Carapace length-weight and width-weight relationships of *Scylla serrata* in Bulungan District, North Kalimantan, Indonesia

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Abstract. *Widigdo B, Rukisah, Laga A, Hakim AA, Wardiatno Y. 2017. Carapace length-weight and width-weight relationships of* Scylla serrata *in Bulungan District, North Kalimantan, Indonesia. Biodiversitas 18: 1316-1323.* The mud crab, *Scylla serrata* lives associated with mangrove ecosystems and is widely distributed in the Indo West-Pacific. The present work was aimed to reveal the carapace length/width-weight relationships of *Scylla serrata* in two mangrove ecosystem area of Bulungan District, North Kalimantan-Indonesia, i.e. Kahayan Delta and Tibi Island. The crabs were collected by using *ambau pancang* (trap) for two months from November to December 2016. A total of 522 individuals were collected and their carapace length, carapace width, and weight were measured. The sex ratio of total collected samples (male to female) was 1:0.79. Carapace length and width of *S. serrata* caught in these two study area ranged from 40 to 89 mm for male; 32 to 91 mm for female and 59 to 128 mm for male; 53 to 122 mm for female, respectively. The carapace length-weight relationships of total samples showed logarithmic equations as follow: W = -3.2194 + 2.9725 Log CL for male and Log W = -2.2010 + 2.3750 Log CL for female. While the carapace width-weight relationships are as follow: W = -3.9162 + 3.1012 Log CW for male and Log W = -2.6001 + 2.3968 Log CW for female. The b values of carapace width-weight relationship indicated that the growth pattern of male was positive allometric and female was negative allometric. Size frequency of crab population is also presented.

Keywords: Allometric relationship, crustacea, growth pattern, mangrove, mud crab

INTRODUCTION

The mud crab, *Scylla serrata* is known to live associated with mangrove ecosystems and is widely distributed in the Indo West-Pacific. The mud crab is a nocturnal organism and is mostly burrowing during low tide (Hill 1976; Barnes et al. 2002), but they will be very active to forage when the habitat is covered by seawater at high tide (Nirmale et al. 2012). The crab is abundant in estuaries and swamps water with dense of mangrove vegetation (Keenan et al. 1998; Barnes et al. 2002). Genus *Scylla* is a commercially important species of the Indonesian crustaceans and has become a high economic value commodity (Cholik 2005). Increasing of the mangrove crabs demand can threaten existence of the population. So, the biological information is needed as a basis for utilization and management of mud crab resources.

One of potential location to catch mud crabs is mangrove ecosystem in Bulungan District, North Kalimantan-Indonesia. The ecosystem is located between 2°26.5'-3°45' North latitude and 117°18'-117°58' East longitude. The local fishermen catch the crab by using a local trap, so-called *ambau pancang*. Up to now, there were only a few researches on mud crab of North Kalimantan, e.g. resource potential (Natanael and Wiharyanto 2016),

meroplankton of *Scylla* sp. (Triana and Wiharyanto 2016), and reproductive biology (Farizah 2011; Iromo et al. 2013; Iromo and Farizah 2014).

The study of carapace width-weight relationships assumes an important prerequisite in biology, physiology and ecology (Froese 2006; Mohapatra et al. 2010; Thirunavukkarasu and Shanmugam 2011). The estimation is useful to determine the variations in expected weight from the known length groups which are one after another the indication of size, reproduction and nourishing states (Gayathre et al. 2016). Application of this study for aquatic animals has done in delineating the growth patterns during their developmental pathways (Bagenal 1978). Information about individual carapace width-weight relationship is important to estimate the population size or stock structure (Josileen 2011) and to use the stock assessment model (Moutopolos and Stergiou 2002). Some crustacean research used the carapace width-weight relationship as more suitable for evaluating populations (Atar and Sector 2003; Gorce et al. 2006, Sangun et al. 2009). The present work was aimed to reveal the carapace width-body weight relationship of mangrove mud crab (*Scylla serrata*) in two area of mangrove ecosystem in Bulungan District, North Kalimantan, Indonesia. The result is compared with the different population of the same species in other locations.

MATERIALS AND METHODS

Study site and sampling methods

The samples were collected on November until December 2016 from Kahayan Delta and Tibi Island, Bulungan District, North Kalimantan Province, Indonesia (Figure 1). Totally 522 samples were caught using *ambau pancang* (local name) by fishermen. The specimens were transported to the laboratory for identification and measurement of carapace width and weight. Identification of species was based on FAO book identification (Ng 1998) and Keenan et al. (1998). Carapace Length (CL) was taken as the distance between the tips of the posterior most lateral carapace spines. Carapace Width (CW) was measured dorsally along the midline, between the frontal notch and the posterior margin of the carapace (Josileen 2011). Individual crab weight (W) was measured by digital scales. All samples were analyzed in fresh condition (living crabs).

Data analysis

The sex ratio was calculated using the formula: total number of males ($\sum$M)/total number of females ($\sum$F). The ratio was tested to see if it differs from a 50/50 ratio by Chi-Square test (Steel and Torrie I980). The carapace length/width-weight relationship was estimated using the exponential equation $W = aL^b$ (Ricker 1975). The exponential equation was transformed to logarithmic equation $\log W = \log a + b \log L$, where W = weight, L =

carapace width, a = 'y'-intercept and b = the slope or growth coefficient. The R-squared was determined to identify the association degree of two variables. Growth pattern was determined by value of growth coefficient (b value). The pattern was defined as follows: isometric growth (b = 3), or positive allometric (b > 3) or negative allometric (b < 3). The differences of the carapace width-weight relationship between sexes were tested by one-way ANOVA at p = 0.05.

RESULTS AND DISCUSSION

Results

A total of 522 mud crabs were sampled in two locations, 291 samples from Kahayan Delta and 231 samples from Tibi Island. The sex of mud crabs was determined in accordance to Keenan et al. (1998) and showed in Figure 2. The shape of the abdomen or tail flat is a thin triangular apron for males, while the female's is larger.

Sex ratios of male to female of total collected sample and each location (Kahayan Delta and Tibi Island) were 1:0.79, 1:0.82 and 1:0.76, respectively. Chi-Square test of sex indicated a significantly different (p < 0.05), meaning that the population was not in balance between of the number on male and female crab the two locations. Detail information of the sex ration at the two location is presented in Table 1.
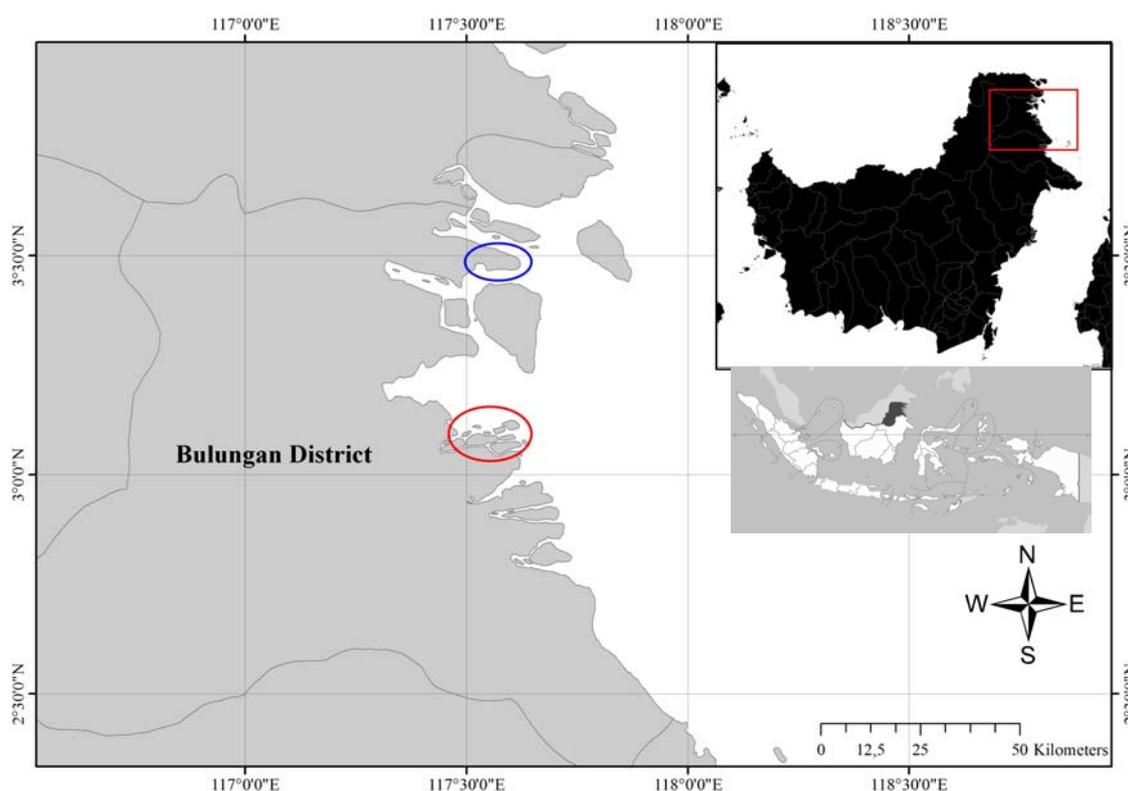

Figure 1. Locations where the mud crabs were collected. The red ellipse indicates Kahayan Delta and the blue ellipse indicates Tibi Island, Bulungan District, North Kalimantan, Indonesia

Figure 2. Sex of mud crabs (A) male, (B) female. The shape of the abdomen or tail flat is a thin triangular apron for males, while the females is larger

Tabel 1. Sex ratio of *Scylla serrata* from Bulungan District, North Kalimantan, Indonesia

Location	Sex	Number of samples	Carapace Length (mm)		Carapace Width (mm)		Sex ratio
			Min	Max	Min	Max	
Total	Male	291	40	89	59	128	1: 0.79
	Female	231	32	91	53	122	
Kahayan Delta	Male	159	40	89	59	128	1: 0.82
	Female	131	32	89	53	122	
Tibi Island	Male	132	40	87	62	127	1: 0.76
	Female	100	43	91	61	122	

In total carapace length of *S. serrata* caught in the two study area ranged from 40 to 89 mm for male and 32 to 91 mm for female. In terms of location, the carapace length of the crab ranged from 32 to 89 mm in Kahayan Delta and 40 to 91 mm in Tibi Island (Table 1). The minimum size of carapace length was found in Kahayan Delta and the maximum size was found in Tibi Island. Size frequency distribution of carapace length is shown in Figure 3. Based on the figures, male and female crabs exhibited some size variation. The maximum size of *S. serrata* was found in 84-89 mm CL for male and 90-95 mm CL for female. No male was found with carapace length more than 89 mm. The situation is the same with Tibi Island, but different with Kahayan Delta. In Kahayan Delta, no male and female were found more than 89 mm. The dominant size of *S. serrata* in total, Kahayan Delta, and Tibi Island were found 60-65 mm for male and 54-59 mm for female.

Carapace width of *S. serrata* caught in the two study area ranged from 59 to 128 mm in male and 53 to 122 mm in female. While, the carapace width ranged from 53 to 128 mm in Kahayan Delta and 61 to 127 mm in Tibi Island (Table 1). The minimum and maximum size of carapace width were found in Kahayan Delta. Size frequency distribution of carapace width is shown in Figure 4. Base on the figure, male and female crabs exhibited some size variation. The maximum size group of *S. serrata* was found in 127-133 mm CW for male and 120-126 mm CW for female. No female was found with carapace width more than 133 mm. The condition occurred in both locations. The dominant size of *S. serrata* in total, Kahayan Delta, and Tibi Island were 92-98 mm for male, but it was not the case for female. The total and Kahayan Delta for female were dominated by 78-84 mm sizes, but it was 71-77 mm in Tibi Island.

A Scatter diagram was composed by plotting logarithm of carapace length/width against logarithm of weight of individual crabs (Figure 5 and Figure 6). The logarithmic equation log W = log a + b log L was used to estimated carapace length/width-weight relationship of mud crabs. The carapace length-weight relationship results of total showed logarithmic equations are as follows: W = -3.2194 + 2.9725 Log CL for male and Log W = -2.2010 + 2.3750 Log CL for female. While, the result of carapace Length-weight relationship in Kahayan Delta and Tibi Island are-3.0117 + 2.8570 Log CL for male and Log W = -1.9701 + 2.2455 Log CL for female, and Log W = -3.4634 + 3.1081 Log CL for male and Log W = -2.6013 + 2.6017 Log CL for female. The R-squared obtained for the carapace length and weight of males and females were nearly equal to 1 (0.83-0.91). The value indicated a high degree of positive correlation of length and weight for male and female crabs.
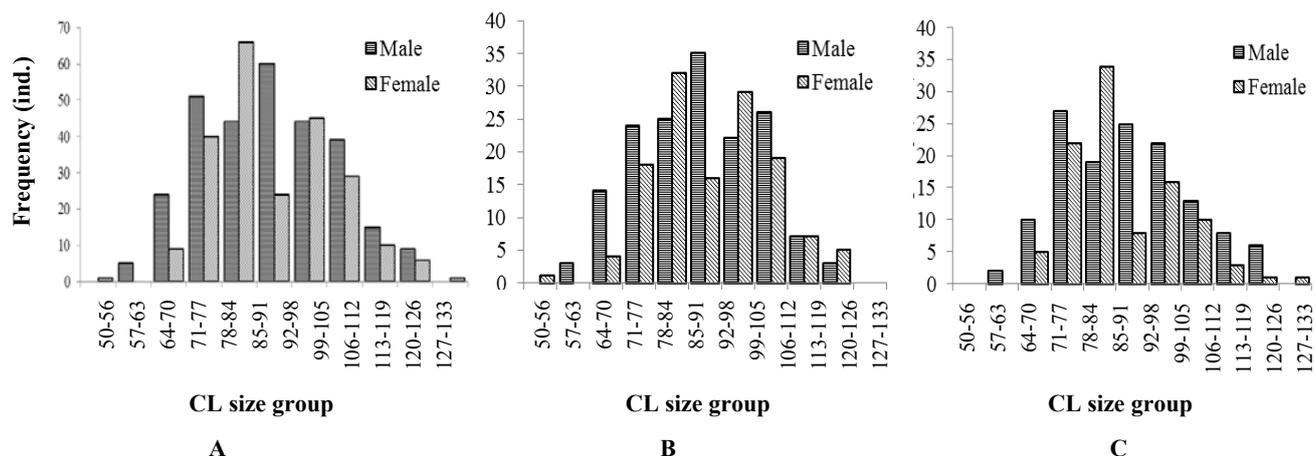
Figure 3. Size frequency distribution of carapace length of *Scylla serrata* in different location (A) total, (B) Kahayan delta, (C) Tibi island, Bulungan District, North Kalimantan, Indonesia
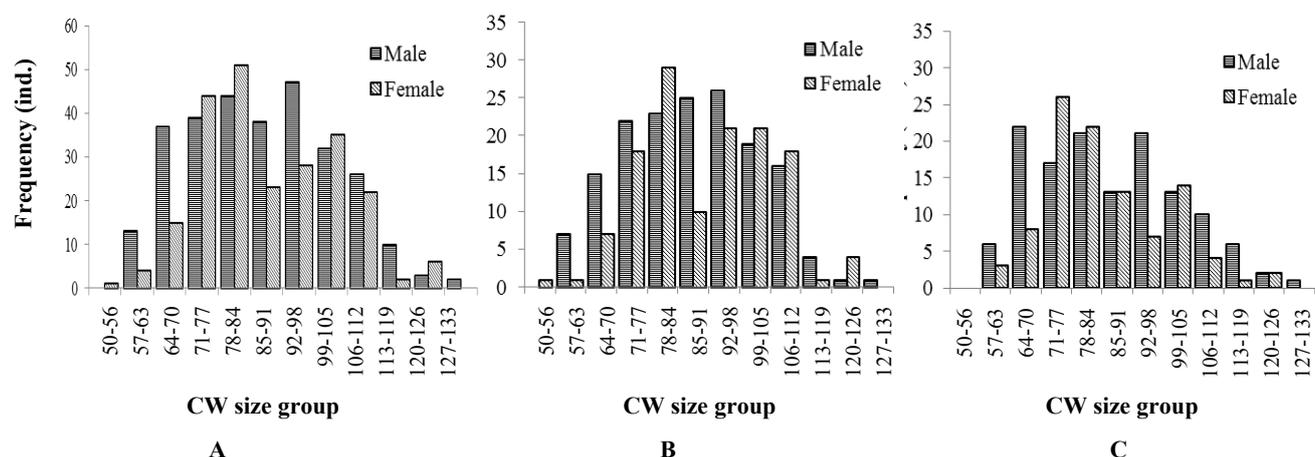

Figure 4. Size frequency distribution of carapace width of *Scylla serrata* in different location (A) total, (B) Kahayan Delta, (C) Tibi Island, Bulungan District, North Kalimantan, Indonesia

The carapace width-weight relationship results of total showed logarithmic equations are as follows: W = -3.9162 + 3.1012 Log CW for male and Log W = -2.6001 + 2.3968 Log CW for female. While, the result of carapace width-weight relationship in Kahayan Delta and Tibi Island are -3.6917 + 2.9809 Log CW for male and Log W = -2.6134 + 2.3982 Log CW for female, and Log W = -4.1882 + 3.2474 Log CW for male and Log W = -2.7538 + 2.4840 Log CW for female. The R-squared obtained for the carapace width, and weight of males and females were nearly equal to 1 (0.86-0.92). The value indicated a high degree of positive correlation of width-weight for both sexes.

The growth pattern was estimated by b value from carapace width-weight relationship. The growth coefficient values (b) of male and female width-weight were 3.1012 and 2.3968. Based on the values, we found b value more than 3 for male indicating a positive allometric. It means the increase of weight is faster than the increase of carapace width. But, it was not the case in female with b value less than 3. The value indicates negative allometric of growth pattern. The b values were different between male and female crab (ANOVA, $P < 0.05$).

Discussion

The information on sex ratio is important in the interpretation of the population structure and reproductive performance in crustaceans (Cheewasedtham 1990; Wardiatno 2004; Wardiatno and Mashar 2010). In our study, sex ratio showed that male is excessive than female in Bulungan District, North Kalimantan. The result of the present study agreed with other studies by Akter (2003), Ali et al (2004), Ikhwanuddin et al. (2010) and Musa et al. (2017). The dominance of males over females was proved to occur frequently in crab populations (Warburg et al. 2012).
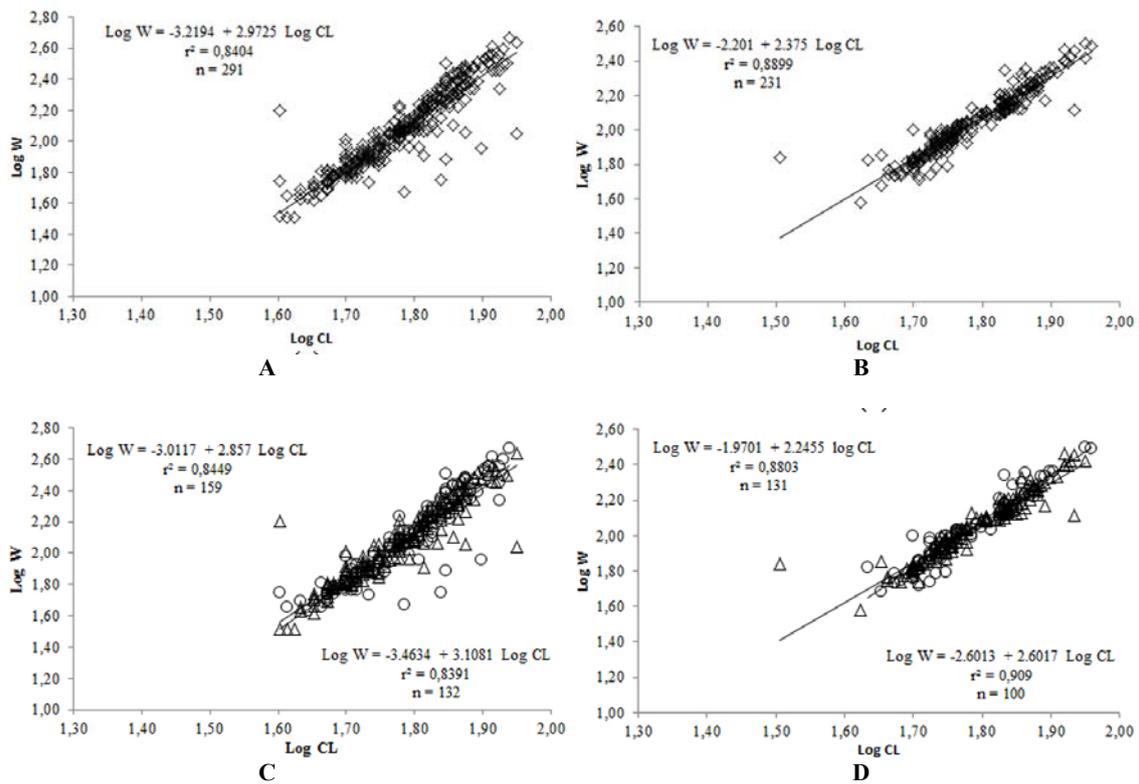
Figure 5. Carapace length (CL)-weight (W) relationship of *Scylla serrata*. (A) total male n = 291, (B) total female n = 231, (C) male, ○: Kahayan Delta n = 159; Δ: Tibi Island n = 132 (d) female, ○: Kahayan Delta n = 131; Δ: Tibi Island n = 100
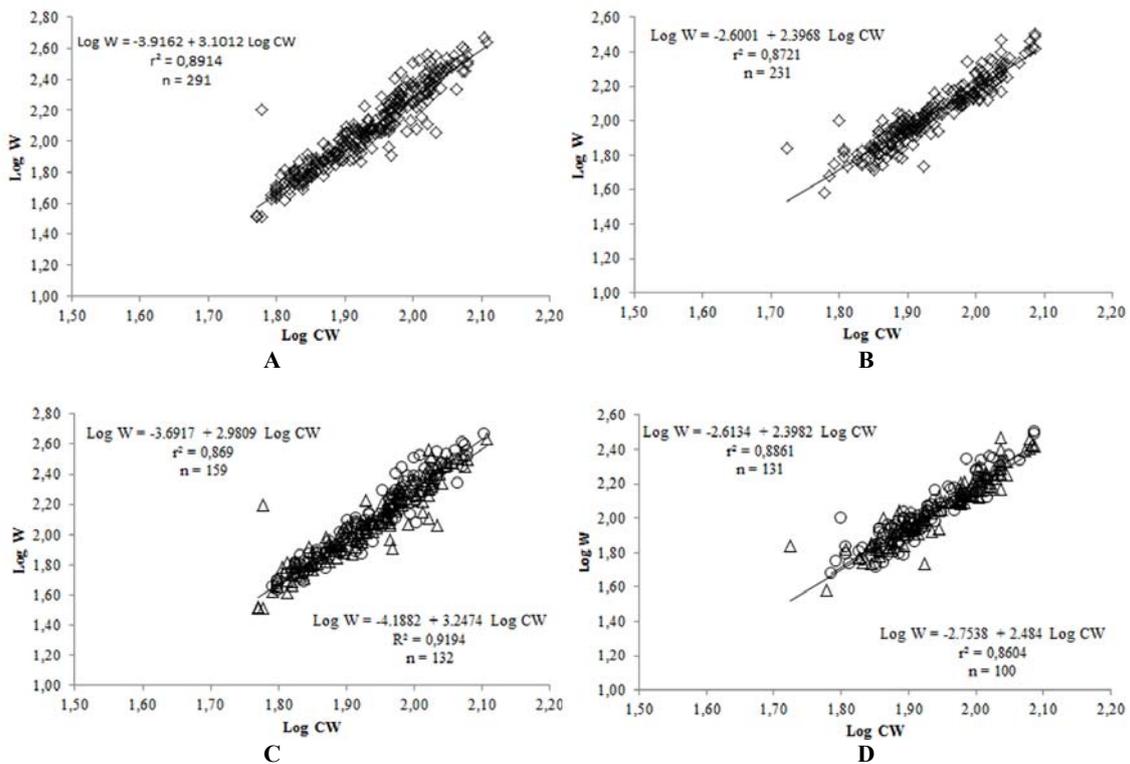

Figure 6. Carapace width (CW)-weight (W) relationship of *Scylla serrata*. (A) total male n = 291 (B), total female n = 231, (C) male, ○: Kahayan Delta n = 159; Δ: Tibi Island n = 132 (d) female, ○: Kahayan Delta n = 131; Δ: Tibi Island n = 100

Table 2. The growth coefficient values of *Scylla serrata* and *S. tranquebarica* in some locations.

Species	Sex	Location	b value	Reference
S. serrata	Male	Chilika Lagoon, India	3.2150	Mohapatra et al. (2010)
	Female		2.7510	
	Male	Inhace Island, Mozambique	3.0244	Toivio (2015)
	Female		2.4345	
	Male	Khulna region, Bangladesh	3.0600	Ali et al. (2004)
	Female		1.8928	
	Male	Bulungan district, Indonesia	3.1012	Present study
	Female		2.3968	
S. tranquebarica	Male	Chilika Lagoon, India	3.0060	Mohapatra et al. (2010)
	Female		2.7820	
	Male	Parangipettai coastal, India	3.2718	Thirunavukkarasu and Shanmugam (2011)
	Female		3.0202	

In terms of size the crabs collected from Kahayan Delta was smaller than that from Tibi Island. This phenomenon might be caused by the discrepancies of habitat conditions in both locations (Tahmid et al. 2015a, 2015b). Similar result was also found in east Kutai (Wijaya et al. 2010), that have crabs size smaller than in mangrove habitat or the sea. In fishery point of view the smaller size may also be due to higher effort in capture fisheries (Sharpe and Hendry 2009).

The b value of carapace width-weight relationship ranged from 2.3968 for female and 3.1012 for male. According Allen (1938), an ideal organism which maintains its shape throughout, the value of 'b' will be '3'. But in few of organisms, the value of 'b' lies between 2.5 and 4.0 (Martin 1949). The b value of male crab was higher than female crab. Higher b value of male crabs was observed in other research of *S. serrata* in India (Mohapatra et al. 2010), Andaman Sea (Poovachiranon 1992), and Bengkulu (Herliany and Zamdial 2015). Other brachyuran species had estimated to have higher b value in males than female (Josileen 2011; de Araújo and de Lira 2012). The male has the b value more than 3, but the female has the b value less than 3. This condition indicated the growth pattern is different for male and female. The growth pattern male is positive allometric and female is negative allometric. The growth is influenced by internal and external factors. Sex, age, nutrition and disease resistance include of internal factors, while water quality, predator, and habitat include of external factors (Effendie 1997; Levay and Walton 2007).

By comparing with some studies of *S. serrata,* the carapace width-weight relationship also showed similar results in the b value. The b value of male (more than 3) was higher than that of female (less than 3) (see Table 2). The similar results were found in some locations such as: India (Mohapatra et al. 2010), Mozambique (Toivio 2015), and Bangladesh (Ali et al. 2004). This biological character was also discovered in *S. tranquebarica*. The b value of male in *S. tranquebarica* was higher than that in female in India (Mohapatra et al. 2010; Thirunavukkarasu and Shanmugam 2011). The relationship between carapace width and weight showed that the growth pattern indicated faster and larger in male. It is common phenomenon since the claws of male grows significantly larger than female in mud crabs. Pinheiro and Fiscarelli (2009) mentioned that bigger claw in male is enabled them to protect the females successfully during and after copulation. Pinheiro and Hattori (2006) revealed that females tend to reduce their chelae growth as they grow bigger, while males tend to do the opposite. Mature females utilize much of their energy into egg production and cause reducing their somatic growth (Pinheiro and Fransozo 2002; Ferkau and Fischer 2006).

Study of carapace width-weight relationship is important in fishery biology. If data of size frequency is available, it can be used to convert length to weight in order to estimate biomass (Effendie 1997; Froese 2006). In addition, it can be purposed for proper conservation and management of mud crabs (Ali et al. 2004).

In conclusion, the sex ratio of total collected samples (male to female) was 1:0.79. Crab size of Kahayan Delta was smaller than that of Tibi Island. The carapace length-weight relationship of total samples showed logarithmic equations as follow: W = -3.2194 + 2.9725 Log CL for male and Log W = -2.2010 + 2.3750 Log CL for female. While the carapace width-weight relationships are as follow: W = -3.9162 + 3.1012 Log CW for male and Log W = -2.6001 + 2.3968 Log CW for female. Based on the b values of carapace width-weight relationship, the growth pattern of male was positive allometric and female was negative allometric.

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