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CARAPACE WIDTH-BODY WEIGHT RELATIONSHIP AND CONDITION FACTORS OF *Portunus sanguinolentus* IN SOUTHEASTERN BONE GULF, SOUTHEAST SULAWESI

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ABSTRACT

This study aimed to determine the body size, carapace width-weight relationship, and condition factors of *Portunus sanguinolentus* in southeastern Bone Gulf, Southeast Sulawesi. Samples of *P. sanguinolentus* were obtained from crab fishermen and were collected monthly. The measured data consisted of carapace width and body weight, stratified by sex. The Mann-Whitney test was used to assess differences in body size between males and females. The carapace width-body weight relationship was analyzed using nonlinear and linear regression analysis, and a t-test was performed on the value of b = 3 to determine the growth pattern of the crab. The condition factor analyzed was the relative condition factor. The results showed that male *P. sanguinolentus* had a larger body size than females. The carapace width-body weight relationship of male, female, and pooled *P. sanguinolentus* showed a strong and positive correlation, and the growth pattern was negative allometric. The relative condition factor of males was higher than that of females. The results of this study can be used as a basis for managing *P. sanguinolentus* in the southeastern Bone Gulf.

Keywords: Body size, Bone Gulf, condition factors, growth patterns, *Portunus sanguinolentus*

1. INTRODUCTION

Portunus sanguinolentus is a species of crab that has important economic value with a wide distribution area in the world, including East and South Africa, Madagascar, the Red Sea, India, China, Hong Kong, Japan, the Philippines, Thailand, Malaysia, Singapore, Indonesia, and Australia, as well as the Hawaiian Islands[1-5]. This crab is carnivorous and is found living from intertidal areas to a depth of 80 m, on sand to mud substrates[3,6,7]. This type of crab is also widely distributed in Indonesian waters, including those found in the waters of Southeast Sulawesi[8].

Body size can be used to determine the general welfare of aquatic animals, so body size information is very necessary in research on the biology, physiology, and ecology of a species. The relationship between carapace width and body weight is useful for studying the life history of a crab species[9-10] and for comparing stocks of crabs of the same species but with different geographic distributions[9-12], and is needed in crab management. Condition factors are estimated from the carapace width-body weight relationship and are used as quantitative indicators of the welfare of a crab species with its habitat conditions [10,11,13,14].

Several factors, such as body size, environmental conditions, sex, gonad development, growth, food availability, parasite burden, and exploitation rate, influence crab condition factors[9,10,13,15,16]. These factors often vary between seasons, populations, and crab exploitation rate[13,16]. These three factors are important and very necessary information in managing crab resources[11,17], especially in designing

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fishing gear that is appropriate to the body size that can be caught[17].

Several studies of *P. sanguinolentus* that have been conducted include those on aspects of population dynamics[3,8], fisheries and stocks[1,19], feeding and mating behavior[7,20-22], nutritional content[23] and other biological aspects[12,24,26-28]. Research related to morphometrics, especially on size, carapace width-body weight relationship, and condition factors of *P. sanguinolentus* in Indonesia is still limited[12].

Southeastern Bone Gulf is part of the waters of Kolaka Regency, Southeast Sulawesi. In these waters, *P. sanguinolentus* was found as a bycatch of the blue swimming crab (*P. pelagicus*) fishery[8]. To date, no research has been conducted on the body size, carapace width-body weight relationship, and condition factors of this crab in the waters of southeastern Bone Gulf. This study aimed to determine the body size, carapace width-body weight relationship, growth patterns, and condition factors of the *P. sanguinolentus* in the southeastern Bone Gulf, Southeast Sulawesi.

2. RESEARCH METHOD

Time and Location

This research was conducted in the southeastern part of Bone Gulf, which includes five crab fishing locations: Kolakasi, Tahoa (Kali Merah), Towua I, Dawi-Dawi-Pomalaa, and Tambea, in Kolaka Regency, Southeast Sulawesi, Indonesia (Figure 1), from February to November 2021. Crab fishing in this area is carried out by small-scale fishermen using traps and gillnets with fishing areas in the southeastern part of Bone Gulf, starting from the intertidal area to a depth of 30 m.

Sampling Procedure

Samples of *P. sanguinolentus* were collected from bycatch from blue swimming crab fisheries using traps and gillnets with various body sizes. Crab sampling was conducted monthly using purposive sampling. The crab samples collected each month were separated by sex and counted. Males and females were determined based on the shape of the abdomen[9]. Carapace width was measured with a vernier caliper (accuracy 0.01 mm), and body weight was measured with an analytical balance (accuracy 0.01 g)..

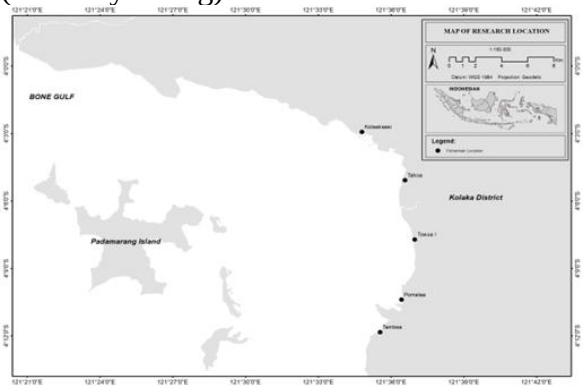

Figure 1. Map of research locations in southeastern Bone Gulf, Southeast Sulawesi, Indonesia

Data Analysis

Size-frequency distribution was constructed by determining class intervals using Sturges formula: k = 1 +3,3 log n
Where:
k = number of classes;
n = number of data.

The class interval was calculated as:

$$C = \frac{X_n - X_1}{k}$$

Where:
C = class interval,
X_n = maximum value;
X_1 = minimum value.

Data were grouped by class intervals and presented graphically. The Mann–Whitney test (p = 0.05)[29] was applied to test for size differences between sexes.

The carapace width (CW)- body weight (BW) relationship was analyzed using the power function[32]: $BW = aCW^b$
Where:
a = regression intercept,
b = growth coefficient.

The equation was log-transformed to linear form: log BW = log a + b log CW

The correlation coefficient (r) determines the strength of the relationship. Growth patterns were classified as isometric

when b = 3, positive allometric when b > 3, and negative allometric when b < 3. A t-test (p = 0.05) was applied to test deviations from isometry[11]. Relative condition factor (Kn) was calculated using Le Cren[15] formula:

$$Kn = \frac{BW}{aCW^b}$$

Where:
BW = mean body weight (g),
CW = mean carapace width (mm),
a = intercept,
b = growth coefficient

3. RESULT AND DISCUSSION

Body Size

Male *P. sanguinolentus* ranged from 46.88-97.75 mm carapace width (mean 82.37 mm) and 11.06-55.02 g body weight (mean 36.37 g). Females ranged from 55.72-95.60 mm carapace width (mean 79.22 mm) and 17.84-53.08 g body weight (mean 30.39 g). Size- frequency distributions were dominated by mean carapace widths of 89.35 mm for males and 83.25 mm for females (Figure 2). The results of the Mann-Whitney test for carapace width and body weight in male and *female P. sanguinolentus* showed a significant difference ($p<0.05$), indicating that male body size is larger than that of females (Table 1). The results of this study are identical to those found in the Karnataka Coast, India[32]; Veraval, Gujarat, India[19]; northern Taiwan[3]; and Madura Island, Indonesia12, in contrast to those found in the Gulf of Mannar, India[21], and Pati, Indonesia[18]. The size of male crabs was smaller than that of females (Table 2).

The carapace width of male and female *P. sanguinolentus* found in this study was still within the range found in several other waters, ranging from 33.2 to 193 mm for males and 33.2 to 182 mm for females (Table 2). The carapace widths found in several waters also varied considerably between waters. Variations in size across regions may be influenced by food availability, age structure, parasitism, and water quality[31]. Sukumaran[32] classified *P. sanguinolentus* with carapace widths <80 mm as juveniles and >80 mm as adults. Based on these categories, 64% of the male crabs in this study were classified as adults, and 36% as juveniles; among females, 58% were adults and 42% were juveniles (Figure 2).

Table 1. Mean body sizes of male and female *P. sanguinolentus*

Sex	Body size	
	Carapace width (mm)	Body weight (g)
Male	82.37*	36.37*
Female	79.22*	30.39*

* = Significant difference ($p< 0.05$)

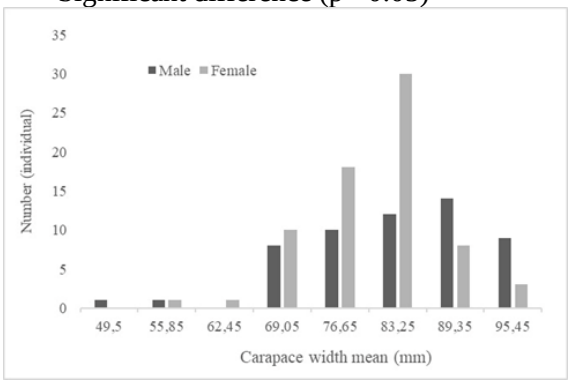

Figure 2. Distribution of carapace width sizes of male and female *P. sanguinolentus*

Based on Figure 2, the size frequency distribution is dominated by the 89.35 mm class for males, and the 83.25 mm class for females, and according to Sukumaran's criteria[32], the population structure *of P. sanguinolentus* at the research location was dominated by an adult with low exploitation pressure. This crab is not currently the main target of fishing, or is only a bycatch, in the P. pelagicus fishery at this location.

Carapace Width–Body Weight Relationship and Growth Pattern

The results of the analysis of the carapace width-weight relationship of male, female, and pooled *P. sanguinolentus* showed a strong and positive relationship, as seen from the regression coefficient (r) value of >0.8 (Table 3 and Figure 3). Results of this were identical to several previous studies[7,12,21,27,33-34] regarding the carapace width-weight relationship of *P. sanguinolentus* of both sexes, also showed a

strong and very strong positive relationship with r value ranging from 0.7937 to 0.98850 (Table 4).

The growth coefficient (b) values of both sexes of these crabs were <3 (Table 3), indicating a negative allometric growth pattern, meaning the carapace width increases faster than the body weight. Negative allometric growth patterns in this crab were also reported in the Gulf of Manar, India[22], in Veraval, India[7,27], and in females in the southeastern Arabian Sea[14]. In contrast, the growth patterns of this crab in Baai-Bengkulu Island, Indonesia[34] and Madura Island, Indonesia[12] were positively allometric. In contrast, those found on the coast of Karnataka, India[32], and Honghai Bay, China[33], and in the southeastern Arabian Sea for males[14] are isometric (Table 4). The differences in *P. sanguinolentus* growth patterns are influenced by geographical variation among populations, exploitation rates, and differences in abiotic factors[13,37].

The results of the analysis of the carapace width-body weight relationship showed that the growth coefficient for male *P. sanguinolentus* was relatively smaller than that for females, namely 2.0328 for males and 2.0961 for females (Table 3). The results of this study are identical to those found in Manar Bay, India[21]; Veraval, Gujarat, India[7,27]; Baai Island, Bengkulu, Indonesia[34]; and the southeastern part of the Arabian Sea[14]. In contrast, found on the coast of Karnataka, India[32], Honghai Bay, China[33], and Madura Island, Indonesia[12] showed that the b value of males *P. sanguinolentus* was smaller than that of females (Table 4).

The b-values found in this study are very low, ranging from 2.03 to 2.12 (Table 3), much lower than those reported in several previous studies, which ranged from 2.5 to 3.5 (Table 5). This is related to the much smaller sample size used in the analysis compared to several previous studies, and it is suspected that there may be measurement bias, but further research is needed to confirm both.

Table 2. Sizes of male and female *P. sanguinolentus* in the various locations.

Location	Sex	Carapace width (mm)	Source
Karnataka coast, India	Male Female	33.2-124.0 33.2-114.0	32
Veraval, Gujarat, India	Male Female	118.76* 114.84*	19
Honghai Bay, China	Male Female	49.5-144.4 44.3-139.6	34
Mannar Gulf, India	Male Female	71.2-17,02 29.7-191.0	21
Northern Taiwan	Male Female	90-193 68-182	3
Pati, Indonesia	Male Female	103.95** 106.24**	18
Madura Island, Indonesia	Male Female	60-135 60-130	12
Southeastern Arabian Sea, India	Male Female	55-171 54-170	14
Southeastern Bone Gulf, Indonesia	Male Female	46.88- 97.75 55.72-95.60	This study

Note: * dominant size; ** mean size

Table 3. Linear equation of the carapace width-weight relationship, correlation coefficient (r), growth coefficient (b), and growth pattern of *P. sanguinolentus*

Sex	Linear equation	r	b	Growth pattern
Male	LogBW= -2.3446+2.0328logCW	0.8707	2.0328*	Negative allometric
Female	LogBW= -2.5057+2.0961logCW	0.8367	2.0961*	Negative allometric
Pooled	LogBW= -2.5300+2.1181 logCW	0.8542	2.1181*	Negative allometric

* = Significant difference ($p < 0.05$)

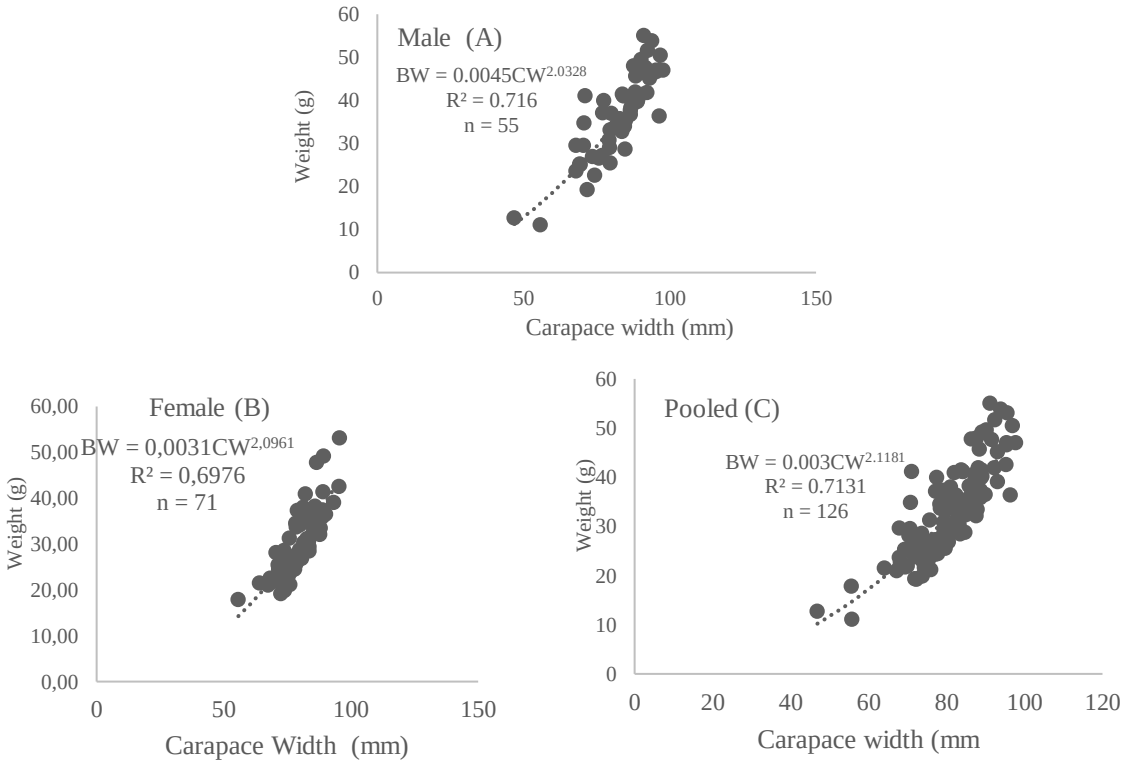

Figure 3. Carapace width body weight relationships of male (A), female (B), and pooled (C) *P. sanguinolentus*

Table 4. Growth coefficient (b), correlation coefficient (r), and growth pattern of male and female *P. sanguinolentus* from various locations

Location	Sex	b	r	Growth pattern	Source
Karnataka coast, India	Male	3.0996	0.98850	Isometric	32
	Female	2.9604	0.98206	Isometric	
Honghai Bay, Cina	Male	3.0234	0.9873	Isometric	33
	Female	3.0911	0.9797	Isometric	
Mannar Gulf, India	Male	2.755	0.9198	- Allometric	21
	Female	2.411	0.9306	- Allometric	
Veraval Gujarat, India	Male	2.95	0.88	- Allometric	27
	Female	2.74	0.84	- Allometric	
Veraval Gujarat, India	Male	2.196	0.9910	- Allometric	7
	Female	2.0076	0.9865	- Allometric	
Baai Island, Bengkulu, Indonesia	Male	3.1562	0.7937	+ Allometric	34
	Female	2.9168	0.9446	- Allometric	
Madura Island, Indonesia	Male	3.0181	0.8989	+ Allometric	12
	Female	3.1973	0.9186	+ Allometric	
Southeastern Arabian Sea, India	Male	2.9657	-	Isometric	14
	Female	2.8028		- Allometric	
Southeastern Bone Gulf, Indonesia	Male	2.0328	0.8707	- Allometric	This study
	Female	2.0961	0.8367	- Allometric	

Condition Factor

The results of the analysis of the relative condition factor of male, female, and pooled *P. sanguinolentus* based on average body size obtained a Kn value of > 1 (Tabel 5), and this indicates that the growth of both sexes of these crabs is in good condition. This is because food availability for these crabs is sufficient, and environmental conditions are optimal for the growth of *P.*

sanguinolentus in the southeastern Bone Gulf. Food availability, sexual cycle, habitat conditions, and season[11,36] influence the value of the relative condition factor. In addition, the value of the relative condition factor of male and female crabs varies temporally in relation to the reproductive cycle, especially the peak spawning[11].

Table 5. Condition factors for male, female, and pooled *P. sanguinolentus* based on body size

No.	Sex	Condition factors of the body size based on		
		Minium	Maximun	Mean
1.	Male	0.9857	1.1010	1.0308
2.	Female	1.2596	1.2087	1.0262
3.	Pooled	1.0649	0.9546	1.0085

The relative condition factor of male *P. sanguinolentus* is lower than that of females; this is identical to that found in Veraval, Gujarat, India, namely males of 1.00461 and females of 1.00908[7], and in the southeastern Arabian Sea, India, namely males of 0.942 and females of 1.371[14]. The same condition is also found in several other species of crustaceans, such as the *P. pelagicus*[11], *Callinactes sapidus*[37], *C. danae*[13], and *Charybdis anisodon*[31]. In contrast, the relative condition factor of male *Scylla serrata* was higher than that of females[38]. In *Aranaeus cribrarius*[35] and *C. lucifera*[36], the relative condition factors of males and females are the same. The higher relative condition factor in females than in males is related to the greater energy requirements for gonad development and the maintenance of broodstock recruitment[7].

4. CONCLUSION

Male *P. sanguinolentus* in the southeastern Bone Gulf ranged from 46.88–97.75 mm carapace length and 11.06–55.02 g body weight, while females ranged from 55.72–95.60 mm and 17.84–53.08 g. Males are significantly larger than females. Growth patterns are negatively allometric for both sexes, and relative condition factors are > 1, with condition factors of males and females similar. These results are valuable for estimating crab body weight from carapace width and may provide a scientific basis for sustainable management strategies for *P. sanguinolentus* in the southeastern Bone Gulf.

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