Bioecological aspects of *Hampala macrolepidota* in Lake Singkarak, West Sumatera, Indonesia

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Abstract. Hampala barb, *Hampala macrolepidota* is a fish species recorded in Lake Singkarak, which has an important economic value, therefore it is harvested by fishermen using fishing rods, gill nets and explosives. Inappropriate methods of harvesting can result in the decrease of fish population, but no recovery action, like artificial breeding, is conducted at the present. Prior to such an initiative, it is necessary to study the biological aspects of *H. macrolepidota*. This study aimed to determine the range of size, length-weight relationship and growth pattern of *H. macrolepidota.* This research had been conducted from November 2015 until October 2016 using gill nets and fishing pole as collection methods. The results showed that the distributional frequency of the total length of juveniles ranged from 54 to 166 mm (119.01±24.50), among which males ranged from 175 to 405 mm (284.76±37.54) and females ranged from 167 to 581 mm (380.38±80.93). The body weight of juveniles ranged from 1.2 to 97 g (18.94±10.96), among which males ranged from 50.90 to 821.2 g (264.86±112.87) and females from 41.2 to 2226.7 g (596.40±451.37). The relationship between length (L) and weight (W) for juveniles was $W=0.975\ L^{0.581}$ (r^2=0.907), for males was $W=0.992\ L^{0.974}$ (r^2=0.836) and for females was $W=0.985\ L^{1.053}$ (r^2=0.801). The allometric growth pattern was negative with the model of equation Y=0.975+0.581 X for juveniles, Y=0.993+0.974 X for males and Y=0.984+1.053 X for females, where X=Log W and Y=Log L.
Key Words: range of size, length-weight relationships, growth pattern.

Introduction. Hampala barb, *Hampala macrolepidota*, local name Sasau, is a carnivorous freshwater finfish living in Lake Singkarak (Salsabila 1997; Risdawati 1997; Uslichah & Syandri 2003). Taxonomically, *H. macrolepidota* belongs to the Cyprinidae family. This species is widely distributed across Sundaland and Indochina. The *H. macrolepidota* broodstock has black patches between the dorsal and pelvic fins which become vague when fish grow bigger (Kottelat et al 1993; Weber 1916; Allen 2013).

This fish species has an important economic value in the local market, therefore it became a capture target for fishing sport in lakes and rivers (Salsabila 1997; Soetignya et al 2016). Catching methods applied to *H. macrolepidota* are not selective, using various types of fishing gear, such as gill nets, explosives and electrical current, which can cause the wild population to decline. *H. macrolepidota* is classified as renewable natural resources, however, without a proper fishing management, this species population, along with other fish species, will continue to decline. Therefore, the management of the *H. macrolepidota* population and its domestication are very important for the future.

Fisheries management and *H. macrolepidota* domestication require information on size ranges, length-weight relationships and growth. There are no researchers who reported data on the *H. macrolepidota* biological parameters' monitoring in Lake Singkarak, over a whole year. In other habitats it has been reported by Rahardjo (1977) in the Jatiluhur Reservoir, Uslichah & Syandri (2003) in Lake Singkarak, Soetignya et al (2016) in Kalimantan, Musrin (2014) in the Sudirman Reservoir, Jubaedah (2004) in the Reservoir Cirata, and Zulkafli et al (2016) in Sungai Tembeling Malaysia. The study aimed to determine the range of size, length-weight relationship and growth risk of the *H. macrolepidota* in Lake Singkarak.

Material and Method

Description of the study sites. This research was undertaken at Lake Singkarak, West Sumatera, Indonesia. Fish sampling lasted from November 2015 until October 2016 and it was conducted twice a month. Four sampling locations were selected based on the differences on their conditions, namely (1) Sumpur (location 1: 00º 32' 30.5" S and 100º 30' 28.2" E), an inlet with clear water; (2) Ombilin (location 2: 00º 54' 35.5" S and 100º 22' 01.7" E), an outlet; (3) Sumani, (location 3: 00º 39' 58.3" S and 100º 32' 43.4" E), an inlet with turbid water; (4) Paninggahan (location 4: 00º 41' 50. 9" S and 100º 53' 15.9" E), a location filled with many aquatic plants (Figure 1).

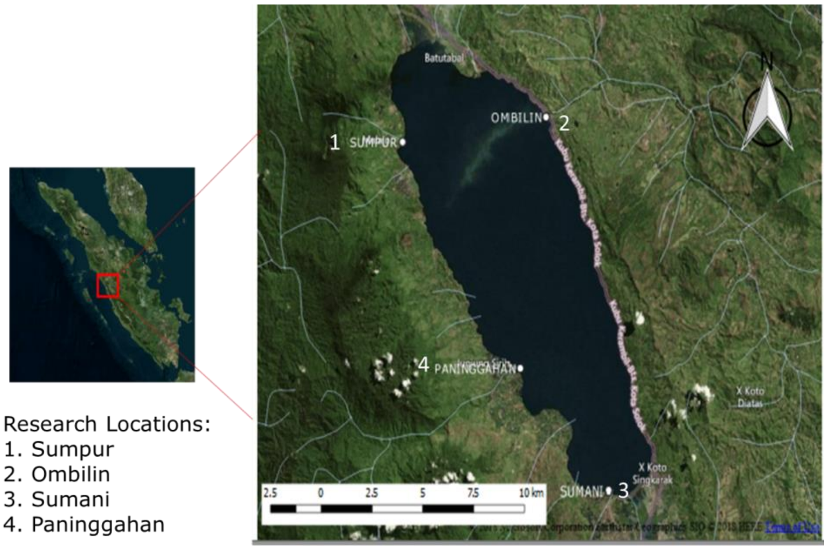

Figure 1. Map of the research location at the Singkarak Lake.

Range of size. The sampling locations differed in their environmental conditions. For sampling, the assistance from local fishermen was required. The samples of *H. macrolepidota* barb were collected using gill nets (0.75, 1, 1.5 and 4 inches mesh size) and fishing pole. The morphometric character is the total length (mm) with an accuracy of up to 1 mm. The range of size was divided into 11 class intervals. The body weight was taken with Osuka Series HWH digital scales, with an accuracy of 0.1 g. The samples were organized according to their sex, time of collection and research location. The fishes were then preserved with 10% formalin and species identification was confirmed in the laboratory of the Andalas University, with the help of relevant guides (Kottelat et al 1993; Weber 1916).

Length-weight relationship. The total length was grouped into 11 classes of intervals for analysis. The length-weight relationship was estimated by the exponential equation (Effendie 2002; Pauly 1987): $W=aL^b$, where W is the body weight (g), L is the total length (mm), a=constant, b=regression coefficient. The relationship $W=aL^b$, when converted into its logarithmic form, gives a linear dependence: Log W=Log a+b Log L (Patiyal et al 2013). The slope b has a numerical value mostly ranging between 2.5 and 3.5 and often close to 3 (Soriano & Brey 1988; Pauly 1987).

Growth pattern. There are three types of growth within the relationship between weight and length, namely: (1) the isometric growth, where the weight gain is balanced by length increment (b=3); (2) the positive allometric growth, where the body weight increases faster than the length increment (b>3); and (3) the negative allometric growth, in which the weight gain is slower than the length increment (b<3). The growth pattern can be seen from the regression coefficient of the weight-length relationship. The regression coefficient values range from 2.5 to 3.5 (Uslichah & Syandri 2003; Syandri 1996; Pauly 1987).

Results and Discussion

Range of size. The study analyzed a sample of 839 fish. The measured lengths were grouped into 11 classes and 49 intervals as shown in Table 1. The total length of *H. macrolepidota* observed in this study ranged from 54 to 590 mm. Most of the sample population belonged to the class from 104 to 553 mm, with 371 individuals (44.22%). Only two individuals (0.002%) belonged to the class 554 to 603 mm. The largest sample population was collected in August, 195 individuals (23.24%), more than in March, when 149 individuals were captured (17.76%). The least capture was in June, namely 23 individuals (2.74%) (Table 1). In previous studies, at the Cirata reservoir, the temporal abundance of *H. macrolepidota* was dominant in February (40.74%) and May (14.81%), when compared to other fish species populations (Wahyuni & Affandi 2004).

Table 1
Number of capture and range of size of *Hampala macrolepidota* at Lake Singkarak

Total length range (mm)	*2015*		*2016*										*Total*
	Nov	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	
54-103	6	0	0	15	26	5	8	1	3	72	7	6	149
104-153	3	0	1	10	89	31	17	3	15	96	60	46	371
154-203	4	0	7	2	19	5	0	1	0	10	5	5	58
203-253	7	0	0	1	0	0	1	3	1	0	0	1	14
254-303	6	7	8	23	4	10	21	12	4	10	8	1	114
304-353	9	6	13	7	9	9	7	3	7	3	2	0	75
354-403	1	10	7	4	0	0	1	0	1	1	0	1	26
404-453	1	1	0	1	1	0	2	0	1	1	2	3	13
454-503	0	1	0	1	1	1	1	0	1	1	1	1	9
504-553	0	1	1	1	0	1	1	0	0	1	0	2	8
554-603	0	1	0	0	0	0	1	0	0	0	0	0	2
Total	37	27	37	65	149	62	60	23	33	195	85	66	839

Table 2 shows the measured total length of juveniles which ranged between 54 to 166 mm (119.01±24.50 mm), while their body weight ranged from 1.2 to 94 g (18.94±10.96 g). For the studied males, the total measured length ranged from 175 to 405 mm (284.76±37.54 mm) and the body weight ranged between 50.9 to 821.2 g (264.86 to 112.87 g). For the studied females, the total length ranged from 167 to 581 mm (360.38±80.93 mm), while the body weight ranged from 41.2 to 2,226.7 g (596.40 to 451.37 g). *H. macrolepidota* are presumably matured at the size of 167 mm, for the females, and at 175 mm for the males. The excessive weight of the females is thought to be part of the gonad weight.

Table 2
The total number of juvenile, male, female *Hampala macrolepidota* and their total length and body weight observed from Lake Singkarak

Category	*N*	*Range total length (mm)*	*Mean total length (±SD)*	*Range body weight (g)*	*Mean body weight (±SD)*
Juvenile	567	54-166	119.01±24.50	1.2–94	18.94–10.96
Male	156	175–405	284.76±37.54	50.9–821.2	264.86–112.87
Female	116	167–581	360.38±80.93	41.2–2226.7	596.40–451.37

The total length and body weight observed in this study were different than in the previous studies (Table 3). The length and body weight of *H. macrolepidota* at Jatiluhur Reservoir (Indonesia) ranged from 185 to 507 mm, and 90 to 1,420 g, respectively

(Rahardjo 1977). Extreme overfishing of commercially important fish species caused the decrease of their biomass in the lake (Ostrovsky et al 2012; Ostrovsky et al 2014).

Table 3
Comparison of total length and body weight of *Hampala macrolepidota* at Lake Singkarak and other locations

Location	*Total length (mm)*	*Body weight (g)*	*Reference*
Lake Singkarak, Indonesia	54-590	1.2–2,226.7	Current study
Zoo Negara Lake, Malaysia	106-349	209-750.6	Abidin et al 1986
Jatiluhur Reservoir, Indonesia	185-507	90–142	Rahardjo 1997
Kenyir Lake, Malaysia	75–555	46–2,140	Zakaria et al 2000
Tembeling River, Malaysia	121–639	195–917	Zulkafli et al 2006
Sudirman Reservoir, Indonesia	120-400	170–917	Musrin et al 2013

Most of the samples were captured in March and August, which lead to the assumption *that H. macrolepidota* probably spawn twice a year, predicting that the spawning occurs in the preceding months. Previous studies found that *H. macrolepidota* spawning occurs during the rainy season, that last from November to March each year (Abidin 1984; Jubaedah 2004). The spawning may start at the end of the dry season up until the beginning of the rainy season. This fish has gradual spawning type (Musrin 2013). It can spawn more than once annually (partial spawning) (Uslichah & Syandri 2003).

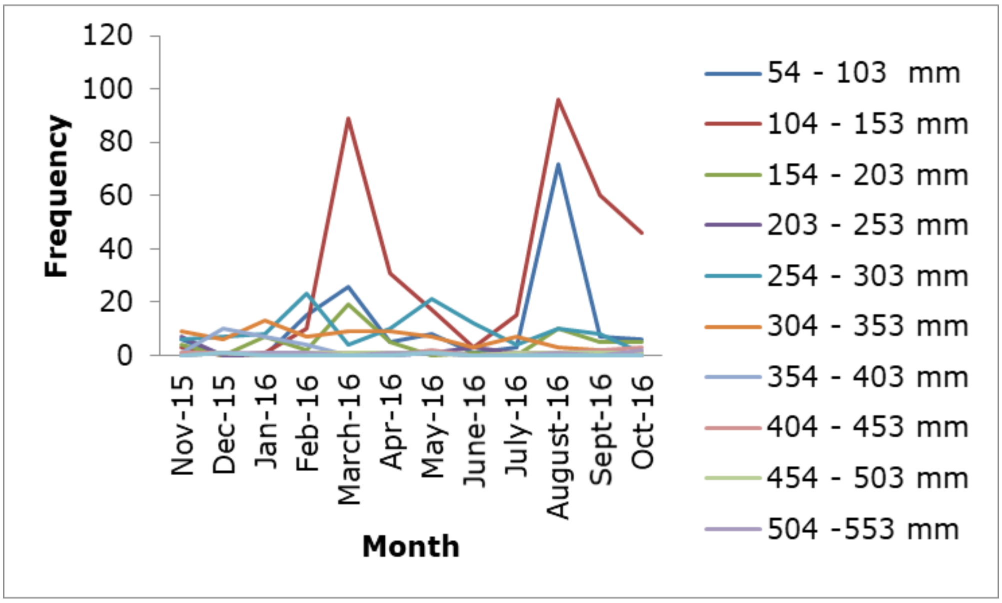

Figure 2. Range of size of *Hampala macrolepidota* during the study period.

Figure 2 illustrates the range of size of *H. macrolepidota* by interval classes. The two peaks in the graphic at the interval 104 to 153 mm denote the prominence of juvenile group. The two peaks of juvenile number hint on the two spawning peaks in a year. Juveniles were predominant in March and August during the study period. Hence, the peak spawning is estimated to be in February and July.

The highest capture for male occurred in February and May, while for female in January and April. Figure 3 shows the imbalance of the amount among juvenile, male and female, with catch ratios 1:0.28:0.20. For some fish, genetic, physiological and environmental conditions affect the sex ratio (Devlin & Nagahama 2002). February and March are the rainy seasons, where food availability is abundant. Surface fluctuations affect the productivity of water (Jubaedah 2004).

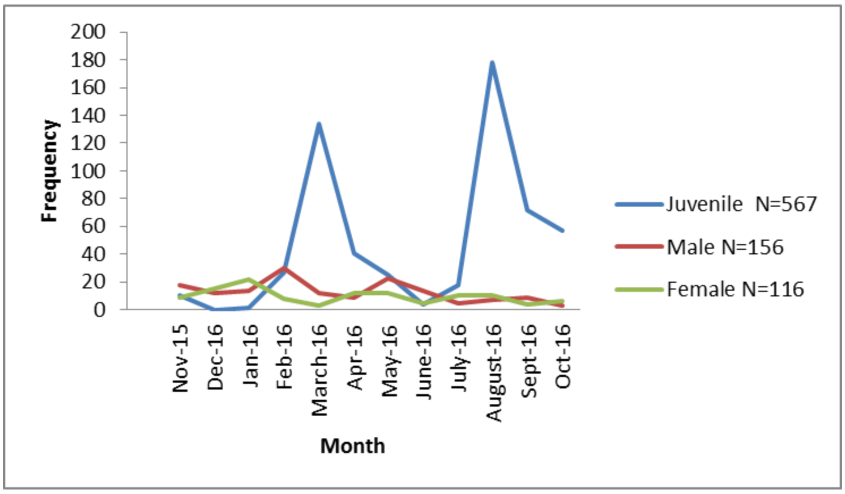

Figure 3. Distribution of juvenile, male and female *Hampala macrolepidota* during the study period.

Sumani site contributed the most to the sampling capture (Table 4). Sumani River is an inlet for Lake Singkarak with many aquatic plants such as *Eichhornia crassipes*, *Potamogeton malaianus*, *Ipomea aquatica*, *Monochoria hastata*, *Hydrilla* sp. and others (Sunanisari et al 2008). Considering the total amount of juvenile found there, the estuary of Sumani River is thought to be suitable for spawning and juvenile breeding. River estuaries with sendiments along with the submerging aquatic plants provide an array of food, habitat and protection sources for fish (Ismail et al 2013). A previous study indicated that suitable habitat for *H. macrolepidota* should be not too steep at the bottom, with many bays, abundance of plankton population, high dissolved oxygen and flowing water or lotic (Jubaedah 2004). The least capture was at station 2, Ombilin, which is an outlet of Lake Singkarak. The flow of Ombilin River is regulated in such a way to fulfill the intake of hydroelectric power plant. During the rainy season, the water loosely discharged. Conversely, during the dry season the water is carefully retained in Lake Singkarak for the purpose of provision for hydroelectric generation. At this station, fewer water plants were found.

Changes in body length and weight during a certain period are defined as growth or addition of biomass to an organism. Fish growth is a complex process, influenced by several factors including: 1) temperature and quality of water, 2) size, age, and sex of fish, 3) size and quality of food organisms, 4) fish population using the same source (Aziz 1989). Fish growth is often described in the form of a series of temporal weight, while the curves for body length and weight can differ at those times (Ostrovsky 2005).

Table 4

Distribution of *Hampala macrolepidota* in Lake Singkarak during the study period

Monthly	*Sumpur*	*Ombilin*	*Sumani*	*Paninggahan*	*Total*
Nov 2015	7	17	1	12	37
Dec 2015	1	13	9	4	27
Jan 2016	12	5	11	9	37
Feb 2016	24	14	13	14	65
March 2016	35	16	40	58	149
Apr 2016	9	0	42	11	62
May 2016	13	5	19	23	60
June 2016	3	11	9	0	23
July 2016	23	9	0	1	33
August 2016	46	39	108	2	195
Sept 2016	20	4	55	6	85
Oct 2016	1	3	57	5	66
Total	194	136	364	145	839

Length-weight relationship. The long-term relationship between juvenile, male and female *H. macrolepidota* with correlation coefficients is shown in Table 5. The samples consisted of juveniles *H. macrolepidota* with an average body weight of 219 g and 119 mm average length, males with 285 g average weight and 256 mm average length, and females with 360 g average weight and 596 mm average length. These three groups indicate negative allometric growth patterns with a value of b<3.

Table 5

The length-weight relationship of *Hampala macrolepidota*

Category	*n*	*K*	*a*	*b*	*r*	*r²*	*W*	*W=aL^b^*	*p-value*
Juvenile	567	1.2	0.975	0.581	0.952	0.907	3.95	$W=0.975\ L^{0.581}$	0.01
Female	156	1.09	0.992	0.974	0.895	0.801	4.72	$W=0.992\ L^{0.974}$	0.01
Male	116	1.23	0.985	1.053	0.914	0.836	4.77	$W=0.985\ L^{1.053}$	0.01

K-condition factor; a, b-parameters of relationship; W-length-weight relationship; r-correlation coefficient; r^2-determination coefficient; p- significant correlation; $W=aL^b$ -equation length-weight relationship.

The correlation coefficient (r) between the total length and the body weight was: 0.952 for juvenile, 0.914 for male and 0.895 for female, all greater than the r table values: 0.080, 0.159 and 0.176, respectively, suggesting a significant relationship of total length and body weight. According to Sugiono (2014) the correlation for juvenile, male, and female is classified as very strong, with r values between 0.8 and 1.00. In addition, the coefficients of determination (r^2) for the juveniles, males and females were 0.907, 0.836 and 0.801, respectively. These results were interpreted as follows: the juveniles' body weight is predicted in proportion of 90.7% by their length, males' body weight is predicted in proportion of 83.6% by their length of and females' body weight is predicted in proportion of 80.1% by their length. A lower effect on females and males than on juvenile is assumed to be influenced by the presence of gonads.

The Scatterplot charts showed strong positive relationship between total length and body weight whenever it forms a straight line. Such a close relationship between the total length and body weight was observed in three fish groups (Figures 4, 5, 6).

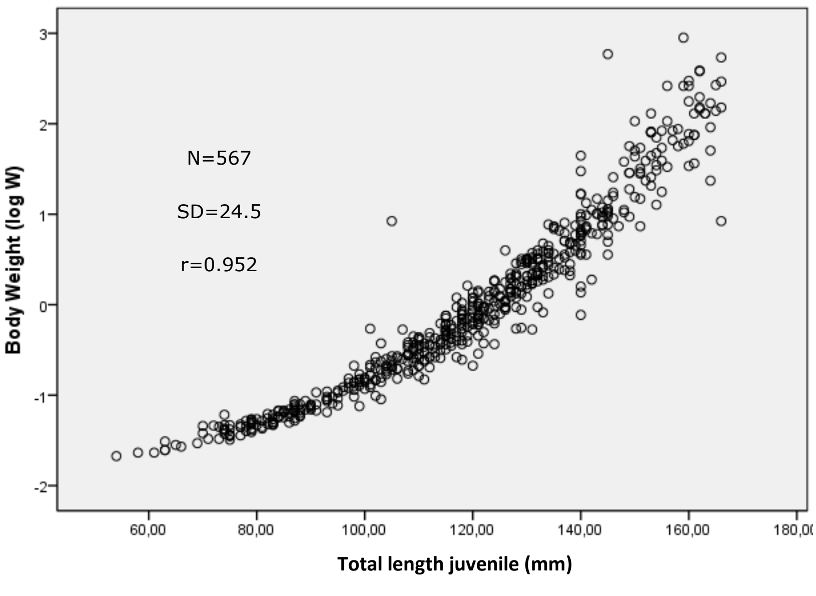

Figure 4. Length-weight relationship of *Hampala macrolepidota* juveniles.

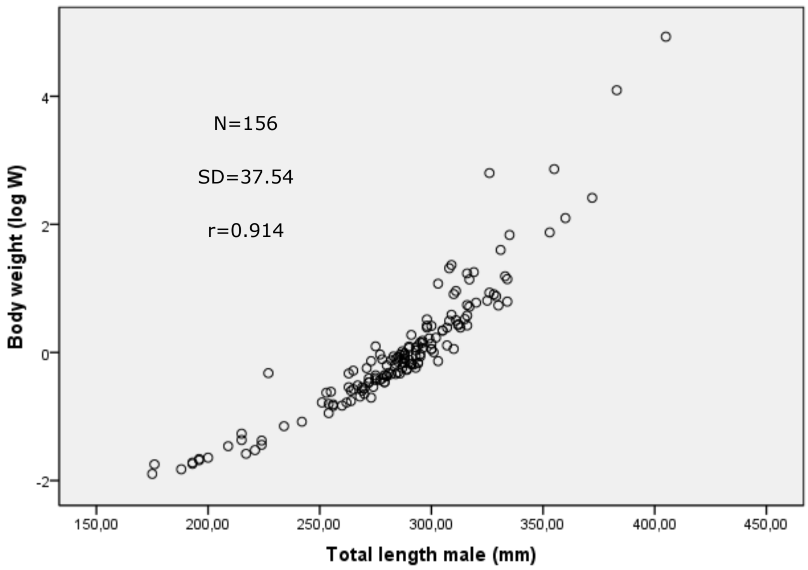

Figure 5. Length-weight relationship of *Hampala macrolepidota* males*.*

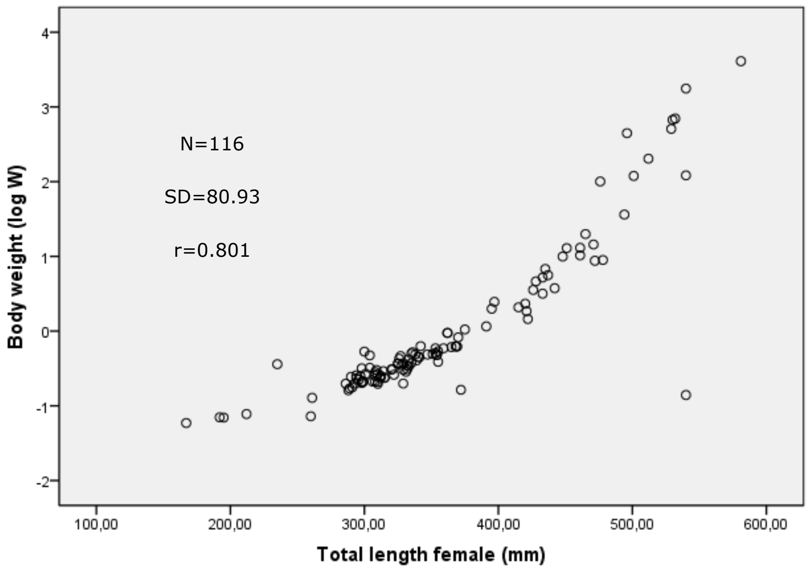

Figure 6. Length-weight relationship in *Hampala macrolepidota* females*.*

The shape of *H. macrolepidota* will resemble its adult whenever the larva stadium ends. Afterwards, the changes are insignificant and only happen in body parts, such as fins. Allometric or heterogenic growth consists in a disproportionate change between body length and weight, whereas if changes are continuous and proportional it is called isometric or isogenic growth (Effendie 2002).

Growth pattern. The analysis on *H. macrolepidota* showed negative allometric growth across the sex and age groups: juveniles with b=0.581 (Y=0.975+0.581 X), males with b=0.974 (Y=0.992+0.974 X) and females with b=1.053 (Y=0.985+1.053 X). It indicated that the total length increments are not in line with the gain in body weight. Based on the regression equation value, *H. macrolepidota* growth was presumed to be negative allometric with b value <3. It also means that the growth of the total length is not balanced with the increasing of the body weight. One cause of this negative allometric is the effect of gonad weight in the body weight even though the fishes are already mature. In line with Uslichah & Syandri (2003), males and females *H. macrolepidota* are found to have isometric growth patterns. According to researchers, fish growth patterns differences can occur due to the variations in dietary aspects and physical-chemical quality of water (Aryani et al 2018; Fagbuaro et al 2019).

Conclusions. The range of size of *H. macrolepidota* in Lake Singkarak followed the normal curve. The total length and body weight were strongly correlated, which means an increment of the body length will result in additional body weight. Moreover, the growth pattern in this fish is indicated as negative allometric. Most females are stockier than juveniles and males. In addition, spawning is presumed to occur in February and July. Finally, the results of this study can provide baseline data for the development of fishing management on *H. macrolepidota* in Lake Singkarak.

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