

Length-weight relationships of squid *Loligo chinensis* in the waters of Bangka Regency, the Province of Bangka Belitung Island, Indonesia

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Abstract. Bangka Regency waters in Bangka Belitung Islands Province is one of the squid fishing ground. The dominant squid which is captured in this area is *Loligo chinensis*. This study was conducted to determine the relationship of length-weight and to estimate the relative condition factor of squid *L. chinensis* in Bangka Regency waters. During this research, measurement was conducted on 392 squids consisting of 223 females and 169 males. The female *L. chinensis* mantle length range was 78-252 mm, and 14-277 g weight. The male *L. chinensis* has 84-370 mm mantle length range and 9-349 g weight. The relationship between mantle length and body weight is $W = 0.0008 L^{2.315}$ for the females and $W = 0.0082 L^{1.803}$ for the males. Regression coefficient (β) obtained for both female and male squids shows negative allometric growth which means that the increase of mantle length is slower than body weight. *L. chinensis* squids are less flattened in shape because they have a value of condition factor between one and three.

Key Words: Length-weight relationships, *Loligo chinensis*, negative allometric, condition factor, Bangka Regency waters.

Introduction. Squid is one of the main fishery commodities in the Province of Bangka Belitung Islands. In 2012, the squid production of this area reached 7,650 tons, or 5.43% of the national squid production (Ministry of Marine Affairs and Fisheries, Indonesia 2013). The waters of this province is also the squid fishing ground for fishermen from other areas such as Province of Jakarta, Lampung, Banten and West Java. This shows that the waters of this province are one of the potential areas for squid fishing.

The waters of Bangka Regency are one of the squid fishing ground in the Province of Bangka Belitung Islands. Syari (2014) reported that there are two dominant types of squids that were caught in this district *i.e.* Bangka squid or *Loligo chinensis* (Gray, 1849) and cuttlefish or *Sepia* sp. *L. chinensis* is the dominant commodity species captured by fishermen. Fishing gear used by local fishermen to catch squid is stationary lift net and squid jigging.

According to Carpenter & Niem (1998) *L. chinensis* is found in the waters of the East China Sea, South China Sea, the Gulf of Thailand, the Arafura Sea, Timor Sea and the waters of northern Australia. In the waters of Thailand is *L. Chinensis* reported as *L. Formosana* which belongs to the loliginid types widely caught by fishermen (Sithigorakul 1974). Rubaie et al (2012) reported that *Uroteuthis chinensis* is the type from Loliginidae class that is dominantly caught in China (90%) and 15-40% of trawlers catch in the Gulf of Thailand.

Some studies on several aspects of the squid growth in the waters of Indonesia had been conducted by Andy Omar (2002), Sulityowati (2002) and Danakusumah et al

(1977). These studies were about *Sepioteuthis lessoniana* types, while *L. chinensis* has not been studied in Indonesia. Therefore, the researchers were interested in studying the growth of *L. chinensis* in the waters of Bangka Regency. This study aimed to determine the length-weight relationship and to estimate the relative condition factor of squid *L. chinensis* caught in the waters of Bangka Regency.

Material and Method. This research was conducted from April to August 2014. Squid *L. chinensis* were caught by the fishermen using stationary lift net at fish landing sites in Rebo Village, Sungailiat Sub-district, Bangka Regency (Figure 1). Measurements were carried out on the mantle length (mm) and weight (g) of male and female *L. chinensis* (Figure 2).



Figure 1. Map of Bangka Regency, Bangka Belitung Islands Province (redrawn from a map of Bangka Regency provided by Bangka Regency Government 2015).

The estimation of the length-weight relationship used the formula $W = aL^\beta$ (Ricker 1979), where W = weight of squid (g), L = mantle length of squid (mm), a = constant or intercept and β = regression coefficient. By using the least squares method, the equation was transformed into a linear form, $\log W = a + \beta \log L$. β value was then tested to determine the type and pattern of growth of the squid. Testing was conducted to determine whether the β value is equal to three or not by using the t test (Walpole 1993). Condition factor or squid Ponderal Index was calculated based on the length-weight relationship using the formula $Kn = W/aL^\beta$ (Effendie 1979).

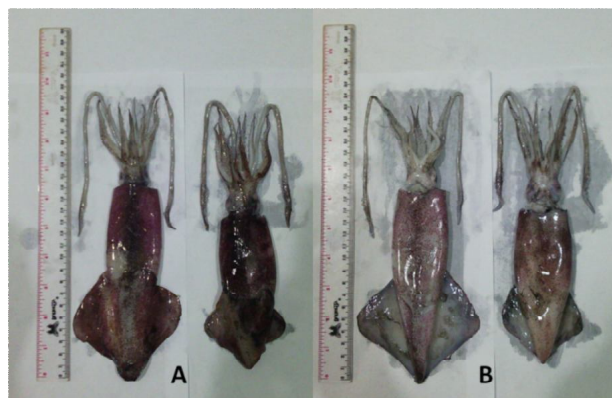


Figure 2. *Loligo chinensis* dorsal view (A), and ventral view (B).

Results and Discussion. The total number of squid *L. chinensis* obtained to be measured was 392 individuals, consisting of 223 females and 169 males. Mantle length of the females ranged from 78 to 252 mm and their weight ranged from 14 to 277 g. Mantle length of the male ranged from 84 to 370 mm and 9 to 349 g weight.

A research conducted by Yunrong et al (2013) in the Beibu Gulf – China showed that the mantle length of squid *U. chinensis* was 49 to 438 mm and their weight ranged from 7.3 to 723 g. The mantle length of *L. chinensis* in the Gulf of Andaman, Thailand, was from 50 to 286 mm for males and from 46 to 235 mm for females (Sukramongkol et al 2006).

Based on measurement of the sample length, it is known that the male *L. chinensis* mostly caught were from the 144-176 mm class (20.11%) and the females caught were from 144-176 mm class (43.50%). Length size distribution is presented in Figure 3. Figure 3 also shows that there are no samples of female *L. chinensis* whose length is more than 275 mm.

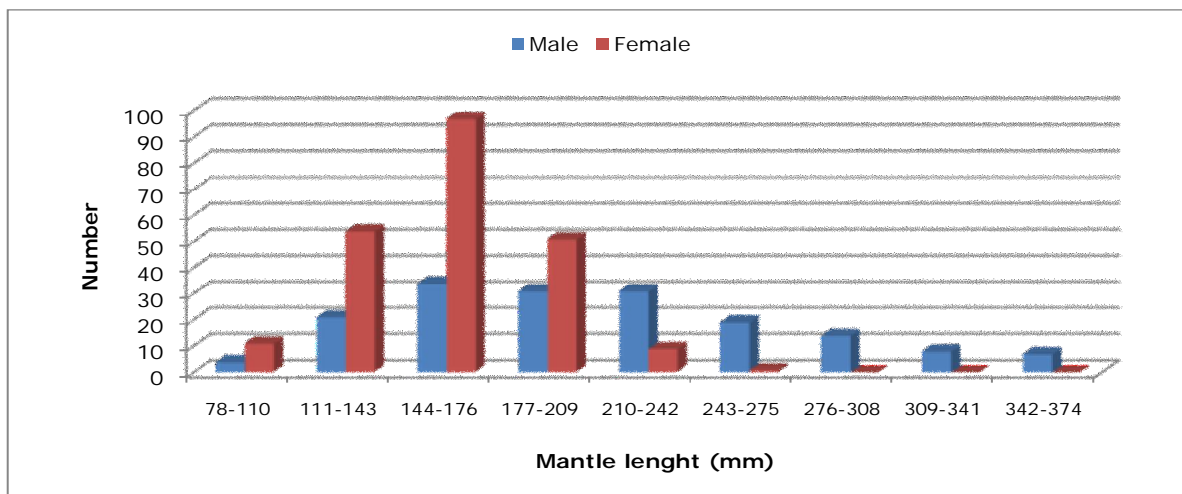


Figure 3. Distribution of male and female length of *Loligo chinensis*.

It is known also that the weight of male *L. chinensis* mostly caught was 87-125 g (28.99%) and that of the females was 87-125 g (40.81%). Weight size distribution is presented in Figure 4. Figure 4 also showed that there are no females of *L. chinensis* whose weight is over 242 g.

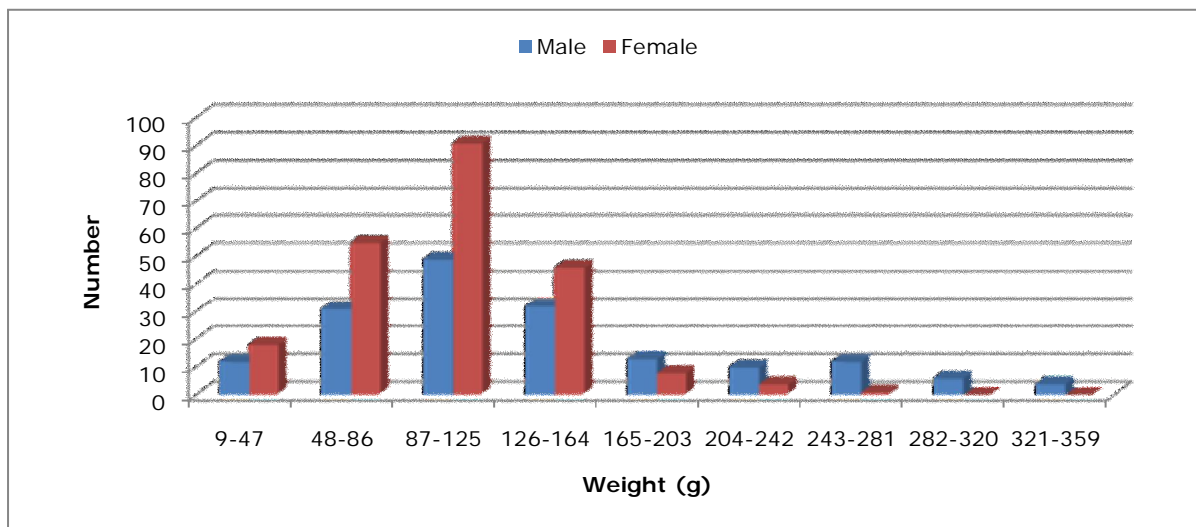


Figure 4. Distribution of weight for male and female *Loligo chinensis*.

The calculation of length mantle-weight relationship of *L. chinensis* in this study was conducted both on males and females. The results of the analysis are presented in Table 1. Although male squids have a weight and length greater than the females, the values of α and β for the male squids are smaller than those of the females.

Table 1

Equation of length mantle-weight relationship in male and female *Loligo chinensis*

Sexes	Equation
Male	Log W = -2.083 + 1.803 log L
	or
	W = 0.0082 L ^{1.803} N = 169; R ² = 0.868
Female	Log W = -3.117 + 2.315 log L
	or
	W = 0.0008 L ^{2.315} N = 223; R ² = 0.891

F test showed that the diversity of mantle length on each male and female *L. chinensis* can explain the diversity of body weight. As we can see from Table 1, there are differences in the relationship between length mantle and body weight on male and female *L. chinensis*.

The t-student test showed that the growth pattern of both types of *L. chinensis* is significantly different from 3. The obtained β values for males *L. chinensis* are 1.803 and 2.315 for the females (Figure 5). The β value is less than 3, which means that both growth patterns are negative allometric, or the increase of the length is smaller than the gained weight. For the same type of squid, the value α obtained in the research of Yunrong et al (2013) in the Beibu Gulf, China, was 0.00143 and the value $\beta = 2.19$. The research of Sukramongkol et al (2006) in the Andaman Sea obtained 0.006 and 0.0008 of value α , and 1.82 and 2.29 of value β , respectively for male and female of *L. chinensis*.

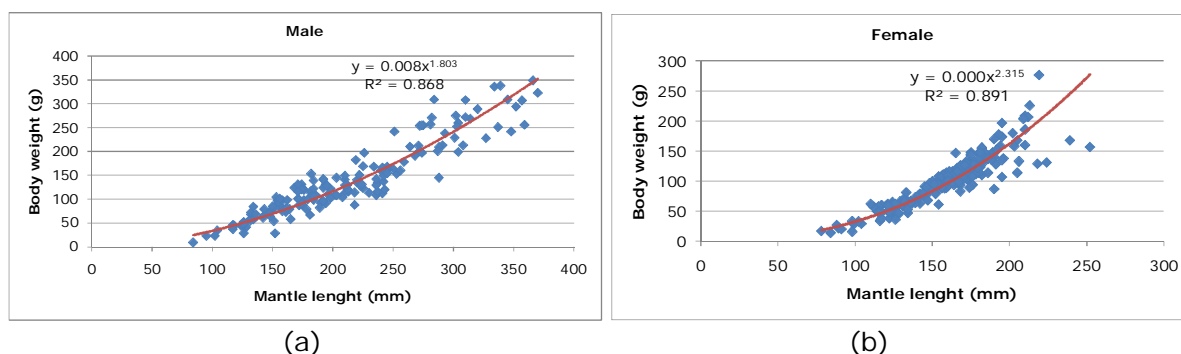


Figure 5. Length-weight relationship for male (a) and female (b) *Loligo chinensis*.

Observation on the study location showed that male *L. chinensis* can reach a larger size than females, and this indication is shown in Figure 5. The growth of female *L. chinensis* entirely completed before the mature of gonads. Meanwhile, the male growth keeps occurring even when the gonads are already mature. The value β of female *L. chinensis* is higher than that of the male. This shows that the growth of the females is faster than that of the males, and that the females reached the maximum size more quickly than males.

Ponderal index or condition factor is a situation that states animal plumpness with number and value which is influenced by age, sex, food and level of gonad maturity. Condition factor is the result of the weight comparison based on the observation of weight by estimating the mantle length. According to Effendie (1997) condition factor is the condition of the physical aspect for survival and reproduction.

The average value of male *L. chinensis* condition factor ranges from 0.69 to 1.13 and that of the females is from 0.57 to 1.04. Condition factor values are presented in Table 2. These values indicate that the *L. chinensis* is less flattened in shape because the values are between 1 and 3. Values which are smaller than one indicate that the weight based on the observation is smaller than the weight based on the presumption of mantle length and vice versa. Table 2 shows that the highest condition factor value is in the class of 144-176 mm mantle length in both male and female *L. chinensis*.

Table 2

Condition factor for male and female *Loligo chinensis*

Mantle length class (mm)	Male			Female		
	Total sample	Condition factor	Average weight (g)	Total sample	Condition factor	Average weight (g)
78-110	4	0.69	22.25	11	0.92	27.36
111-143	21	1.03	55.71	54	1.01	57.94
144-176	34	1.13	91.06	97	1.04	104.84
177-209	31	1.04	111.13	51	1.00	140.10
210-242	31	0.95	137.42	9	0.97	188.11
243-275	19	1.02	191.32	1	0.57	157.00
276-308	14	1.01	233.64	-	-	-
309-341	8	1.03	286.38	-	-	-
342-374	7	0.90	297.14	-	-	-

Table 2 also shows that the female *L. chinensis* squids have a greater weight than males in each the same mantle length. This condition, which is called 'sexual dimorphism', was also observed in the studies of *L. chinensis* and *L. duvauceli* in the Andaman Sea (Sukramongkol et al 2006), *L. chinensis* in the Gulf of Thailand (Chotiyaputta 1994) and North Queensland, Australia (Jackson 1993).

K Value is a quantitative parameter of the feeding conditions (Le Cren 1951). Higher K value indicates relative better feeding condition. Figure 6 shows that the longer the *L. chinensis*, the higher the K values. This shows that the bigger size of squid will gain more good food. Squid's food is influenced by size: small squid feed on planktonic organism and larger squid feed on crustaceans and small fish. Squid feeding conditions are also influenced by the change of seasons and geographical differences.

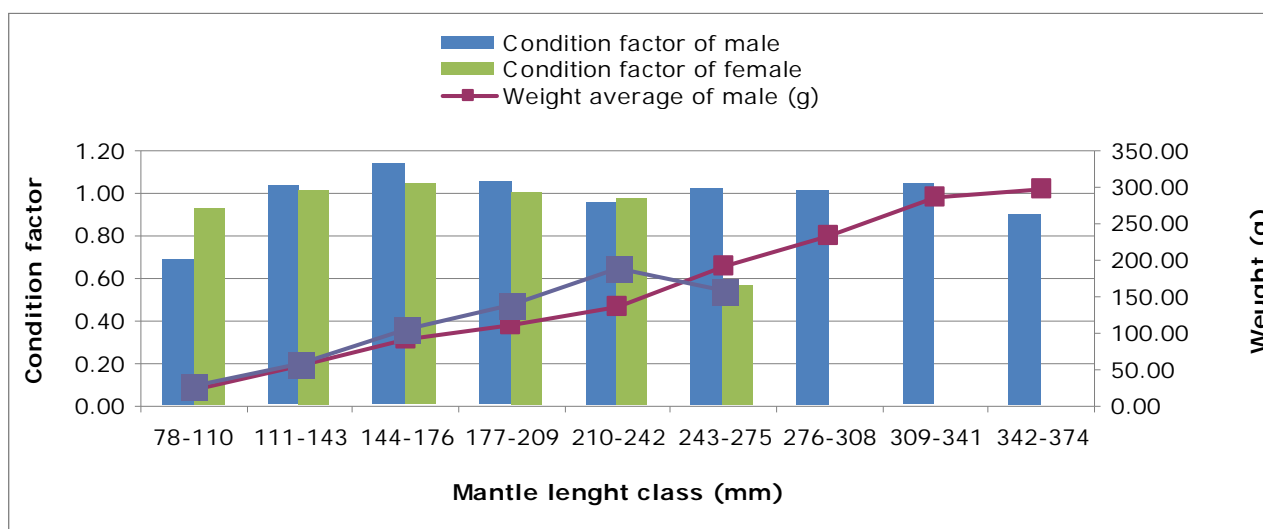


Figure 6. Relations of condition factor with the weight average of male and female *Loligo chinensis* based on mantle length class.

The study of Jackson (1995) showed the influence of seasonality on statolith growth of *L. chinensis*. In the summer, a rapid increase was found in the statolith length in a short period of 60-100 days. Otherwise, it was slower in the winter, the statolith length increased gradually in the 80-170 days.

Conclusions. Male *L. chinensis* squids in the waters of Bangka Regency have greater length and weight than the females. Mantle length of male squid is from 84 to 370 mm and its weight is from 9 to 349 g. Female squid length ranges from 78-252 mm and weight 14-227 g. Relationship of mantle length and body weight of male and female *L. chinensis* is different. Coefficient value of the females is larger than that of the males. This shows that the growth of female *L. chinensis* is faster than male. In other words, female *L. chinensis* reaches the maximum size faster than male does. The growth of *L. chinensis* is negative allometric. The increase of length, both on male and female squids is slower than increase of weight. This is evidenced by the coefficient of β whose value is not equal to 3. Based on the value of condition factor, the studied *L. chinensis* squids are less flattened in shape because they have a value between 1 and 3. The bigger the squid is, the higher condition factor value it has.

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