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Sex Ratio and Growth Pattern of Coconut Crabs *Birgus latro* (Crustacea, Decapoda, Cianobitidae) in North Moluccas Province, Indonesia

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ABSTRACT

Coconut crab (*Birgus latro*) is a crustacean that has a large size until four kilograms. The study aimed to analyze sex ratio and growth pattern including the relationship of thorax length - body weight, thorax width - body weight and cephalothorax length plus rostrum - body weight in Daeo (Morotai Island), Laigoma (South Halmahera District) and Fitako (North Halmahera District). The sex ratio was determined using χ^2 test and the growth pattern was tested by the b value through t test. The results showed sex ratio of 1: 0.9 in Daeo (n = 581), 1: 0.6 in Laigoma (n = 24), and 1: 2 in Fitako (n = 31). The relationship of thorax length, thorax width and cephalothorax length plus rostrum with body weight were strongly correlated (R^2> 70%). The growth pattern of coconut crab in Daeo was negative allometric, while in Laigoma and Fitako were negative allometric and isometric.

Keywords: *Birgus latro*, *sex ratio, growth pattern, north moluccas*

1. Introduction

Robber crab or coconut crab (*Birgus latro*) is a crustacean group of the Coenobitidae family found primarily in tropical regions of the Indo Pacific (Drew et al., 2010) and in sub-tropical of Japan (Hamasaki et al., 2011; Sato et al., 2013). This species is also found in three island groups at Indian Ocean, there are Aldabra Atoll, Chagos Islands and Nicobar, and Andaman Islands. In the Western Pacific, coconut crab is found in many islands including the Solomon Islands, Guam, Carolin Island and Fiji (Drew et al., 2010).

Indonesia is one of the potential areas of coconut crab, but its distribution is only in eastern of Indonesia. North Moluccas is one of these potential areas. Coconut crabs have different names, in Ternate commonly known as a walnut crab or walnut stalk, while in Daeo (Regency of Morotai Island) known as “kutati”. Other names are “butati” in Fitako and surrounding areas (North Halmahera Regency) and “gafan” in Laigoma region (South Halmahera Regency).

Coconut crabs have a large size and have a very strong tear ability (Oka et al., 2016). Exploitation of coconut crabs by humans and other predatory animals, slow population growth rates and habitat degradation has caused a decline in the population of coconut crabs in their natural habitat (Helagi et al., 2015). Coconut crabs are a lot of exploitation because they are relatively easy to catch and have high price. Coconut crabs are widely caught and used as special menu in some restaurants because of its excellent meat taste especially the female coconut crabs laying eggs (Kesler, 2006; Buden, 2012; Sato and Yoseda, 2010). Coconut crab meat also has a high nutrient content (Serosero et al., 2014).

Coconut crab is currently categorized as a data deficient resource in the International Union for Conservation of Nature (IUCN) red list (Eldredge, 1996;

Drew and Hanson, 2014) and previous information about its potential in North Moluccas area is not yet available. In Indonesia through the Minister of Forestry Regulation Number P.57/Menhut-II/2008, coconut crab was categorized as deficient data due to lack of information about distribution. Through this research also adds information about spread area of coconut crab in North Moluccas.

Biological information is one of parameters that are needed to predict stock availability and to formulate management. Sex ratios and growth patterns are biological studies required as a base to manage coconut crab resources in their natural habitat. The length or width and weight in the determination of growth patterns and the relationship of length-weight are important parameters in biological, physiological and ecological studies because the weight estimation can be determined by knowing the length or width. Length and body weight information can also be used to predict food and feeding habits. Several studies on this biota in Indonesia have been done among others, i.e. Sulistiono et al. (2007), Sulistiono et al. (2008), Sulistiono et al. (2013), Sulistiono et al. (2009), Refiani and Sulistiono (2009), Supyan et al. (2015), Jahidin (2010), Supyan et al. (2013), Handa (2013), Serosero et al. (2016), Serosero et al. (2018a; 2018b). However, research on sex ratio and growth pattern of coconut crab in Morotai Island and surrounding area has never been done. This study aimed to analyze the sex ratio and growth pattern included the relationship of thorax length-body weight, thorax width-body weight and cephalothorax length plus rostrum-body weight in Daeo District Morotai Island, Laigoma District of South Halmahera and Faitako District of North Halmahera Indonesia. This data is very important as a basis for management of the coconut crab resources in North Moluccas Province.

2. Material and Methods

2.1 Time and location

The research was conducted at three locations in North Moluccas Province, i.e. Daeo (Morotai Island), Laigoma (South Halmahera District) and Fitako (North Halmahera District) (Figure 1). The specimens were collected for one year in Daeo, and only one sampling in Laigoma and Fitako.

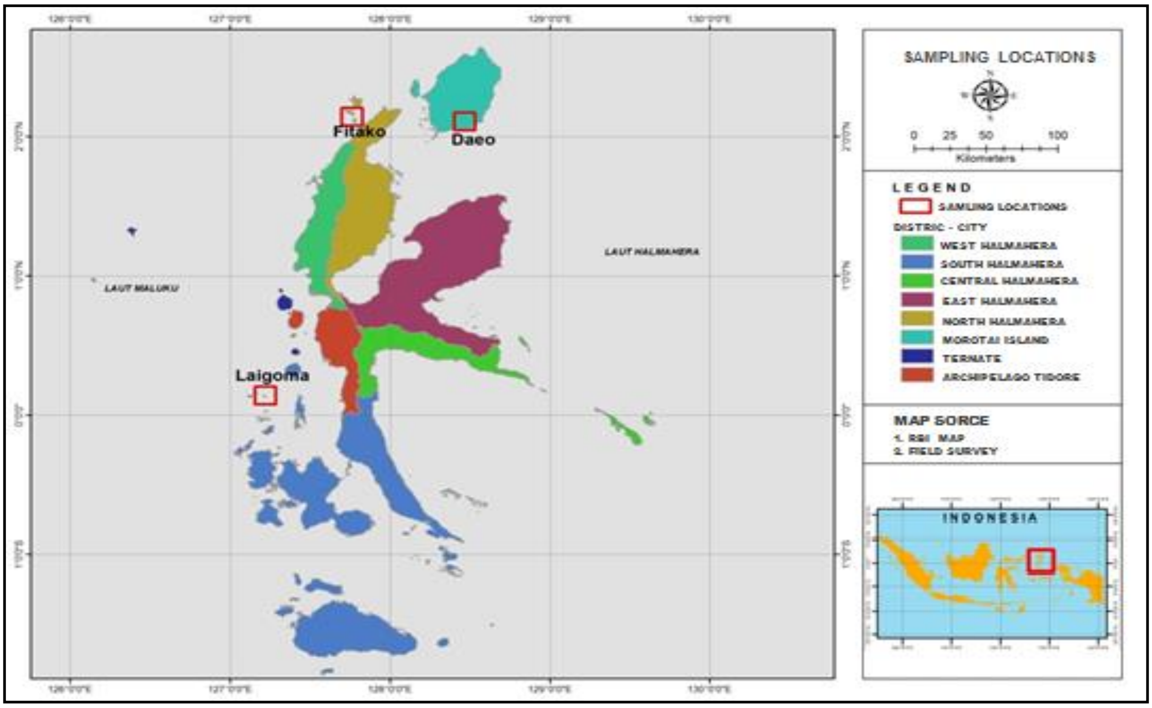

Figure 1. Sampling location of coconut crab in Daeo (Morotai Island), Laigoma (South Halmahera District) and Fitako (North Halmahera District).

2.2 Coconut crabs sampling

The coconut crab samples were obtained using direct capture by hand. Coconut crab bait was several cut of coconut fruit that placed in coconut crabs habitat, i.e. front of stone holes, tree crevices, and ground holes. The number of samples were found various in all locations (n = 581 in Daeo, n = 24 in Laigoma and n = 31 in Fitako).

The thorax length, thorax width and length of cephalothorax plus rostrum (Cp + r) (Fletcher, 1990) of coconut crabs were measured by using a digital caliper with a precision of 0.01 mm (Figure 2). The weight was measured by a hanging digital scale with a precision of 0.1 gram.

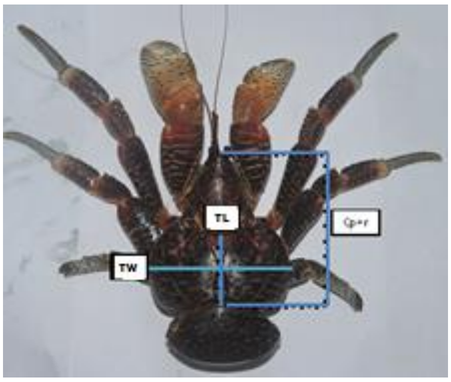

Figure 2. Measurement of cephalothorax length plus rostrum (Cp + r), thorax width (TW) and thorax length (TL) of coconut crab (Source: Serosero et al., 2018a).

2.3 Data analysis

The sex ratio of coconut crabs was calculated by comparing the total number of males with the total number of females. The sex ratio was tested by Chi-Square test (Siregar, 2004).

$$x^2hit=\sum_{i=1}^{n}\frac{(oi-ei)}{ei}$$

Where:

$\chi^2 hit = \chi^2_{count\ value}$
oi = frequency to-i
ei = frequency of expectation to-i

The parameters relation measured (TL, TW, Cp + r) with body weight were calculated using the following equation (Effendie, 2002).

$$W = aL^b$$

Where:
W = body weight (g)
L = thorax length (TL) (mm); length of cephalothorax plus rostrum (Cp + r) (mm); thorax width (TW) (mm)
a and b = constants.

The linear relationship of TL, Cp + r, TW with W was determined by transforming those parameters to logarithmic equation log W = log a + b log L. Allometric model (growth pattern) was applied to relationship of TL - W, Cp + r - W and TW - W. The b value tested using t test, with the hypothesis: H_0: b = 3, isometric and H_1: b ≠ 3, allometric consisting of positive allometric and negative allometric. Positive allometric was the b value > 3 that increased in length not as fast as weight and negative allometric was the b value <3 that increased in weight not as fast as the length (Effendie, 1979).

$$t_{hit}=\frac{(b-3)}{S_b} \quad ; \quad S_b=\sqrt{\frac{1}{n-2}\left\{\left(\frac{sy}{sx}\right)^2-b^2\right\}}$$

Where:
$t_{hit} = t_{count}$ value
b = the slope value
Sb = standard error value b

The t_{count} is compared with t_{table} ($t_{\alpha/2}$, n-2) on $t_{-student}$ table with α = 0.05. The growth pattern of coconut crab is determined by considering the rules of decision as follows: If the value of $t_{count} > t_{table}$, then reject the null hypothesis (H_0), If the value of $t_{count} < t_{table}$, then accept the null hypothesis (H_0).

Differences in carapace relationships of TL-W, TW-W and Cp+r-W between the sexes were tested with one-way ANOVA ($p = 0.05$).

3. Results

3.1 Sex ratio

The coconut crab samples during this study were 636 individuals consisting of 581 individuals collected in Daeo (54% male and 46% female), 24 individuals collected in Laigoma (62.50% male and 37.50% female) and 31 individuals in Fitako (29.03% male and 70.97% female). Coconut crabs were distinguished by males and females based on morphological characteristic (absent or present of pleopods). The female coconut crabs have three pleopods to incubate the eggs before they are released into the sea, while the males do not have pleopods (Figure 3).

Overall, sex ratio between males and females in Daeo was 1: 0,9 which meant male coconut crabs dominant. The temporal sex ratio based on the χ^2 test indicated that sex ratio of 83% was balanced except in December and February. The highest proportions of male and female were in February and May, while the lowest proportions of male and female were May and February. Coconut crab in Laigoma was dominated by male with a ratio of sex ratio of 1: 0.6, whereas in Fitako was dominated by female coconut crab with a sex ratio of 1: 2.4 (Table 1).

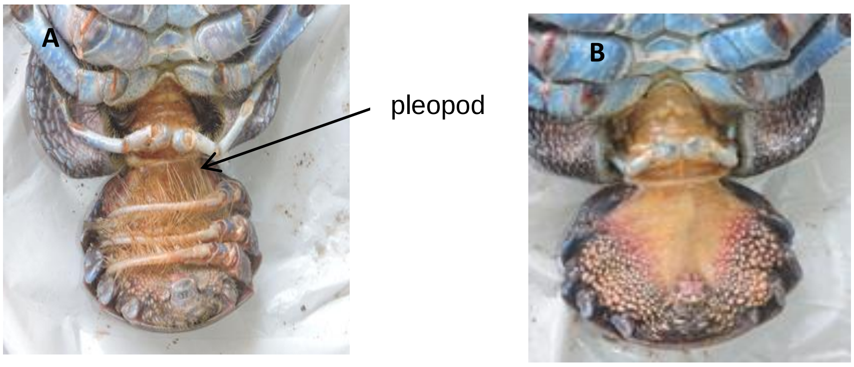

Figure 3. Morphology differences of female (A) and male (B) coconut crab.

Table 1. The sex ratio of coconut crabs from Daeo (Morotai Island District), Laigoma (South Halmahera District) and Fitako (North Halmahera District).

Location and time sampling	N		Proportion		Sex Ratio	χ^2
	Males	Females	Males	Females		
Daeo						
October-16	22	21	51.16	48.84	1 : 1.0	0.0233
November-16	26	23	53.06	46.94	1 : 0.9	0.1837
Desember-16	35	21	62.50	37.50	1 : 0.6	3.5000
January-17	28	21	57.14	42.86	1 : 0.8	1.0000
February-17	35	17	67.31	32.69	1 : 0.5	6.2308
March-17	25	22	53.19	46.81	1 : 0.9	0.1915
April-17	27	27	50.00	50.00	1 : 1.0	0.0000
May-17	19	26	42.22	57.78	1 : 1.4	1.0889
June-17	31	23	57.41	42.59	1 : 0.7	1.1852
July-17	24	17	58.54	41.46	1 : 0.7	1.1951
August-17	23	24	48.94	51.06	1 : 1.0	0.0213
September-17	19	25	43.18	56.82	1 : 1.3	0.8182
Laigoma	15	9	62.50	37.50	1 : 0.6	1.5000
Fitako	9	22	29.03	70.97	1 : 2.4	5.4516

3.2 Size distribution

Coconut crabs have variation size in three locations (Table 2). Overall, TL, TW, and Cp + r size ranged from 19.56 to 54.86 mm, 36.67-109.98 mm, and 43.98-114.72 mm.

Table 2 shows that the TL of male was larger than female in each location, i.e. Daeo (19.58-54.86 mm for male and 19.56-48.65 mm for female), Laigoma (28.56-33.48 mm for male and 28.44-34.66 mm for female) and Fitako (27.44-46.39 mm for male and 24.33-34.50 mm for female). The TW parameters have variation size range in each location, but average of male has a larger size than female one. The TW size in each location ranged from 36.67-106.98 mm for male and 37.67-82.44 mm for female (Daeo), 51.25-75.33 mm for male and 41.58-76.25 mm for female (Laigoma), and 60.89-77.56 mm for male and 46.47-76.88 mm for female (Fitako). While, the average of Cp + r parameter of male was larger than females in each location, i.e. 43.98-114.72 mm (male) and 43.90-90.67 mm (female) in Daeo, 65.23- 76.12 mm (male) and 61.38-87.36 mm (female) in Laigoma and 60.48-77.12 mm (male) and 55.47-78.16 mm (female) in Fitako. Overall, weight of male was larger than female with a range of 50-990 grams (male) and 50-520 grams (female) in Daeo, 140-310 grams (male) and 140-290 grams (female) in Laigoma, and 160-410 grams (male) and 110-300 grams (females) in Fitako.

Table 2. Measure range of TL, TW, Cp + r (minimum, maximum, mean and standard deviation) coconut crabs in Daeo (Morotai Island District), Laigoma (South Halmahera District) and Fitako (North Halmahera District)

Sampling location	Sex	n	Parameter	Minimum	Maximum	mean± standard deviation
Daeo	Male	314	TL	19.58	54.86	33.53±4.89
			TW	36.67	106.98	70.87±11.03
			Cp+r	43.98	114.72	76.29±10.47
			Weight	50	990	237.58±134.53
	Female	267	TL	19.56	48.65	29.71±3.86
			TW	37.67	82.44	62.47±9.33
			Cp+r	43.90	90.67	68.13±8.50
			Weight	50	520	214.94±82.45
Laigoma	Male	15	TL	28.56	33.48	31.32±1.63
			TW	51.25	75.33	65.13±7.07
			Cp+r	65.23	76.12	70.55±3.67
			Weight	140	310	223.33±43.86
	Female	9	TL	28.44	34.66	31.21±2.29
			TW	41.58	76.25	63.02±10.68
			Cp+r	61.38	87.36	70.97±7.60
			Weight	140	290	217.78±57.17
Fitako	Male	9	TL	27.44	46.39	32.93±5.700
			TW	60.89	77.56	65.75±8.60
			Cp+r	60.48	77.12	69.85±5.11
			Weight	160	410	243.33±74.33
	Female	22	TL	24.33	34.50	30.03±2.72
			TW	46.47	76.88	63.10±8.93
			Cp+r	55.47	78.16	69.35±5.82
			Weight	110	300	220.00±58.80

3.3 Lenght-body weight relationship

The relationship of TL, TW and Cp + r with weight in the three study sites showed a varied relationship (Table 3). The relationships of TL-W, TW-W and Cp + r-W have a close and fluctuating relationship.

Table 3. Intercept value (a), slope (b), t_{count} value, t_{table} and coefficient determination (R^2) of coconut crab in Daeo (Morotai Island District), Laigoma (South Halmahera District) and Fitako (North Halmahera District) based on TL-W, TW-W and Cp + r-W relationships.

Location and parameter relationship	Sex and constanta				T_{count}		Growth pattern		R^2 (%)	
	Male		Female							
	a	b	a	b	Male	Female	Male	Female	Male	Female
Daeo										
TL-W	0.024	2.689	0.024	2.654	3.448	3.264	Allo-	Allo-	74.05	73.24
TW-W	0.005	2.608	0.011	2.373	6.107	8.197	Allo-	Allo-	84.10	78.42
Cp+r-W	0.001	2.955	0.001	2.811	2.616	2.026	Allo-	Allo-		
Fitako										
TL-W	0.151	1.758	0.196	1.689	5.388	1.071	Allo-	Allo-	85.67	72.27
TW-W	0.001	2.938	0.006	2.540	2.690	5.795	Allo-	Allo-	85.93	73.58
Cp+r-W	0.001	3.086	0.001	2.983	0.196	0.051	Iso	Iso	87.70	80.68
Laigoma										
TL-W	0.032	2.590	0.028	2.589	1.651	0.927	Iso	Iso	89.31	82.96
TW-W	0.151	1.758	0.197	1.689	2.443	0.126	Allo-	Iso	93.34	83.86
Cp+r-W	0.002	3.330	0.001	2.836	0.782	0.329	Iso	Iso	82.73	82.16

Description: Iso: isometric; Allo-: negative allometric.

Table 3 showed close relationship between TW and weight of male (R^2 = 84.10%) and female (R^2 = 78.42%); TL and weight of male (R^2 = 74.05%) and female (R^2 = 73.24%) in Daeo. While in Fitako also seen a close relationship between Cp + r and weight of male (R^2 = 87.70%) and female (R^2 = 80.68%); TW and weight of male (R^2 = 85.93%) and female (R^2 = 73.58%); TL and weight of male (R^2 = 85.67%) and female (R^2 = 72.27%). For Laigoma, there was also a fluctuating relationship that was close relationship between TL and weight of male (R^2 = 89.31%) and female (R^2 = 82.96%); TW and weight of male (R^2 = 93.34%) and female R^2 = 83.86%); length of Cp + r and weight of male (R^2 = 82.73%) and female (R^2 = 82.16%). This condition indicated that TL,TW and Cp + r length contribute greatly to the weight of coconut crabs (> 70%). Those parameters could be used to estimate weight of coconut crabs. Based on The growth pattern of coconut crab in Daeo and Fitako is negative allometric for both male and female, whereas in Laigoma the growth pattern is allometric negative (male) and isometric (female).

The relationship of carapace size (TL-W, TW-W, Cp + r-W) in all research sites also showed a close relationship (Figure 4). The figure described relationship of Cp + r with weight (83.93%), TW with weight (84%) and TL with weight (77.43%).

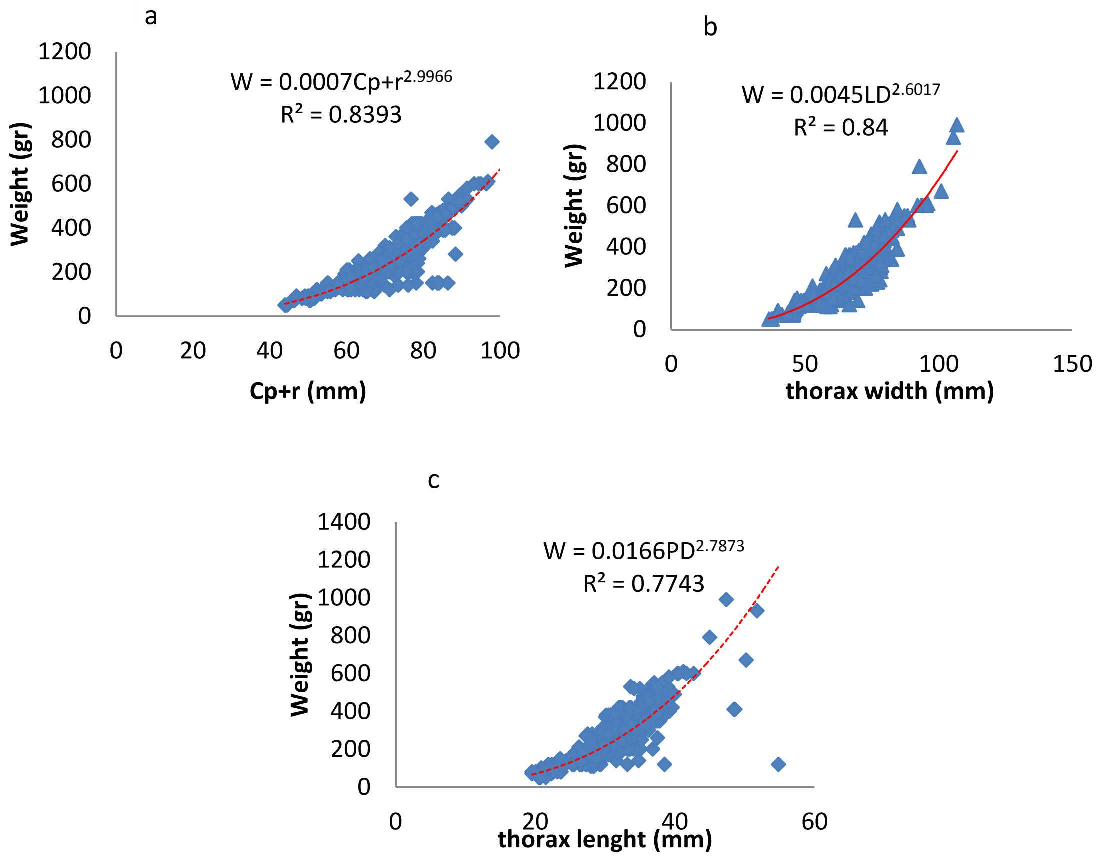

Figure 4. The relationship of cephalothorax plus rostrum (Cp+r) (a), thorax width (TW) (b), and thorax length (TL) (c) with weight.

The male of coconut crabs on three parameters measured had an average b value greater than the female. The a value of female was on average larger than male. The a and b values differed between male and female coconut crabs ($p < 0.05$). Based on the b value and t test obtained the average growth pattern of male coconut crab is negative allometric, except at Fitako on Cp + r parameter and Laigoma on TL and Cp + r parameter were isometric. In female coconut crabs, isometric growth patterns were found in TL-W and Cp + r - W (Fitako) relationships as well as the relationship of TL, TW and Cp + r parameters with weight in Laigoma.

4. Discussion

Coconut crab in this study was dominated by male coconut crabs at Daeo and female at Laigoma. The large number of coconut crabs in each catching period was especially in Daeo for one year (October 2016-September 2017) because female crabs are target of fishermen catch for higher selling price. Gonad mature of coconut crab in some Ternate restaurants could reach 500,000 IDR/individual. Crab populations generally, was often found that male crabs were more dominant than female crabs (Warburg et al., 2012).

The number of male coconut crab catches in Daeo and Laigoma were higher than female with a sex ratio of 1: 0.9 and 1: 0.6, but in Fitako was 1: 2.4. The sex ratio showed temporarily fluctuations At all times was dominated by male except in May (1: 1.4), August (1: 1.0) and September (1: 1.3). Nevertheless, the overall sex ratio based on Chi Square test was balanced. Sulistiono et al. (2008) found coconut crabs with a balanced sex ratio (1: 1.1) in Pasoso Island, Central Sulawesi. Abubakar (2009) also found a 1: 1 sex ratio on Yoi Halmahera Central Island and Supyan found a sex ratio of 1: 1.78 on the Uta Island of Central Halmahera. Effendie (2002) suggested that an imbalance of sex ratio was caused by lifestyle for food availability, population density, and food balance. The difference of male and female numbers in population was due to extent of exploitation and existence of variations in environmental conditions

Coconut crab catches during the study at all three sites showed that male coconut crabs had a range of TL, TW and Cp + r length greater than female coconut crabs. Male have larger sizes than female (Anagnostow and Schubart, 2014; Drew and Hansson, 2014). The smallest and largest of TL size were 19.58 mm and 54.86 mm for male and 19.56 mm and 48.65 mm for female. While the smallest and largest of TW were 36.67 mm and 106.98 mm for male and 37.67 mm and 82.44 mm for female. The smallest and largest of Cp + r size were 43.98 mm and 114.72 mm for male and 43.90 mm and 90.67 mm for female. Drew and Hansson (2014) on Christmas Island found thorax length female with 16.9 to 51.2 mm and male with 19.4 to 76.1 mm. Budden (2012) in Micronesia also found a male with the largest thoracic length of 71.4 mm and female of 44.0 mm. Gurusu et al. (2016) found coconut crabs in CP + r lengths ranging from 18-130 mm in Menui Islands. Heryanto and Wowor (2017) also found coconut crabs with a size of Cp + r male length 4.10-12.40 cm and females 3.92-9.10 cm in Batudaka Island, Central Sulawesi.

The TL size showed that size of coconut crabs at all three locations was smaller than the coconut crab from Christmas Island and Micronesia. Mean of TW was ≥ 39.25 mm in male and ≥ 42.25 mm in female that found only one individual. The high catches with small size during this study indicated that coconut crab populations in all three locations were depressed, so their growth became obstructed and catch activity in larger size. Wang et al. (2007) stated that decline populations were occurred human intervention inhabited areas. It was also influenced by the biological characteristics of coconut crabs that have slow growth (Drew and Hansson, 2014; Helagi et al., 2015). Hamasaki et al. (2014) found juvenile coconut crabs with a thoracic length of 4 mm at the age of 24 months.

The relationship of Cp + r with weight, thorax width with weight and thorax length with weight showed a close relationship with R2> 70%. These three parameters could be used to estimate the weight. Nevertheless, the use of Cp + r size should be seen in condition of sample used (rostrum was not damaged). Anagnostou and Schubart (2014) stated that Cp + r or carapace length was most susceptible parameter to measurement variations due to damage body parts. The growth pattern in three research sites was isometric and negative allometric. Anagnostou and Schubart (2014) found an isometric relationship between thorax length (TL) with weight from Chrirstmas Island in the Indian Ocean.

The growth pattern of Cp + r and thorax length in male and female was isometric. The growth of Cp + r with thorax length was proportional between length and weight. While the growth pattern of thorax width with weight was negative allometric. This meant that growth of thorax width was faster than weight. Hamasaki et al. (2014) stated that coconut crab growth only occurred during molting like other crustacean classes. This growth variation was influenced by sex and size of coconut crab. Length, width, and weight are important parameters in determining growth patterns. Long-term relationships are useful in the study of biology, physiology and ecology (Satake et al., 2009) especially species that have commercial value (Mohapatra et al., 2010). Weight estimates can be determined by knowing the size of length or width and can be used to compare between populations. This relationship analysis could also be used to determinate conservation and management concept of coconut crab.

The b value of male has relatively larger than female at all three locations. This showed that male have more rapid growth than females. Male crabs have faster growth of claws that served to protect females from predator attacks and during marriage. Female could excrete an egg packet in a year with weight up to one-third of total body so that female crabs have slower growth than male crab. Based on TL-W, TW-W and Cp + r-W relationships (Table 3), females have a larger a (intercept) value than male. This indicated that the increase in body weight of female in this study faster than male. In female, ovarian filling conditions (maturity) greatly affected the body weight. Individuals who have the same of Cp + r, TW and TL could have different weight at different stages of ovarian maturity.

The difference of b value between male and female coconut crabs could occur by sex, size, and food availability. The relationship analysis of length-weight could be used as an indicator to estimate the stock population size as well as information to exploit and evaluate a resource (Atar and Secer, 2003; Josileen, 2011).

5. Conclusion

The total sex ratio at Daeo, Laigoma and Fitako locations was 1: 0.9. The Cp + r, thorax width (TW) and thorax length (TL) varied across the three location sites. The relationship of Cp + r, TW and TL was closely related determination coefficient > 70%, so the three parameters can be used to estimate the weight of coconut crab. Based on the b value and t test value, relationship of Cp + r with weight and thorax length with weight was obtained isometric growth pattern between male and female. While, the thorax width with weight was negative allometric.

References

Abubakar, Y., 2009. Studi Biologi Reproduksi Sebagai Dasar Pengelolaan Kepiting kelapa (B*irgus latro*) di Pulau Yoi, Kecamatan P. Gebe, Maluku Utara. Tesis. Institut Pertanian Bogor. 107 p.

Anagnostou, C., Schubart, C.D., 2014. Morphometric characterisation of a population of adult coconut crabs *Birgus latro* (Decapoda: Anomura: Coenobitidae) from Christmas Island in the Indian Ocean. Raffles Bulletin of Zoology*,* 30: 136-149.

Atar H.H, Sector, S., 2003. Width/length-weight relationships of the blue crab (*Callinectes sapidus* Rathbun, 1896) population living in Beymelek lagoon lake. Journal Veteriner Animal Science. 27: 443-447

Buden, D.W., 2012. Coconut Crabs, *Birgus latro* (Anomura: Coenobitidae), of Sorol Atoll, Yap, with Remarks on the Status of *B. latro* in the Federated States of Micronesia. Pacific Science. 66(4):509-522.

Drew, M.M., Hansson, B.S., 2014. The population structure of *Birgus latro* (Crustacea: Decapoda: Anomura: Coenobitidae) on Christmas Island with incidental notes on behaviour. Raffles Bulletin of Zoology. 30:150-161.

Drew, M.M., Harzsch, S., Stensmyr, M., Erland, S., Hansson, B.S., 2010. Areview of the biology and ecology of the robber crab, *Birgus latro* (Linnaeus, 1767) (Anomura : Coenpbitidae. Elsevies Zoologischer Anzeiger. 249, 45-67.

Effendi M I. 1979. Metode *Biologi Perikanan*. Bogor (ID). Yayasan Dewi Sri. Bogor. p112.

Effendi, M.I. 2002. Biologi Perikanaan. Yogyakarta. Yayasan Pustaka Nusatama. p163.

Eldredge, L.G. 1996. *Birgus latro*, 2008 IUCN Red List of Threatened Species. www.iucnredlist.org (Accessed 15 Augustus 2015).

Gurusu, I., Ramli, M., Oetam, D. 2016. Hubungan panjang berat Ketam Kelapa (*Birgus latro L*.) yang tertangkap di daerah Menui Kepulauan. Jurnal Jurusan Manajemen Sumberdaya Perairan. 2(2): 145-152.

Hamasaki, K., Kato, S., Hatta, S., Murakami, Y.S., Kitada, S. 2014. Larval development and emigration behavior during sea-to-land transition of the land hermit crab *Coeno bita brevimanus* Dana, 1852 (Crustacea: Deca - poda: Anomura: Coenobitidae) under laboratory conditions. Journal of Natural History. 48: 1061-1084.

Hamasaki, K., Sugizaki, M., Sugimoto, A., Murakami, Y., Kitada, S. 2011. Emigration behavior during sea-to-land-transition of the coconut crab *Birgus latro* : Effects of gastropod shells, substrata, shelters and humidity. Journal of Experimental Marine Biologi and Ecology. 403:81-89.

Handa, A.H., Sara, L., Ishak E. 2013. Kepadatan relatif dan pola penyebaran kepiting kelapa *Birgus latro* di Menui, Kepulauan Kabupaten Morowali, Sulawesi Tengah. Jurnal Mina Laut Indonesia. 03(12): 36-45.

Helagi, N., Tafatu, J., Bertram, I., Moore, B., Linawak, M., Pakoa, K., 2015. Status of the coconutcrab of the Niue. Pacific community Noumea, New Caledonia. p49.

Heryanto., Wowor, D. 2017. Kajian Populasi Kepiting Kenari di Pulau Batudaka Kepulauan Togean, Sulawesi

Tengah dan Rekomendasi Manajemen Populasi. Jurnal Biologi Indonesi. 13(1): 149-156.

Jahidin, 2010. Estimasi Populasi Ketam Kenari (*Birgus latro*) Pulau Siompu. Jurnal Berkala Penelitian Hayati : 15:139-142.

Josileen J. 2011. Morphometrics and length-weight relationship in the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura) from the Mandapam Coast. India. Crustaceana. 84 (14): 1665-1681

Kessler, 2006. Management implications of a coconut crab *(Birgus latro)* removal study in Saipan, Commonwealth of the Northern Mariana Islands. Micronesica *:* 39(1):31-39.

Mohapatra, A., Mohanty, R.K., Mohanty, S.K., Dey, S.K. 2010. Carapace width and weight relationships, condition factor, relative condition factor and gonadosomatic index (GSI) of mud crabs (*Scylla spp.*) from Chilika Lagoon, India. Indian Jornal Marine Science. 39(1): 120-127

Oka, S.I., Tomita, T., Miyamoto, K. 2016b. A Mighty Claw: Pinching Force of the Coconut Crab, the Largest Terrestrial Crustacean. *PLoS ONE*. 11 (11): e0166108.

Refiani, S., Sulistiono. 2009. Struktur morfologis dan histologis gonad kepiting kelapa (*Birgus latro*). Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia. 16(1): 1-6

Satake, F., Ishikawa, M.M., Hisano, H., Pádua, S.B.,Tavares-Dias, M. 2009. Relação peso-comprimento, fator de condição e parâmetros hematológicos de dourado *Salminus brasiliensis* cultivado em condições experimentais. *Boletim de Pesquisa e Desenvolvimento*. 51: 1-22.

Sato, T., Yoseda, K. 2010. Influence of size and sex biased harvesting on reproduction of the coconut crab *Birgus latro.* Marine Ecology Progres Series. 402: 171-178.

Sato, T., Yoseda, K. 2013. Reproductive migration of the coconut crab *Birgus latro*. Plankton and Benthos Research*.* 8(1): 49-54.

Serosero, R., Suryani., Rina. 2014. Analisis proksimat kepiting kelapa (*Birgus latro*) selama pemeliharaan dalam wadah terkontrol. Jurnal Marikultur. 2 (2): 103-111.

Serosero, R., Suryani., Rina. 2016. Karakteristik habitat dan pola pertumbuhan kepiting kelapa (*Birgus latro*) di Pulau Ternate dan Kabupaten Halmahera Barat Provinsi Maluku Utara. Jurnal Depik. 5(2): 48-56.

Serosero, R., Sulistiono., Butet, N.B., Riani, E. 2018a. Morphometric characteristics of coconut crabs (*Birgus latro* Linnaeus, 1767) in North Moluccas Province, Indonesia Aquaculture, Aquarium, Conservation & Legislation International Journal of the Bioflux Society. 11(5): 1616-1632.

Serosero, R., Sulistiono., Butet, N.B., Riani, E. 2018b. Distribusi spasial dan temporal kepiting kelapa (*Birgus latro* Linn 1767) di Daeo Kabupaten Pulau Morotai, Maluku Utara. Jurnal Ilmu Pertanian Indonesia. Vol. 23 (3): 211-219.

Siregar S, 2004. Statistik terapan untuk penelitian. Gramedia Widiyasarana Indonesia. Jakarta. p399.

Sulistiono., Refiani, S. Tantu, F.Y., Muslihuddin. 2007. Kajian awal penangkaran kepiting kelapa (*Birgus latro*). Jurnal Akuakultur Indonesia 6(2) :183-189.

Sulistiono., Refiani, S., Tantu, F.Y., Muslihuddin. 2008. Kematangan gonad kepiting kelapa (*Birgus latro*) di Pulau Pasoso, Sulawesi tengah**.** Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia. 2: 127-134

Sulistiono., Kamal, M.M., Butet, N.A., Nugroho, T. 2009. Kegiatan penangkapan dan pemasaran lokal kepiting kelapa (*Birgus latro*) di Pulau Yoi, Maluku Utara. Buletin PSP. Fakultas Perikanan dan Ilmu Kelautan Institut Pertanian Bogor. XVIII (2). 65-71.

Sulistiono., Affandi, R. , Supyan. 2013. Studi potensi kepiting kenari (*Birgus latro*) ukuran kecil (Crablet) sebagai dasar upaya domestikasi di Pulau Yoi, Halmahera Tengah. Prosiding Forum Nasional Pemulihan dan Konservasi Sumberdaya Ikan - IV. Fakultas Perikanan dan Ilmu Kelautan Institut Pertanian Bogor.

Supyan., Sulistiono., Riani, E. 2013. Karakteristik Habitat dan Tingkat Kematangan Gonad Kepiting Kelapa (*Birgus latro*) di Pulau Uta, Propinsi Maluku Utara. Jurnal Ilmu Perikanan dan Sumberdaya Perairan. 2:73-82.

Supyan., Sulistiono., Syazili, A. 2015. Pertumbuhan dan pendugaan ukuran pertama kali matang gonad kepiting kelapa (*Birgus latro*) di Pulau Uta Propinsi Maluku Utara. Jurnal Torani (Jurnal Ilmu Kelautan dan Perikanan). 25(2): 122-133

Wang, F.L., Hsieh, H.L., Chen, C.P. 2007. Larval growth of the coconut crab *Birgus latro* with a discussion on the development mode of terresterial hermit crabs**.** Journal The Crustacean Biology. 27(4): 616-625.

Warburg, M.R., Davidson, D., Yifrach, H., Sayag, L., Tichomirova, Y. 2012. Changes in population structure and body dimensions of two xanthid crabs: A long-term study in a single boulder-shore. Arthropods. 1: 40-54.