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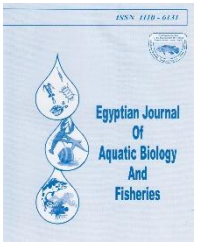

Morphometric-Meristic Characters and Length-Weight Relationships of *Macrobrachium mammillodactylus* (Thallwitz, 1892) Inhabiting Downstream of Rongkong Watershed, South Sulawesi, Indonesia

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ABSTRACT

Macrobrachium is a freshwater prawn genus with a high economic value and habitability in Sulawesi, Indonesia. One of *Macrobrachium* that has not been described in many characteristics, is namely *M. mammillodactylus*. This study aimed to determine morphometric and meristic variance, length-weight relationships, and condition factors of *M. mammillodactylus* from three rivers downstream of Rongkong watershed, South Sulawesi, Indonesia. A sampling of *M. mammillodactylus* was conducted from September 2018 to August 2019. The parameters observed were morphometrics, meristics, length-weight relationships, and condition factors. The observed variables were total weight and total length to see growth patterns and condition factors, while 9 morphometric parameters and the number of serrations contained in the dorsal and ventral rostrum sections were conducted to see the discriminant of the observed variable characteristics. The coefficient values indicated female morphometric parameters were more heterogeneous than male. The population of *M. mammillodactylus* at Waelawi, Salujambu, and Pombakka Rivers obtained 2 groups, with the parameter morphometric and meristic not significantly different. The negative allometric growth pattern and condition factor (k) > 1, showed that the three rivers provide sufficient feed, low predator density, and moderate flow velocity. This study could be used for sustainable fisheries management and as primary data in conservation efforts of *M. mammillodactylus* at Rongkong watershed, South Sulawesi, Indonesia.

INTRODUCTION

Indonesia's freshwater organisms are very diverse and have high potential for aquaculture. One of the many of genus of freshwater organisms found in Indonesia is *Macrobrachium* freshwater prawns. These freshwater prawns were divided into major

and minor prawn depending upon their body size. Majority of major prawn species are marine and few of them are freshwater **(Kumar *et al*., 2018)**. Since the end of the 19th century, the genus *Macrobrachium* has been reported from Ilhabela **(Mossolin *et al*., 2010)**. The invasion of family Palaemonidae to freshwaters was recorded during the late Mesozoic or early Cenozoic era **(Anger, 2013)**. *Macrobrachium* is a species of freshwater prawn that widely distributed in Indonesia **(Binur and Pancoro, 2017)**. The genus *Macrobrachium* is distributed in the world's biogeographic regions, namely the Afrotropical, Australasian, Neotropical, and Oriental regions **(de Grave *et al*., 2008)**. *Macrobrachium* belongs to the family Palaemonidae and seemingly easy to differentiated from other genera **(Torati *et al*., 2011)** and have 230 species **(Andrade *et al*., 2017)**. The genus *Macrobrachium* has a hepatic spine, the last three legs have a simple dactylus, and has no supraorbital and branchiostegal spines. It has well developed, compressed and toothed rostrum.The telson has two pairs of dorsal and posterior spines **(de Grave *et al*., 2011)**. *Macrobrachium* is a freshwater prawns that has high economic value **(Trijoko *et al*., 2015; Fadli *et al*., 2018)**.

Sulawesi is one of the freshwater prawn habitats of the genus *Macrobrachium* and has economic value to be developed. **Laewa *et al*. (2018)** reported the Sulawesi island is one of the distribution regions of the genus *Macrobrachium*. Sulawesi Island is included in the transition zone in the Wallace grouping and reported to store biodiversity of high potential biota **(Tanod *et al*., 2019; Menajang *et al*., 2020)**. Sulawesi Island has biodiversity with a high level of endemicity and is one of the areas of spreading freshwater prawn **(Annawaty *et al*., 2016; Swiyanto *et al*., 2018; Dwiyanto *et al*., 2020)**.

Previous studies reported that there were 19 species from Sulawesi, Indonesia, namely *M. gracilirostre* **(Wowor *et al*., 2009)**; *M. bariense*, *M. mammillodactylus*, *M. placidum*, *M. sulcicarpale*, *M. weberi*, *M. spinipes* **(de Grave *et al*., 2013)**; *M. lepidactyloides* **(Annawaty and Wowor, 2015)**; *M. rosenbergii*; *M. idae* **(Wahidah *et al*., 2015, 2017)**; *M. lanchesteri* **(Mangesa *et al*., 2016)**; *M. scabriculum* **(Dwiyanto *et al*., 2017)**; *Macrobrachium australe*, *M. horstii*, *M. lar*, *M. placidulum* **(Swiyanto *et al*., 2018)**; *M. equidens*, *M. latidactylus* **(Laewa *et al*., 2018)** and **(Rahayu and Annawaty, 2019)**; and *M. esculentum* **(Jurniati *et al*., 2020, 2021)**. One of the species whose characteristics have not been described was *M. mammillodactylus*.

de Grave *et al*. (2013) in their report only explained the species of *M. mammillodactylus* originating from Sulawesi, Indonesia. While **Jose and Harikrishnan (2018)** reported *M. mammillodactylus* from Philippines living in euryhaline habitats. Recently, there is no publication analyzing the characteristics of *M. mammillodactylus* from South Sulawesi, Indonesia. Information on the genus *Macrobranchium* of South Sulawesi comes from *M. horstii* from a river near Palopo **(Wowor and Choy, 2001)**; *M. rosenbergii* and *M. idae* from the Waelawi, Kariango, and Kalibone rivers **(Wahidah *et al*., 2017)**; and Lake Tempe **(Wahidah *et al*., 2015)**; *M. esculentum* from the Pongkeru River **(Wowor *et al*., 2009).** This study is the first report to measure morphometric-

meristic characteristics and the length-weight relationship of *M. mammillodactylus* from South Sulawesi, Indonesia.

The Rongkong watershed, especially in the downstream, is a main habitat of freshwater prawns that is a source of livelihood for the local community. *M. mammillodactylus* is the most dominant catch of artisanal fishermen who use fishing traps (locally named "kopa"). In the last few years, the catch of fishermen has been declining due to land management (mining, plantations); residues of inorganic fertilizers from agricultural land, anthropogenic waste and destructive fishing **(Setiawan and Nandini, 2006)**. As the rivers are essential reservoirs for *Macrobrachium*, it is important to study the fitness of rivers population, so that it can be useful in the conservation program of a species **(Maidin *et al*., 2017)**. Therefore, this study aimed to determine morphometric-meristic variance, length-weight relatioships and condition factor of *Macrobrachium mammillodactylus* from three rivers in the downstream of Rongkong watershed, South Sulawesi. This study could be used as a preliminary data for conservation management of *M. Mammillodactylus* in South Sulawesi, Indoensia.

MATERIALS AND METHODS

1. Study area

Sampling was carried out from September 2018 to August 2019 in the downstream of Rongkong watershed. There were 3 rivers in downstream Rongkong watershed: Waelawi; Salujambu; and Pombakka which are the Macrobrachium fishing area. Local fishermen install bamboo fishing traps (local name: *kopa*) along the banks of the rivers. There were 3 stations at each sampling location (river). The coordinates of the sampling location could see in **Table 1** and **Fig. 1**.

Table 1. Coordinate point Sampling location *Macrobrachium mammillodactylus*

Sampling Location	Station I	Station 2	Station 3
Waelawi	Lat. 2° 51' 05.03" S Long 120° 18' 21.54" E	Lat 2° 51' 11.37" S Long 120° 18' 30.41" E	Lat 2° 51' 19.05" S Long 120° 18' 43.62" E
Salujambu	Lat 2° 49' 19.51" S Long 120° 15' 18.22" E	Lat 2° 49' 24.07" S Long 120° 15' 38.26" E	Lat 2° 50' 18.57" S Long 120° 15' 21.18" E
Pombakka	Lat 2° 51' 34.40" S Long 120° 16' 14.08" E	Lat 2° 52' 12.30" S Long 120° 16' 29.23" E	Lat 2° 52' 51.29" S Long 120° 16' 24.08" E

2. Research Procedures

Random sampling was conducted 12 times (once a month) using *kopa*. Samples were put into a coolbox, then transported and deposited into the Basic Laboratory of the Faculty of Fisheries, Andi Djemma University, Palopo, South Sulawesi, Indonesia. Samples were preserved in 70% alcohol. Sexing of *M. mammillodactylus* was performed based on morphological features **(Cuvin-Aralar, 2014)**. The number of *M.*

mammillodactylus from the Waelawi river was 1080 individu (440 males, 640 females); Salujambu river was 1080 individu (448 male, 632 female); and Pombakka River was 1065 individu (438 males and 627 females).

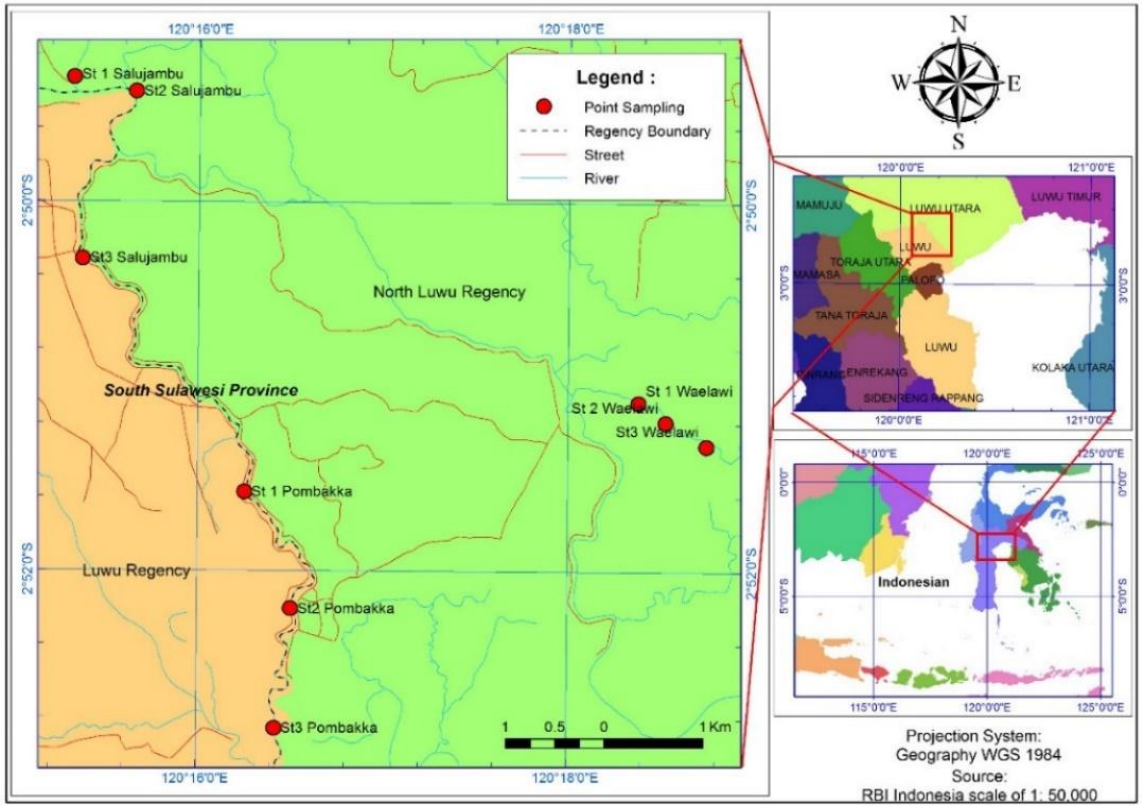

Fig. 1. Map of Sampling area of *M. mammillodactylus* in Rongkong Watershed, South Sulawesi, Indonesia

Morphometric and meristic measurements (**Table 2**) were performed following method developed by **Short (2004); Munasinghe and Thushari (2010); Adite *et al.* (2013)**, by using digital caliper (0.01 mm accuracy). Measurements of total weight was conducted using a digital scale Acis Ad 300i (accuracy 0.01 g). Data on morphometric and meristic measurements from three rivers presented to compare the population. Meristic parameters were measured by counting the number of teeth at the dorsal (upper) and ventral (lower) rostrum.

The allometric linear model (LAM) were used to calculate parameters a and b through measurements of changes in weight and length. Correction of bias of changes in the mean weight of logarithmic units was used to predict the length parameters according to allometric equations of **de Robertis and Williams (2008)**:

$$W = a\, L^b$$

Growth patterns was estimated from the value of b. If b = 3, then weight gain is balanced with length gain (isometric). If b <3, then the length gain is faster than the weight gain (negative allometrics). If b> 3, then weight gain is faster than length gain (positive allometrics).

Table 2. Characteristics, symbol, and definition characteristic morphology *M. mammillodactylus*

No.	Characteristics	Symbol	Defenition of Characteristics
A.	*Morphometric*		
1	Total length	TL	Length from antenula to telson end
2	Abdominal length	AL	Length from the front carapace to the end of Telson
3	Telson length	Tel	Maximum length of telson
4	Carapace length	CL	Length from the base of the eye to the front of the carapace
5	Carapace width	Cw	Carapace Maximum Width
6	Carapace diagonal length	CdL	The length of the base of the eye to the lower carapace
7	Length of the first abdominal	LA1	Maximum length of the first abdominal segment
8	Length of the second abdominal	LA2	Maximum length of the second abdominal segment
9	Rostrum length	RL	Length from the tip to the base of Rostrum
B.	*Meristic*		
1	Number of upper teeth of rostrum	NUT	Total count of upper teeth of the Rostrum
2	Number of lower teeth of rostrum	NLT	Total count of lower teeth of the Rostrum

Condition Factors (K) was established to evaluate the condition of each individual. Wr was determined based on the **Rypel and Richter (2008)** equation as follows:

$$Wr = \left(\frac{W}{Ws}\right) \times 100$$

Wr was the relative weight, W was the weight of individual prawn, and Ws was the standard weight predicted from the same sample because it calculated from the combined length-weight regression, through distances between species:

$$Ws = a\ L^b$$

The Fulton condition coefficient (K) was determined based on the **(Okgerman, 2005)** equation with the following formula:

$$K = W\ L^{-3} \times 100$$

Where K was a condition factor, W was the total weight (g), L was the total length (mm), and -3 is the coefficient of length to ensure that the K value tends to be 1.

3. Data Analysis

Morphological characteristics were analyzed using principal component analysis (PCA) to obtain morphometric characteristics grouping. Hierarchical cluster analysis to analyze a phenotypic level of similarity in the form of the Dendrogram. Discriminant analysis (DA) to analyze description of the morphometric character of each population of *M. mammillodactylus* using IBM SPSS 21 software. Allometric linear models (ALM) was applied to obtain growth patterns.

RESULTS

1. Identification

Samples obtained from the downstream of Rongkong watershed were morphologically identified as *Macrobrachium mammillodactylus* (Thallwitz, 1892). The identification was carried out by Dr. Daisy Wowor (Crustacean Laboratory researcher, Center for Biological Research - Indonesian Institute of Sciences), with letter number B-5940/IPH.1/KS.02.03/XI/2018. This is first report about *M. mammillodactylus* from South Sulawesi, Indonesia. The identification process was based on morphometric and meristic characters, especially rostrum, which is a key taxonomy. The freshwater prawn samples found in the downstream Rongkong watershed were medium to adult size. The sample had a schapocherite length that was shorter than the length of the rostrum, the rostral teeth were equally spaced, 8-14 teeth on the dorsal (NUT) and 3-6 teeth in the ventral rostrum (NLT) **(Wowor and Choy, 2001)**. Sample of *M. mammillodactylus* samples from downstream of the Rongkong watershed, South Sulawesi, Indonesia, could be seen in **Fig. 2**.

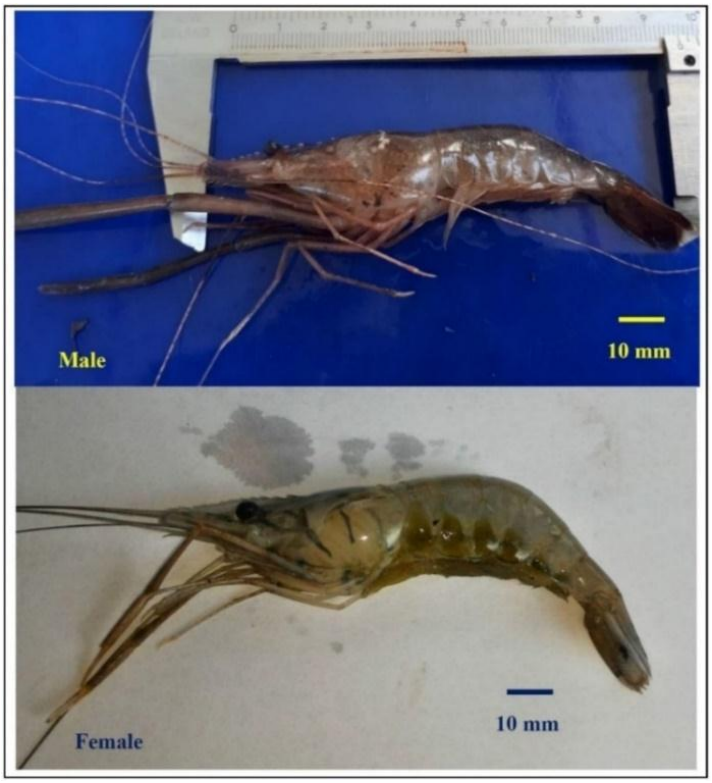

Fig. 2. *Macrobrachium mammillodactylus* from downstream of the Rongkong watershed, South Sulawesi, Indonesia

2. Morphometric

The morphology of a species was influenced by the habitat or environment where the species lives. The morphometric and meristic characters of the male and female populations were also measured separately. In the Waelawi, Salujambu and Pombakka Rivers, male *M. mammillodactylus* has almost the same carapace length (CL).

Meanwhile, female *M. mammillodactylus*, carapace length (CL) in the Waelawi River was greater than in the Pombakka and Salujambu Rivers. Morphometric characteristics of *M. mammillodactylus* can be seen in **Table 3**.

Tabel 3. Morphometric characteristics of *M. mammillodactylus* population in Rongkong Watershed, South Sulawesi, Indonesia

Sampling Location	Charac-teristics	Female			Male		
		Mean ± SE	Range	CV (%)	Mean ± SE	Range	CV (%)
Waelawi	TL	5.87 ± 0.05	2.11 - 9.80	19.68	6.19 ± 0.06	2.42 - 9.91	20.37
	AL	3.32 ± 0.03	0.50 - 6.01	19.92	3.44 ± 0.04	0.18 - 7.38	23.32
	Tel	0.85 ± 0.01	0.14 - 1.93	24.69	0.92 ± 0.01	0.21 - 2.04	24.00
	CL	1.49 ± 0.01	0.31 - 2.99	23.23	1.65 ± 0.02	0.33 - 3.52	25.25
	Cw	0.99 ± 0.01	0.13 - 2.03	25.18	1.09 ± 0.01	0.21 - 2.38	27.50
	CdL	1.66 ± 0.01	1.02 - 3.07	21.99	1.80 ± 0.02	0.38 - 3.61	23.39
	LA1	0.29 ± 0.01	0.13 - 1.30	35.89	0.28 ± 0.01	0.03 - 0.81	27.11
	LA2	0.64 ± 0.01	0.29 - 1.59	25.30	0.65 ± 0.01	0.12 - 1.96	30.54
	RL	1.63 ± 0.01	0.46 - 2.90	19.62	1.72 ± 0.02	0.59 - 3.43	21.17
Salujambu	TL	5.77 ± 0.05	0.15 - 9.94	21.05	5.75 ± 0.05	2.02 - 9.17	19.61
	AL	3.22 ± 0.03	1.07 - 6.17	20.11	3.21 ± 0.03	1.12 - 5.81	19.39
	Tel	0.84 ± 0.01	0.13 - 1.97	24.92	0.86 ± 0.01	0.15 - 1.93	19.96
	CL	1.47 ± 0.01	0.32 - 2.83	23.54	1.51 ± 0.02	0.31 - 2.95	23.46
	Cw	0.98 ± 0.01	0.21 - 2.48	27.38	1.01 ± 0.01	0.11 - 1.95	25.53
	CdL	1.60 ± 0.02	0.22 - 3.24	24.17	1.65 ± 0.02	0.21 - 2.97	24.62
	LA1	0.27 ± 0.01	0.12 - 1.86	43.42	0.27 ± 0.01	0.10 - 1.23	30.57
	LA2	0.62 ± 0.01	0.10 - 1.72	26.78	0.58 ± 0.01	0.10 - 1.59	26.54
	RL	1.59 ± 0.01	0.41 - 2.95	19.74	1.62 ± 0.01	0.51 - 2.78	16.74
Pombakka	TL	5.86 ± 0.05	1.65 - 9.78	20.80	5.97 ± 0.06	0.71 - 9.22	21.34
	AL	3.25 ± 0.03	0.64 - 6.53	21.17	3.33 ± 0.04	1.08 - 7.38	22.76
	Tel	0.87 ± 0.01	0.20 - 1.97	25.59	0.89 ± 0.01	0.14 - 2.05	23.77
	CL	1.49 ± 0.01	0.32 - 2.49	22.41	1.56 ± 0.02	0.32 - 3.52	25.19
	Cw	0.99 ± 0.01	0.22 - 1.96	25.03	1.05 ± 0.01	0.25 - 2.35	24.80
	CdL	1.63 ± 0.02	0.23 - 2.95	24.12	1.72 ± 0.02	0.22 - 3.24	24.86
	LA1	0.31 ± 0.01	0.11 - 1.07	39.69	0.29 ± 0.01	0.12 - 1.23	42.31
	LA2	0.63 ± 0.01	0.10 - 1.21	25.92	0.61 ± 0.01	0.12 - 1.51	29.79
	RL	1.61 ± 0.01	0.41 - 2.58	20.35	1.69 ± 0.02	0.41 - 3.43	20.73

CV = coefficient of variation, Morphometric parameter unit = mm

Table 3 shows that the range of coefficient of variation (CV) was found for all morphometric variables measured from three rivers between 16.74% and 42.31%, the lowest variance was the male population's rostrum length parameter. Simultaneously, the highest was the first abdominal length parameter in female population from Salujambu. Morphometric variability in the population, high for female groups (19.62% -43.42%), than males (16.74-42.31%).

Correlation analysis was performed to determine the parameters that affect the carapace length size of the sample. Correlation between variables of carapace length (Y) with parameters of total length, abdominal length, telson length, carapace width, carapace diagonal length, length of first abdominal, length of second abdominal, and rostrum length as an influencing variable (X) with linear regression analysis can be seen in **Table 4**.

Table 4. Correlation between carapace length with eight morphometric parameters of *M. mammillodactylus* in Rongkong Watershed, South Sulawesi, Indonesia

Parameters	Waelawi		Salujambu		Pombakka	
	Male	Female	Male	Female	Male	Female
a	-0.159	0.000	-0.076	0.036	-0.123	0.047
b1	0.028	0.032	0.088	0.064	0.067	0.068
b2	0.010	0.023	0.030	-0.015	0.006	-0.005
b3	0.157	0.071	0.176	0.050	0.020	0.048
b4	0.239	0.087	0.200	0.284	0.482	0.076
b5	0.504	0.609	0.361	0.410	0.305	0.407
b6	0.840	0.008	0.177	0.145	0.130	0.236
b7	-0.072	-0.035	-0.024	-0.137	-0.075	0.079
b8	0.054	0.056	-0.001	0.114	0.054	0.056
r^2	0.817	0.770	0.768	0.758	0.783	0.787
n	440	640	448	632	438	627
CL = (a + b1*TL) + (b2*AL) + (b3*Tel) + (b4+Cw) + (b5*CdL) + (b6*LA1) + b7*LA2) + (b8*RL)						

Table 4 shows the range of correlation coefficient values (r) (0.87-0.90). Positive correlation coefficient values indicate that changes in TL, AL, Tel, Cw, CdL, LA1, and LA2 morphometric parameters will affect the carapace length (CL). The regression equation coefficient showed a significant influence between CL with eight morphometric parameters of *M. mammillodactylus* (male and female) in Waelawi, Salujambu, and Pombakka rivers. Population diversity based on morphological differences may indicate the presence of genetic diversity among the population. However, further study was needed in assessing genetic characteristics.

The cluster analysis in **Fig. 3** shows two population groups (male and female) with similarities based on the observed characters. The first group obtained FS (female population of Salujambu river), FW (female population of Waelawi river), FP (female population of Pombakka river), and MS (male population of Salujambu river). The second group was a population of MP (male population of Pombakka river) and MW (male population of Waelawi river).

Discriminant analysis (DA) showed the separation of the population in the Waelawi, Salujambu, and Pombakka river produced very close centroid graphs **(Fig. 4)**. The analysis showed that the eigenvalue of the first was only 12%, and the second function was 1%, with a variation value of 62% for the first function and 38% for the second function. These results showed a low value; thus it was not significant in the separation of populations between the three rivers.

Fig. 4 shows the morphometric parameters of *M. mammillodactylus* population could use as a parameter of separation between rivers. Correlation values of all morphometric parameters was found that the morphometrics of LA2, CdL, AL, TL, CL, RL, Tel, and Cw have a correlation with the discriminant function 1, while the LA1 correlates with the discriminant function 2.

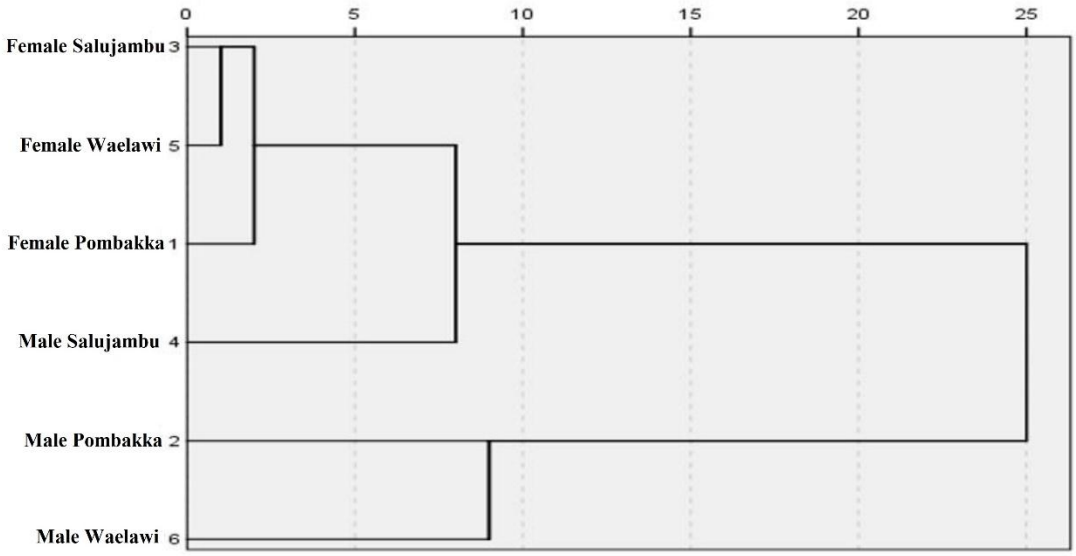

Fig. 3. Dendrogram of characters morphometric *M. mammillodactylus* in Rongkong Watershed, South Sulawesi, Indonesia

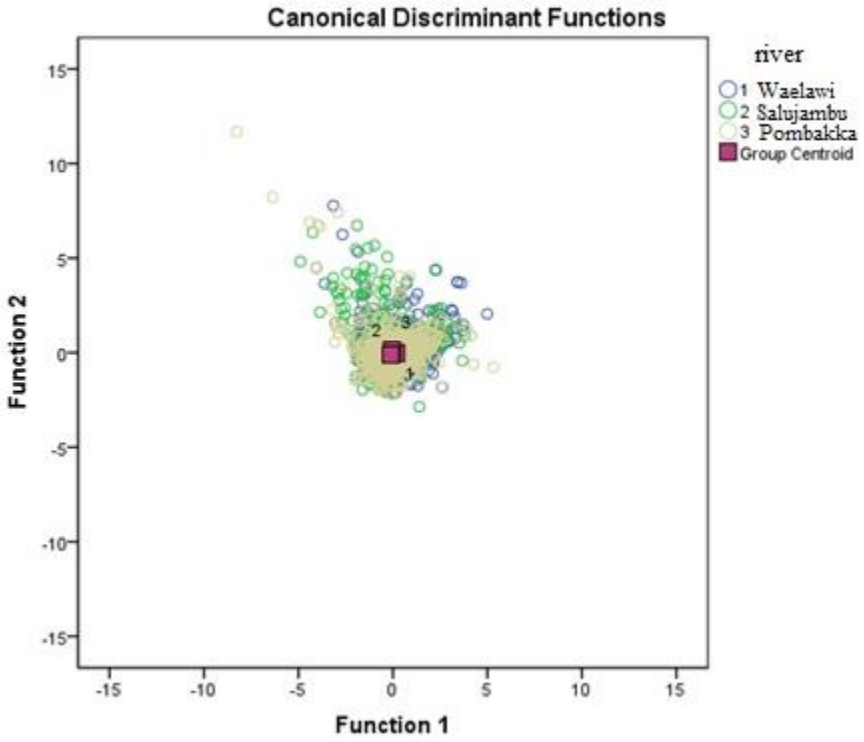

Fig. 4. Cluster Plots between discriminant functions 1 and 2 of *M. mammillodactylus*

3. Meristic

Rostrum spines was commonly used to asses the meristic characteristics of *Macrobrachium* species. The one-way ANOVA analysis in **Table 5** shows no variability of meristic character existed among the population of *Macrobrachium mammillidactylus* in the three rivers. Measurement of meristic characteristics of *M. mammillodactylus* from three rivers could be seen in **Table 5**.

Table 5. Meristic characters of *M. mammillodactylus* in Rongkong Watershed, South Sulawesi, Indonesia

Sampling Location	Meristic characters	Numbers of serrations	Male	Female	Anova
Waelawi	n		440	640	
Salujambu	n		448	632	
Pombakka	n		438	627	
Range number of serrations					
Waelawi	NUT		8 – 14	8 – 14	
Salujambu			8 – 14	8 – 14	
Pombakka			8 – 14	8 – 14	
Waelawi	NLT		3 – 6	3 – 6	
Salujambu			3 – 6	3 – 6	
Pombakka			3 – 6	3 – 6	
Percentage of frequency distribution					
Waelawi	NUT	8	6,82	7,03	P > 0.05
		9	30,68	31,72	
		10	20,91	21,56	
		11	19,55	17,97	
		12	14,32	16,56	
		13	6,14	4,22	
		14	1,59	0,94	
Salujambu		8	6,5	7,9	
		9	29.0	29,4	
		10	22,33	22,3	
		11	20,5	20,9	
		12	13,6	14,9	
		13	4,9	3,8	
		14	3,1	0,8	
Pombakka		8	5,5	8,5	
		9	29,7	29,4	
		10	20,4	21,9	
		11	21,1	17,7	
		12	17,2	16,6	
		13	4,6	5,3	
		14	1,6	0,6	
Waelawi	NLT	3	62,5	69,69	P > 0.05
		4	21,59	18,78	
		5	15,23	10,9	
		6	0,68	0,6	
Salujambu		3	62,5	70,1	
		4	22,5	21,7	
		5	13,4	7,0	
		6	1,6	1,3	
Pombakka		3	66,6	65,2	
		4	21,5	22,8	
		5	11,0	10,7	
		6	0,9	1,3	

4. Lenght-weight relationships

The Length-weight relationships was very important in fisheries management. Estimation of the length-weight relationships of *M. mammillodactylus* could be seen in Table 6.

Table 6. Length-weight relationships of *M.mammillodactylus* from Rongkong Watershed, South Sulawesi, Indonesia

Sampling Location	Sex	n	Range of Total Length (mm) Mean ± SD	Range of Observations Weight (g) Mean ± SD	Range of Prediction Weight (Ws) (g) Mean ± SD	Range of Relative Weight (Wr) (g) Mean ± SD	Range of Condition Factor Fulton K Mean ± SD	Determination Coefficient (r^2)	Correlation coefficient (r)	Regression (b)
Waelawi	Male	433	36.70 – 134.50 62.70 ± 13.44	1.04 – 18.02 3.91 ± 2.68	0.87 – 24.75 3.78 ± 2.40	52.44 – 171.27 101.26 ± 19.57	0.07 – 2.80 1.62 ± 0.57	0.880	0.938	2.582
	Female	640	28.20 – 103.50 57.58 ± 11.68	1.04 – 17.25 3.21 ± 2.20	0.47 – 11.76 3.08 ± 1.68	16.69 – 178.02 99.76 ± 21.39	0.07 - 2.85 1.43 ± 0.56	0.803	0.896	2.470
Salujambu	Male	461	20.20 – 96.10 55.76 ± 11.21	1.01 – 15.60 2.88 ± 1.68	0.36 – 7.30 2.73 ± 1.05	5.71 – 236.55 101.30 ± 28.29	0.02 – 6.81 1.36 ± 0.65	0.601	0.775	1.904
	Female	644	29.10 – 101.30 56.99 ± 12.21	0.70 – 15.25 3.00 ± 1.88	1.09 – 5.81 2.73 ± 0.79	22.25 – 358.08 104.23 ± 32.96	0.56 – 4.10 1.37 ± 0.60	0.735	0.857	2.124
Pombakka	Male	461	32.10 – 134.50 59.72 ± 13.46	0.70 – 20.47 3.51 ± 2.70	1.36 – 8.65 3.08 ± 0.91	26.02 – 381.31 108.05 ± 41.78	0.56 -3.26 1.45 ± 0.65	0.810	0.900	2.570
	Female	628	26.90 – 98.40 57.63 ± 12.16	0.59 – 12.73 3.12 ± 2.03	0.66 – 7.58 2.90 ± 1.18	24.63 – 244.66 102.57 ± 26.12	1.13 – 2.75 1.39 ± 0.62	0.788	0.888	2.315

Table 6 shows correlation coefficient (r) of *M. mammillodactylus* from three rivers indicates a close relationship between total length and body weight of male and female *M. mammillodactylus*, where each increase in total length will be followed by weight gain. The correlation coefficient (r) ranges from 0.775 to 0.938 in the three rivers. These high correlation coefficient values indicated a close relationship between total length and body weight of male and female *M. mammillodactylus*. An increase in total length will be followed by an increase in weight gain.. In addition, the coefficient value terminated (r^2) ranged from 0.601 to 0.880. This explained that the total weight gain variance between 60 to 88%.

The growth coefficient of *M. Mammillodactylus* in **Table 6** shows the growth pattern of negative allometric ($b < 3$), for the population of Waelawi, Salujambu and Pombakka rivers. In the range of b values in female prawn ranging from 2.124 – 2.470, and in male prawn ranging from 1.904 – 2.582.

Tabel 6 also shows that observations weight value ranging from 2.88 – 3.91, was higher than the prediction weight value of 2.73 – 3.78. This indicated that the water qualities in the three rivers were optimal for growth of *M. mammillodactylus*. This was in accordance with the Fulton Condition Factor Values. Male prawn in the three rivers had Fulton condition factors (K) ranging from 1.36 to 1.62, and relative weight (Wr) ranging from 101.26 to 108.05 g. Whereas in female prawn, the Fulton condition factors (K) ranged from 1.37 to 1.43, and the relative weight (Wr) ranged from 99.76 to 104.23 g.

DISCUSSION

Morphological variation due to characters differences resulted from an adaptation of a species to the environment **(Wahidah *et al*., 2015)**. This morphological variation can be assessed by morphometric measurements, which are geometric and biological empirical functions **(Wahidah *et al*., 2017)**. **Konan *et al*. (2010)** stated that the interaction between genotypes and the environment resulted in a morphometric characteristic that can be used to identify the phenotype of a population. The same genotype was subjected to different environments, it could produce a wide range of phenotypes. Phenotypic variations are attributable to the effect of the environment on the expression and function of genes influencing the trait **(Baye *et al*., 2011)**.

Results findings show that the female population's morphometric characters are more heterogeneous than the male population. The ranges of higher CV showed a more heterogeneous morphological character **(Ferrito *et al*., 2007)**. The highest morphometric CV of the three rivers populations was the Pombakka river > Waelawi river > Salujambu river. This is presumably because Pombakka River is closer to the Rongkong watershed's mouth, so the prawn in this river is likely more ready to spawn (also indicated by the increase in egg diameter and level of gonad maturity), affecting the length of the carapace. This reflects the life cycle of prawns (especially the genus *Macrobrachium*) who migrate to the sea as they reach the adult stage to spawn **(Bauer, 2013)**.

Generally, *M. mammillodactylus* obtained during the study has a relatively large size. **Hindell *et al*. (2008)** reported that a species would have a larger size when it migrates for spawning. **Kounthongbang *et al*. (2015)** also reported *M. yui* from northern Laos with carapace length (CL) of about 21-39 cm, has a high gonad somatic index. **Ginting *et al*. (2018)** revealed that the total length of *M. mammillodactylus* in the Sibam River, Pekanbaru, Riau, Indonesia, had a total length of 22.6 to 58.7 mm in male prawns and 25.6 to 32.5 mm in female prawns. **Holthuis (1950)** found that *M. mammillodactylus* could reach a maximum total length of 137 mm. Differences in morphological characteristics, including total length, indicated that there were genotypes that were specifically expressed better in one particular environment but not in other environments **(Mariappan and Balasundaram, 2004; Adite *et al*., 2013; Cartaxana, 2015)**.

Morphological diversity in an environment showed phenotypic flexibility, which was the ability of an individual to produce more than one alternative form of morphology or behavior as a response to the environmental changes to survive and reproduce **(Jayachandran and Indira, 2010; Chen *et al*., 2015; Mar *et al*., 2018)**.

Population characteristics from the three rivers on the 9 morphometric parameters had very close characteristics(Similar). This indicated that the water quality of the three rivers were homogen and then support survival and growth of the prawn in the same way. Observation on morphometric and meristic characters was needed to evaluate genetic diversity. In addition, meristic characters contribute to implementation of management

plans, including habitat protection, species conservation and culture of *Macrobrachium* species **(Fagnon *et al*., 2013; Hurtado *et al*., 2013)**.

Meristic characters of the prawn did not vary between population. **Lawson (2010)** said that if two or more populations had the same meristic features, then they were taxonomically inseparable. **Ginting *et al*. (2018)** reported that the rostrum of *M. mammillodactylus* in Sibam river, Pekanbaru, Riau, Indonesia, had 7 dorsal teeth and 4 ventral teeth. Whereas **Chace and Bruce (1993)** reported that the range of the number of rostrum teeth in the dorsal section 7-15 and ventral section 2-5. *Macrobrachium mammillodactylus* species inhabiting Lake Pangkal Tanjung Balam, Riau, Indonesia, had several teeth 7-9 in the dorsal rostrum and 3-5 in the ventral rostrum **(Nurmanita *et al*., 2019)**.

Length-weight relationship was performed to examine the growth pattern of *M. mammillodactylus*. The growth patterns of a species could be applied to estimate the production and biomass of the species **(Smith ands Addison, 2003; Chang *et al*., 2012; Neumann *et al*., 2012)**. Length-weight relationship was very important in fisheries management as a comparative study for growth to estimate the production and biomass of the species and it can be used as a basis in the assessment of the species populations **(Moutopoulos and Stergiou, 2002)**. Length-weight relationships leads to establish mathematical model between two variables, thus allowing the conversion of one variable to another **(Le Cren, 1951; Llopis-Belenguer *et al*., 2018)**. In addition, the length-weight relationship had several functions including 1). describing growth in nature **(Abohweyere and Williams, 2008; Deekae and Abowei, 2010)**; 2). determining possible differences between different populations of the same species **(Gerritsen and Mcgrath, 2007; King, 2007; Jisr *et al*., 2018)**, and 3). describing stock and comparative growth studies **(Peixoto *et al*., 2004; Silva *et al*., 2015; Maurya *et al*., 2018; Oliveira *et al*., 2020)**.

M. mammillodactylus from three rivers in this study having negative allometric. Previous studies have also reported negative allometric growth patterns in *M. malcolmsonii* **(Hossain *et al*., 2012)**; *M. vollenhovenii* **(Konan *et al*., 2014)**; *M. nipponense* **(Tizkar *et al*., 2018)**; and *Macrobrachium* sp. **(Ahmadi, 2018)**. Regression value (b) was an interpretation of body shape that is directly related to weight, which was influenced by ecological factors such as temperature, food supply, season, spawning time, sex, age, and the presence of fishing activities **(Ricker, 1973; Hamid *et al*., 2015; Ogunola *et al*., 2018)**.

Condition factors can be used to assess the health status, productivity, and physiological conditions of a populations **(Blackwell *et al*., 2000; Richter, 2007; Muchlisin *et al*., 2010)**. Condition factors also reflect the body's morphological characteristics, lipid content, and growth rate **(Bister *et al*., 2000; Froese, 2006; Stevenson and Woods, 2006; Rypel and Richter, 2008; Ighwela *et al*., 2011)**. Condition factors describe physical and biological conditions that may change due to

food availability, parasitic infections, and physiological factors **(Le Cren, 1951; Datta *et al*., 2013; Ndiaye *et al*., 2015)**.

In this study, we found that average weight was higher than the prediction weight. This was in accordance with the Fulton Condition Factor Values. The average of the relative weight (Wr) was above 100 and the fulton condition factor was greater than 1, indicating that the waters of the three rivers provided sufficient food and low density of predators. This condition was supported by rainfall that occured every month (including in the transitional season) as well as moderate flow velocity in the *M. mammillodactylus* habitat. Variations in feed supply that occur between seasons can change condition factor seasonally **(Offem *et al*., 2007; Ahmed *et al*., 2012, 2015)**. According to **Anderson and Newmann (1996); Agista *et al*. (2019)**, the value of relative weight (Wr) below 100 for an individual or population indicated problems such as low availability of prey or high density of a predator. Meanwhile, if the relative weight value (Wr) was above 100, it showed the excess availability of a prey or the low density of a predator. In addition, other factors such as biotic, abiotic and fisheries management could also lead to a variety of condition factors **(Murphy *et al*., 1991; Blackwell *et al*., 2000; Kazemi *et al*., 2013)**.

Generally, the condition factors (environmental condition) of *M. mammillodactylus* in the three rivers were not different. However, the male and female *M. mammillodactylus* condition factors in the Waelawi river are higher than those of Salujambu and Pombakka rivers. Prawn with higher condition factors were expected to have higher fecundity than prawn with lower condition factors **(Blackwell *et al*., 2000; Ara *et al*., 2014)**. This study provides information on morphology characteristics and length-weight relationships of *M. mammillodactylus* in the downstream of Rongkong watershed, South Sulawesi, Indonesia.

CONCLUSION

Analysis of morphometric and meristic characters *M. mammillodactylus* from Waelawi, Salujambu, and Pombakka rivers concluded a close relationship on morphometric and meristic characteristics of *M. mammilodactylus* populations from the three rivers. The length-weight relationships of *M. mammillodactylus* populations was negative allometric. The observed weight value was higher than the predicted weight; the average condition factor (Wr > 100 and K > 1) suggested sufficient availability of food and a low number of predators. This study could be used for sustainable fisheries management and as primary data in conservation efforts *M. mammillodactylus* at Rongkong watershed, South Sulawesi, Indonesia.

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