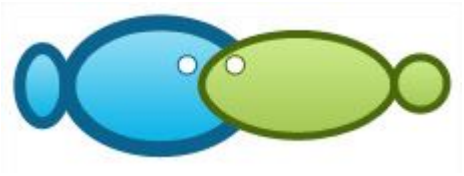

Left-right asymmetry in the giant freshwater prawn population of Sulawesi

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Abstract. This study aimed to evaluate the symmetry and asymmetry in the natural population of the giant freshwater prawn *Macrobrachium rosenbergii* from the Waelawi River and the Kariango River in Sulawesi. Evaluation of 12 paired appendages (symmetry) in 68 samples of giant freshwater prawn from the Welawi River and 74 samples of giant freshwater prawn from the Kariango River has been done. The study results revealed that the population of Waelawi had a higher symmetry score than the Kariango population. The average asymmetry values V_{kk} in the males (1.01) and females (1.07) in the Kariango population were higher than those of the males (0.99) and females (1.06) in the Waelawi population. This condition demonstrated that the Waelawi population had a more stable morphological development.
Key Words: symmetry, asymmetry, giant freshwater prawn, *Macrobrachium rosenbergii*, Sulawesi.

Introduction. The giant freshwater prawn *Macrobrachium rosenbergii* is one of the prawn species that is found throughout Indonesia, including in Sulawesi, which has been identified as having a natural population of giant freshwater prawn with varied morphology (Wahidah & Yusuf 2017; Wahidah et al 2017). The huge distribution area and different habitats make it possible for giant freshwater prawn to have different morphology (Pantaleão et al 2014; Torres et al 2014) and a wide genetic diversity. The habitat of this prawn is fresh water bodies (ponds, lakes, rivers, and irrigation canals) and estuaries (New 2002). Different habitats or environments influence the morphology of a species (Jimoh et al 2013). Furthermore, adaptations to different environments could cause morphological variations. These variations could be evaluated using methods such as the measurement of morphology asymmetry (measurement of paired appendages, the left and right sides).

Asymmetry is defined as an invariant, among normal individuals, difference between the left and right sides of an animal's morphology (Levin & Nascone-Yoder 1997). Studies pertaining to asymmetry in prawns, which compare the number of left and right characters, have often been conducted, including in Palaemonidae prawns (Mariappan et al 2000), and Nephropidae lobsters (Govind & Pearce 1986; Govind 1989). However, studies about symmetry in giant freshwater prawn which compare the size of paired appendages between the left and right side have yet to be conducted.

The natural population of giant freshwater prawn of Sulawesi has potential as a source of parent stock for production activities. At present, the value of giant freshwater prawn production in Sulawesi still relies on catches from the wild. Efforts to cultivate it with attention to morphological performance have yet to receive the people's attention, causing the production of giant freshwater prawn to still be low. One step that could be taken to overcome the issue of low giant freshwater prawn production in relation to morphological performance is by evaluating asymmetry. Therefore, this study aimed to discover asymmetry in the natural population of the giant freshwater prawn from the Waelawi River and the Kariango River in Sulawesi, Indonesia.

Material and Method. The samples were collected from July to October 2017 in Waelawi River (Balease Watershed, North Luwu) and Kariango River (Sawitto-Kariango-Rappang

Watershed, Pinrang). The number of samples taken from the Waelawi River population was 68 individuals (27 males and 41 females) while from Kariango River was 74 samples (29 males and 45 females). The samples were caught using net and immediately placed into the isolated icebox with icepack to maintain the freshness of the samples. The samples were transported to the laboratory for asymmetry measurement. A 0.01 mm digital caliper was used for asymmetry measurement. Measurement of 12 symmetrical appendages was conducted using a 0.01 mm digital caliper (Figure 1). Observation of the symmetry did not include the length of pereiopod 2, because there was a tendency for asymmetry in this character (Juanes et al 2008; Claverie & Smith 2010).

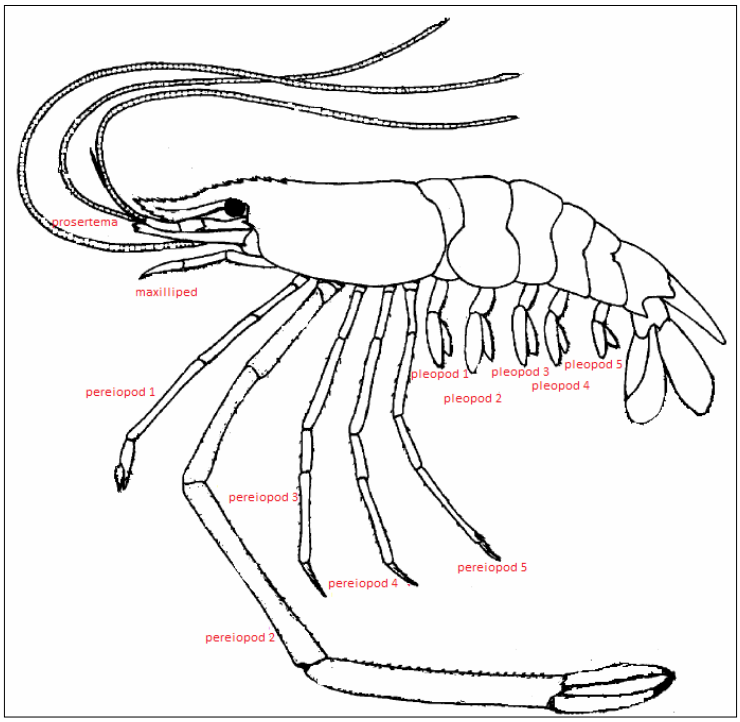

Figure 1. Symmetrical appendages in the giant freshwater prawn *Macrobrachium rosenbergii.*

Statistical analysis. Avoiding the effects of different size and ages differences, characteristic values were standardized based on equation $M_s = M_o(L_s/Lo)^b$ as formulated by Konan et al (2010). M_s was standardized individual characteristics, L_s = standard average length, L_o = standard length of individual, b = slope of regression of $\log_{10}M_o$ on $\text{Log}_{10}L_o$ as formulated by Konan et al (2010), Lleonart et al (2000) and Ferrito et al (2007).

The symmetry analysis was done using the program Excel 2007. The symmetry and asymmetry score approach was done by comparing the bilateral meristic measurement on the paired appendages on the left and right sides of each giant freshwater prawn sample.

Results and Discussion. The current study results revealed that the highest V_{ratio} symmetry value between the length of left and right appendages was in the Kariango male and female populations (Table 1). The differences in the V_{ratio} symmetry values in the Kariango population were because the sample sizes varied. The V_{ratio} asymmetry value of giant freshwater prawn tended to be higher than the V_{ratio} symmetry value. This condition was also found in the observation of the periopod symmetry of *Macrobrachium grandimanus* (Wortham & Maurik 2012).

The average V_{kk} asymmetry value of the male Kariango population (1.01) was higher than that of the male Waelawi population (0.99), as with the average V_{kk} asymmetry value of the female Kariango population (1.07) which was higher than that of the female Waelawi population (1.06) (Table 2).

Table 1

The symmetry in the giant freshwater prawn *Macrobrachium rosenbergii* from the Waelawi River and Kariango River populations

Appendage	*Waelawi population* V_{ratio}		*Kariango population* V_{ratio}	
	Male	*Female*	*Male*	*Female*
Length of prosertema	1.74	1.32	3.00	2.91
Width of prosertema	2.70	1.56	3.75	2.38
Length of pereiopod 1	2.82	1.33	3.54	2.76
Length of pereiopod 3	2.98	1.31	3.76	3.44
Length of pereiopod 4	1.86	1.49	4.40	3.93
Length of pereiopod 5	2.75	1.34	3.44	4.88
Length of maxilliped	1.89	1.52	2.96	2.67
Length of pleopod 1	1.59	1.46	4.88	3.00
Length of pleopod 2	1.16	1.56	4.44	3.00
Length of pleopod 3	2.02	1.54	5.83	2.49
Length of pleopod 4	1.87	1.57	5.96	2.67
Length of pleopod 5	2.50	1.58	5.30	2.75

V_{ratio}: the ratio between the smallest length and the greatest length of the appendage measured.

Table 2

Asymmetry in the giant freshwater prawn *Macrobrachium rosenbergii* in the Waelawi River and Kariango River populations

Appendage	*Waelawi population*				*Kariango population*			
	Male		*Female*		*Male*		*Female*	
	V_{ratio}	V_{kk}	V_{ratio}	V_{kk}	V_{ratio}	V_{kk}	V_{ratio}	V_{kk}
Length of left prosertema	2.45		1.96		3.36		3.22	
Length of right prosertema	2.53		1.48		3.58		3.48	
Length of prosertema		0.97		1.32		0.94		0.93
Width of left prosertema	3.17		2.11		4.50		2.38	
Width of right prosertema	3.33		1.70		4.12		2.87	
Width of prosertema		0.95		1.24		1.09		0.83
Length of left pereiopod 1	3.33		1.51		5.33		6.06	
Length of right pereiopod 1	3.18		1.44		4.50		3.65	
Length of pereiopod		1.05		1.04		1.19		1.66
Length of left pereiopod 3	3.29		1.51		3.84		4.10	
Length of right pereiopod 3	3.38		1.56		3.98		3.72	
Length of pereiopod 3		0.97		0.97		0.96		1.10
Length of left pereiopod 4	3.26		1.37		3.83		3.67	
Length of right pereiopod 4	3.45		1.39		3.54		3.38	
Length of pereiopod 4		0.95		0.98		1.08		1.09
Length of left pereiopod 5	3.21		1.35		4.74		4.49	
Length of right pereiopod 5	3.04		1.29		4.85		3.04	
Length of pereiopod 5		1.06		1.04		0.98		1.48
Length of left maxilliped	2.89		1.44		3.99		3.51	
Length of right maxilliped	2.84		1.43		3.73		3.18	
Length of maxilliped		1.02		1.01		1.07		1.11
Length of left pleopod 1	2.70		1.41		4.39		2.50	
Length of right pleopod 1	2.74		1.50		4.94		3.00	
Length of pleopod 1		0.99		0.94		0.89		0.83
Length of left pleopod 2	2.60		1.44		4.89		2.34	
Length of right pleopod 2	2.67		1.43		5.38		2.47	
Length of pleopod 2		0.97		1.01		0.91		0.95
Length of left pleopod 3	2.37		1.03		4.33		2.75	
Length of right pleopod 3	2.37		1.04		4.23		3.03	
Length of pleopod 3		1.00		1.00		1.02		0.91
Length of left pleopod 4	2.60				5.81		3.24	
Length of right pleopod 4	2.63				5.06		3.74	
Length of pleopod 4		0.99				1.15		0.87
Length of left pleopod 5	2.53		1.52		5.14		3.35	
Length of right pleopod 5	2.76		1.41		5.83		3.05	
Length of pleopod 5		0.91		1.08		0.88		1.10
Average		0.99		1.06		1.01		1.07

V_{ratio}: the ratio between the smallest length and the greatest length of the appendage measured; V_{kk}: the ratio between the V_{ratio} of the appendage on the left side and the right side of the body.

The Waelawi and Kariango populations had symmetrical appendages in the samples evaluated, whereas in the asymmetry evaluation there was an appendage of which all of the samples were symmetrical (the length of Pleopod 4), in the female Waelawi population. This condition showed that the Waelawi population had a more stable morphology.

The male and female population of Kariango had a high V_{ratio} asymmetry value, demonstrating that within these populations there were individuals that tended to have abnormal appearances. Kirpichnikov (1981) explained that abnormal appearances are phenotypic discrepancies for morphological characters which include meristic and morphometric characters. Phenotypic discrepancies could be in the form of abnormalities (change in form, number, or asymmetry in paired organs) (Wilkins et al 1995).

Asymmetry in individuals could be caused by genetic and environmental/habitat influence. Asymmetry which emerges due to environmental influence could be caused by an abnormal environment or drastic disturbances at high intensities. Individuals in such environmental conditions would adapt. Individual adaptation could be in the form of self-defence (Barki et al 1997), adaptations related to physiology (Schmidt & Derby 2004; Takeuchi et al 2008), adaptations in feeding (Takeuchi & Hori 2008), and sexual adaptations (Munoz & Zink 2012). In the giant freshwater prawn in the Waelawi and Kariango populations, asymmetry was possibly caused by fishing activities using chemicals. Therefore, it is postulated that the giant freshwater prawn adapted to this environmental condition.

The high V_{kk} asymmetry value for the length of pereiopod was possibly a form of the giant freshwater prawn's adaptation to its environmental condition. The highest V_{kk} asymmetry value was for the length of pereiopod 1 and length of pereiopod 5. Because the function of pereiopods is for locomotion, this indicates that giant freshwater prawn underwent adaptations that are predicted to be related to its locomotoric activities.

Conclusions. Observations of symmetry revealed that the Waelawi population had a higher symmetry value than the Kariango population. Observations of the average V_{kk} asymmetry in males and females showed that the Waelawi population had a lower V_{kk} than the Kariango population.

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