allometric model should be applied with caution.** *Transactions of the American Fisheries Society*. 2008; 137(3): 707–719.
[Publisher Full Text](#)
 34. Rypel AL, Richter TJ: **Empirical percentile standard weight equation for the Blacktail Redhorse.** *North American Journal of Fisheries Management*. 2008; 28(6): 1843–1846.
[Publisher Full Text](#)
 35. Okgerman H: **Seasonal variations in the length-weight relationship and condition factor of rudd (*Scardinius erythrophthalmus* L.) in Sapanca Lake.** *International Journal of Zoological Research*. 2005; 1(1): 6–10.
[Publisher Full Text](#)
 36. Morton A, Routledge RD: **Fulton's condition factor: Is it a valid measure of sea lice impact on juvenile salmon?** *North American Journal of Fisheries Management*. 2006; 26(1): 56–62.
[Publisher Full Text](#)
 37. Yulianto D, Batubara AS, Efizon D, *et al.*: **Raw Data of Liza macrolepis.xlsx.** *figshare*. Dataset. 2020.
<http://www.doi.org/10.6084/m9.figshare.12028062.v1>
 38. Ayoade AA, Ikulala AO: **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*. 2007; 55(3–4): 969–977.
[PubMed Abstract](#) | [Publisher Full Text](#)
 39. Ogunola OS, Onada OA: **Preliminary investigation of length –weight relationships and condition factors of two commercially important fish species (Mullet, *Mugil cephalus* (Linnaeus 1758) and Sardine, *Sardinella maderensis*. (Lowe 1838)) in Okrika creeks (Niger-Delta) of Nigeria.** *Regional Studies in Marine Science*. 2017; 13: 54–58.
[Publisher Full Text](#)
 40. Blaber SJ: **The food and feeding ecology of Mugilidae in the St. Lucia lake system.** *Biological Journal of the Linnean Society*. 1976; 8(3): 267–277.
[Publisher Full Text](#)
 41. HARI D, Blay J, Yankson K: **Food and feeding habits of grey mullets (Pisces: Mugilidae) in two estuaries in Ghana.** *West African Journal of Applied Ecology*. 2005; 8(1): 1–13.
[Publisher Full Text](#)
 42. Fatema K, Omar WM, Isa MM: **Identification of food and feeding habits of mullet fish, *Liza subviridis* (Valenciennes, 1836), *Valamugil buechanani* (Bleeker, 1853) from Merbok Estuary, Kedah, Malaysia.** *Journal of Life Sciences and Technologies*. 2013; 1(1): 47–50.
[Reference Source](#)
 43. Luther G: **The food habits of *Liza Macrolepis* (Smith) and *Mugil chepalus* Linnaeus (Mugilidae).** *Indian Journal of Fisheries*. 1962; 9(2): 604–626.
[Reference Source](#)
 44. Purnawan S, Setiawan I, Marwatim M: **Studi sebaran sedimen berdasarkan ukuran butir di perairan Kuala Gigieng, Kabupaten Aceh Besar, Provinsi Aceh.** *Depik*. 2012; 1(1): 31–36.
[Publisher Full Text](#)
 45. Bulanin U, Masrizal M, Muchlisin ZA: **Length-weight relationships and condition factors of the whitespotted grouper *Epinephelus coeruleopunctatus*. Bloch, 1790 in the coastal waters of Padang City, Indonesia.** *Aceh Journal of Animal Science*. 2017; 2(1): 23–27.
[Publisher Full Text](#)
 46. Machrizal R, Khaitul K, Nasution J, *et al.*: **Distribution and length-weight relationships of Hilsa shad *Tenulosa ilisha*. in the Bilah River, Labuhanbatu Regency, North Sumatera Province, Indonesia.** *Aceh Journal of Animal Science*. 2019; 4(1): 42–49.
[Publisher Full Text](#)
 47. Ramses R, Ismarti I, Syamsi F: **Length-weight relationships and condition factors of four dominant fish caught by coral bubu trap on the west coast of Batam Island, Indonesia.** *Aceh Journal of Animal Science*. 2020; 5(1): 1–10.
[Reference Source](#)

Open Peer Review

Current Peer Review Status: ? ?

Version 1

Reviewer Report 05 June 2020

<https://doi.org/10.5256/f1000research.24904.r63617>

© 2020 Nugroho R. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Rudy Agung Nugroho

Animal Physiology, Development, and Molecular Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University, Samarinda, Indonesia

Title:

The title is sufficient and reflects the content of the study.

Abstract:

Well-constructed.

Introduction:

Adequate.

Materials and Methods:

1. Please mention in the Time, site, and sampling or LWRs analyses section that male and female fish were measured/analysis for LWR separately.
2. In the fields observation, it is stated that, the weather condition, tides, and water turbidity are also observed visually during the sampling. Is the observed visual data recorded? If yes, please mention in the result section.

Results:

1. Please add field observation results (if the data was recorded as mentioned in the Materials and methods).
2. In the Condition factors section, it mentions about the dry session and rainy session; which dry or rainy session between July and November? Please add information.

Discussion:

1. Develop the discussion by mentioning about the relationship between the environment factor and the results of LWRs and CF fishes', ex: what prey and predator of both fish.
2. It is also mentioned in the discussion that the relative weight condition factor also corresponds to fish health conditions, stock estimates, and management levels. This can be

an interesting discussion to be developed.

Conclusion:

Sufficient, but it is better to add a conclusion regarding the condition factors related to the sex (male/female) of both fish.

References:

Sufficient.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Animal Physiology, Fish nutrition, Fish Conservation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 06 Jun 2020

Zainal Abidin Muchlisin, Universitas Syiah Kuala, Banda Aceh, Indonesia

1. Comment:

Please mention in the Time, site, and sampling or LWRs analyses section that male and female fish were measured/analyzed for LWR separately.

Respond:

We have added this information in the material and method (page 5)

2. Comment:

In the field observation, it is stated that the weather condition, tides, and water turbidity are also observed visually during the sampling. Is the observed visual data recorded? If yes,

please mention in the result section.

Respond:

This information was added in the results section (condition factor subsection) on page 8

4. Comments:

In the condition factors section, it mentions about the dry session and rainy session; which dry or rainy session between July and November? Please add the information.

Respond:

This detail description of the dry and wet/rainy seasons have been added at Time, Site and Sampling Section (page 4)

5. Comment:

Develop the discussion by mentioning the relationship between the environment factor and the results of LWRs and CF fishes', ex: what prey and predator of both fish.

Respond:

We have discussed the relationship between environmental factors and LWRs and the condition factor of the fish (page 10-11). Based on some references, and our data (these data will be published separately) that the prey (food) for the mullets are mostly plankton and algae (we have added this information in the discussion section). But, we have not examined the predator for mullets.

6. Comment:

It is also mentioned in the discussion that the relative weight condition factor also corresponds to fish health conditions, stock estimates, and management levels. This can be an interesting discussion to be developed.

Respond:

We have developed the discussion as suggested by the reviewer (page 11 under quotation to Blackwell et al. (2000)).

7. Comment:

The conclusion is sufficient, but it is better to add a conclusion regarding the condition factors related to the sex (male/female) of both fish.

Respond:

We have extended the conclusion, but we think that the detailed information male and female fish would be better displayed in the Abstract. In the conclusion section, we mentioned generally.

Competing Interests: No competing interests were disclosed

Reviewer Report 01 June 2020

<https://doi.org/10.5256/f1000research.24904.r63616>

© 2020 Hardi E. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Esti Handayani Hardi

Animal physiology, development and molecular laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Mulawarman University, Samarinda, Indonesia

- The method of taking fish has not been clearly described in the Methods.
- The water quality or environment condition has not been mentioned.
- Maybe, add the discussion about the relationship between the environment with the fishes' conditions.
- Many references were old references, need to add the new articles.
- The conclusion part is not enough.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: fish diseases, microbiology, aquaculture biotechnology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 06 Jun 2020

Zainal Abidin Muchlisin, Universitas Syiah Kuala, Banda Aceh, Indonesia

1. Comment:

The method of taking fish has not been clearly described in the Methods.

Respond:

We have mentioned that "The fish sampling was done purposively at these locations as they were easy to access and fish were reported to be present" (page 4)

2. Comment:

The water quality or environment condition has not been mentioned

Respond:

We have not recorded the water quality

3. Comment:

Maybe, add the discussion about the relationship between the environment with the fishes' conditions.

Respond:

The study showed that the fish are growing well during the dry season, this is related to environmental conditions during this season that the turbidity was lower and therefore the sunlight can penetrate into the waters maximumly and trigger the phytoplankton (algae) growing well. The algae are the primary food for mullets. We have mentioned this condition the pages 10-11.

4. Comment:

Many references were old references, need to add the new articles.

Respond:

Very limited reports on mullets were available, but we have added 4 related and up to date references (reference No. 45-48) to support the discussion

5. Comment:

The conclusion part is not enough.

Respond:

We have extended the conclusion (on page 11)

Competing Interests: No competing interests were disclosed

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com

F1000Research