Selection response and heritability of growth traits of giant freshwater prawn (*Macrobrachium rosenbergii*) in Indonesia

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Abstract. Information on heritability of important characters is the prime base to determine a method in the improvement of giant freshwater prawn (GFP), *Macrobrachium rosenbergii*. The information describes population's ability to respond to selection intensity. However, study on the estimation of heritability on growth characters of Indonesian GFP remains limited. The purposes of this study were to evaluate selection response and real heritability both on standard length and body weight of six months old GFP. The selection was conducted by mass selection method on composite population of GFP from Indonesia, which consisted of four strains, including Barito, Musi, Asahan, Ciasem and the previous selected prawn (GIMacro) strain. Selective breeding to create faster grow in GFP was done by selection for four generations on the composite population prawns to obtain 10 percent of the best prawns as broodstock candidates on the next generation. The GFP selection was based on standard length trait because it has high corelation to prawn body weight and more practice to be done. The result of this study showed that response to selection in female prawns was higher than its males, there were 23.99 and 9.56% for female and male respectively. Heritability both on standard length and body weight characters of sixth months old prawn was evaluated. The real heritability of the characters shown sexual dimorphism. Heritability of standard length on female population was higher than male population, there were 0.48 and 0.08 for female and male, respectively. The result suggests that GFP selection on female population will be more effective than selection on male population.
Key Words: growth, heritability, *Macrobrachium rosenbergii,* response to selection, sexual dimorphism.

Introduction. The giant freshwater prawn (GFP) (*Macrobrachium rosenbergii*), Indonesian name being "udang galah", is one of the important crustaceans in the inland aquaculture sector of many tropical and subtropical countries, including Indonesia. In the last decade, because its high commercial value and tolerance to water quality changes, there has been an expansion of GFP farming in many Asian countries (New & Nair 2012; Banu & Cristianus 2016). Accelerating the GFP industry, superior strain of the prawn seeds is urgently needed, especially for faster grow of GFP, and consequently GFP selective breeding program should be intensively conducted.

Selective breeding is one of the most effective means of improving production traits in farmed animals and plants (Gjedrem 1997; Fjalestad et al 2003; Gjedrem & Robinson 2014). In aquaculture, selective breeding has improved several important traits, including growth, feed efficiency, meat quality and disease resistance traits in salmon, tilapia, rohu carp and shrimp (Doupe & Lymbery 2003; Gjedrem et al 2012). Favourable response to selective breeding to improved production of GFP in Vietnam was reported by Luan et al (2012). Furthermore, Pillai et al (2017) reported that weight and length of GFP in India can be improved by selection.

Growth is the most important trait in aquaculture, including for GFP farming (Bentsen & Olesen 2002). Phenotypic measurement on growth trait can be represented by body length and body weight measurements (Piepho & MöHring. 2007). Estimation of heritability value of growth character of GFP has been performed to obtain fundamental base as a reference to determine breeding method of the prawn. Estimated heritability of body weight trait of male GFP was about 0.28±0.17 and 0.12±0.08 for the female. Meanwhile, the estimated heritability of total length of male prawn was about 0.47±0.18

and 0.11±0.07 for the female (Kitcharoen et al 2009). Furthermore, Karplus (2005) reported that the heritability of measured characters (total length, cephalothorax length, and claws length) of female GFP were moderate to high (0.29-0.39) and low (0.02-0.09) for the male. Recently, Pillai et al (2017) stated that weight and length of GFP had a moderate heritability, suggesting that they can be improved by selection. Based on the reported heritability values we conducted selective breeding to improve growth performance of the GFP.

In this study, the GFP selective breeding was focused on growth character, as the most important character in aquaculture (Gjedrem & Baranski 2009). In 2010, GFP based population was created through diallel cross among prawn male and female from each domesticated collection prawn strain, consisting of 9^{th} generation of GIMacro strain (the superior prawn strain), 4^{th} generation of Barito strain, 3^{th} generation of Musi strain, 3^{th} generation of Ciasem strain and 3^{th} generation of Asahan strain (Sopian & Khasani 2011). Mass selection was done every year for 4 years on growth character to compose selected prawn population, namely F1, F2, F3 and F4. The purposes of this study were to evaluate selection response and real heritability on growth character of GFP native of Indonesia.

Material and Method. This study was conducted in 2011-2014 at Research Institute for Fish Breeding, Subang, West Java, Indonesia. In this study, five prawn populations, consisting of one domesticated strain and four wild strains were used to establish a diverse genetic base for population. The wild prawns were collected from four locations, consisting of Asahan river (Medan, North Sumatera), Musi river (Palembang, South Sumatera), Ciasem river (Subang, West Java) and Barito river (Mandiangin, South Kalimantan) (Figure 1). The domesticated strain, the GIMacro is a superior prawn strain, especially on growth character and edible portion that was resulted from individual selection and released in 2000 (Nugroho et al 2005).

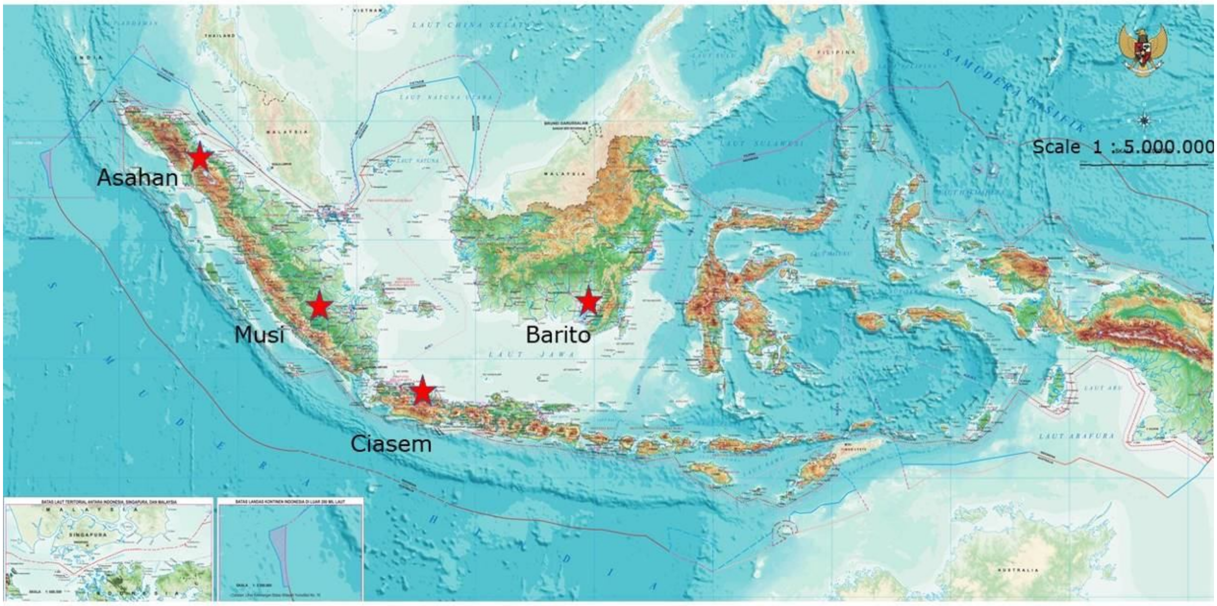

Figure 1. The location of GFP populations source.

The base population (F0) was composed by mix communal mating of 325 female and 131 male prawns from five strains in 200 m^2 concrete pond for 20 days. The prawn number and body weigt of each strain were showed in Table 1.

Table 1

The amount and body weight of GFP in base population formation

Population	*Female*		*Male*	
	Quantity (prawn)	*Average of body weight (g)*	*Quantity (prawn)*	*Average of body weight (g)*
GI Macro	89	27.10±6.60	34	40.40±27.11
Asahan	50	27.80±13.06	20	31.60±13.84
Musi	60	36.40±8.07	26	31.90±15.85
Barito	87	26.00±5.74	20	24.20±16.37
Ciasem	39	29.60±7.97	31	29.10±9.80

The first generation (F1) was composed by mating 230 female and 230 male prawns from selected broodstock of F0 population. The F2 population and F3 population were composed by matting selected broodstock from previous generation consist of 450 female and 300 male prawns; 200 females and 200 males for F2 and F3 respectively. The last population, F4 was composed from 667 females and 272 males of selected F3.

Mass selection was applied in this study by selecting 10% of best performance GFP on standard length (SL) of prawn body for every generation. Prawn selection was conducted on six months old prawn population. The adult prawns were obtained by larvae rearing for 30 days in clear water system, nursery of post larvae for 60 days in concrete ponds and juvenile grow-out for 90 days in earthen ponds. Due to sexual dimorphism on prawn growth, prawn sexing were done before selection. Control populations for every generation were created by using 40-60% ranked prawn based on SL character. The simple illustration of GFP selection method was showed in Figure 2.

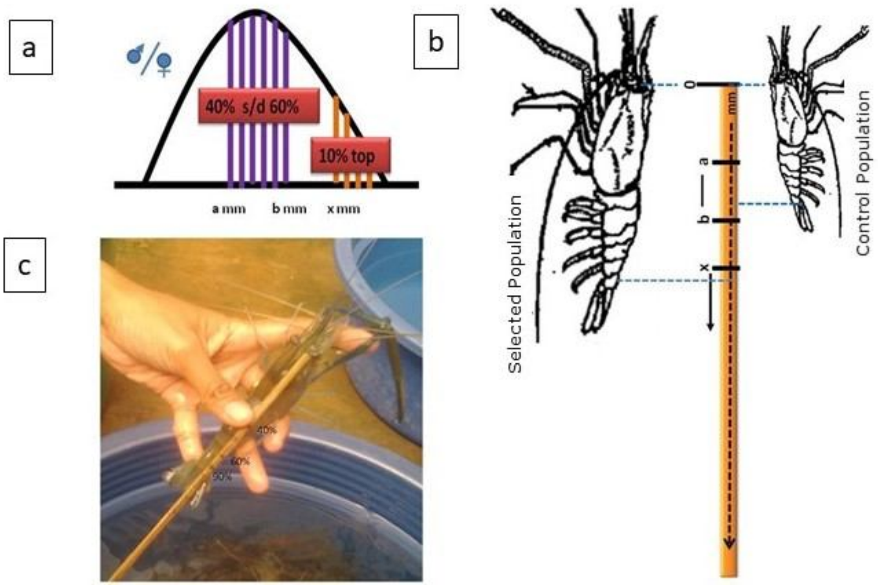

Figure 2. Selection procedure of selected and control line based on standard length (SL) of sixth moonths old. (a) distribution of prawn SL; (b) bamboo stick to determine selected and control line; and (c) selection process.

Statistical analysis. Selection differential was determined by reducing average phenotipic data of selected population with average phenotipic data of initial population. Selection response is average phenotipic data of selected population progeny be reduced with average phenotipic data of control population progeny (Tave 1995; Gjedrem & Baranski 2009). Heritability was calculated based on the selection response value divided by differentially selection (Gjedrem 2005).

$$SD = X_s - X$$

where: SD = selection differential;

X = phenotipic average of initial population;

X_s = phenotipic average of selected population (10% of top).

$$h^2 = \frac{SR}{SD}$$

where: h^2 = heritability;

SR = selection response;

SD = selection differential.

Analyses on selection response and selection diferential on body weight trait were calculated based on measured SL. Regression between body weight and SL refered to Krettiawan et al (2013):

$$W = (2x10^{-5})\ SL^{3.219}$$

where: W = body weight (g);

PS = standard length (mm).

Results. Total selection response (SR) on SL trait of female prawn during four generations (F1-F4) is about 22.7 mm, meanwhile SR on male is lower, about 6.64 mm (Table 2).

Table 2

Selection response on prawn standard length (mm)

Population	*SR (mm)*		*SR (%)*	
	Female	*Male*	*Female*	*Male*
F1	11.09	0.89	7.61	0.69
F2	0.67	3.77	1.01	5.81
F3	7.38	-1.22	10.68	-1.83
F4	3.59	3.2	4.69	4.89
Total	22.73	6.64	23.99	9.56
Average	5.68	1.66	6.00	2.39
Std Dev.	4.53	2.29	4.13	3.59

Total of selection response (F1 to F4) on body weight trait, as resulted from conversion of SL trait into body weight trait is about 24.01 g on female population and 6.79 g on male population. The SR on body weight trait is showed in Table 3.

Table 3

Selection response on prawn body weight (g)

Population	*SR (g)*		*SR %)*	
	Female	*Male*	*Female*	*Male*
F1	9.18	1.0	41.4	20.94
F2	0.67	3.76	3.36	20.45
F3	9.0	-1.18	39.65	-5.86
F4	5.16	3.21	16.3	16.98
Total	24.01	6.79	100.71	52.51
Average	6.00	1.70	25.18	13.127
Std Dev.	4.01	2.26	18.51	11.06

The average heritability of SL character of the F1-F4 populations in the female prawn population is about 0.48±0.45, whereas its value in the male population is about 0.08±0.11, as shown in Table 4.

Table 4

Heritability (h^2) on standard length trait of six months old prawns

Population	*SD (mm)*		*SR (mm)*		*h^2*	
	Female	*Male*	*Female*	*Male*	*Female*	*Male*
F1	10.36	12.6	11.09	0.89	1.1	0.07
F2	12.65	20.69	0.67	3.77	0.05	0.18
F3	15.34	18.11	7.38	-1.22	0.48	-0.07
F4	12.73	23.31	3.59	3.2	0.28	0.14
Average	12.77	18.68	5.68	1.66	0.48	0.08
Std Dev.	2.04	4.57	4.53	2.29	0.45	0.11

SD - selection differential; SR - selection response.

The heritability value of the prawn weight character is 0.35±0.27 in the female populations and 0.05±0.07 in the male populations. The heritabilities are shown in Table 5.

Table 5

Heritability (h^2) on body weight of sixth month old prawns

Population	*SD (mm)*		*SR (mm)*		*h^2*	
	Female	*Male*	*Female*	*Male*	*Female*	*Male*
F1	13.96	27.62	9.18	1.0	0.66	0.04
F2	20.61	40.35	0.67	3.76	0.03	0.1
F3	19.93	25.72	9.0	-1.18	0.45	-0.05
F4	20.87	32.71	5.16	3.21	0.25	0.1
Average	18.84	31.60	6.00	1.70	0.35	0.05
Std Dev.	3.28	6.54	4.01	2.26	0.27	0.07

SD - selection differential; SR - selection response.

Discussion. The best performing male and female GFP were selected as a broodstock population for next generation formation. The principle of selection is that the average genetic value of selected individuals is higher than the average genetic value of all individuals in their population. Hopefully the selection program will produce offspring with better genetic value than previous generation (Hung et al 2013). The general aim of breeding programs is to obtain individuals which have best set of superior genes and could produce better progeny (Kerr 1984; WorldFish Center 2004; Dunham 2004; Gjedrem & Robinson 2014).

The superiority of prawns selection on a population is reflected by SD value. It means that selection on population with high SD will result in high improvement level. In this study, SD in male populations was about 18.68±4.57 mm, higher than SD of females population (12.77±2.04 mm), but the SR on male population was lower than SR on female. The result due to high size variation on the male population is not caused by genetic factor, but it is caused by social interaction. Karplus (2005) stated that male morphotype variation potentially results from a social dominance hierarchy, where BC males (the largest male) release chemical and behavioural signals that inhibit growth of the other two subdominant male. Ranjeet & Kurup (2002) and Ra'anan et al (1991) stated that in the normal population of GFP grow-out pond the adult male prawns can be differentiated into three main morphotypes, namely blue-claw male (BC), orange-claw male (OC) and small-male (SM).

The SR value is an important genetic parameter in the breeding program. It mean differentiation of a trait mean value from before and after selection process. In the study of Doyle (1980), the SR was measured in length and weight units of the GFP. The SR on SL character of female population was about 5.68±4.53 mm per generation (equivalent to 6.0±4.13%), higher than SR in male population, which was 1.66±2.29 mm (2±3.59%). The SR based on body weights was relatively higher than on SL trait. According to Doyle (1980), the selection response on prawn SL was about 0.321-0.75

cm, or 3.3-7.9% per generation, while selection response on weights trait was about 2.7-6.3 g, or 11.3-33%. SR on prawn body weight of about 26.22% per generation was reported by Luan et al (2012).

The heritability on SL of six months old GFP was significantly different between male and female populations. There was 0.48±0.45 in female population and 0.08±0.11 in male population. The higher heritability of female population was also showed in body weight character. Karplus (2005) mentioned that heritability of size characters in giant prawns is sexually dimorphic. Heritability in body size (total length, cephalothorax length, and claws length) of prawns was grouped into medium to high, the value was 0.29-0.39 in female population and 0.02-0.09 in male population. Heritability on carcass weight was moderate to high, both on female populations (0.37-0.41) and male population (0.16-0.23), and they were not significantly different between the sexes (Hung et al 2013). Furthermore, Kitcharoen et al (2009) said that heritability both on weight and total length of female population of GFP were higher than on male population. Heritability on the female prawns' weight on female population was about 0.28±0.17, whereas heritability on male population was about 0.12±0.08. Similar pattern show in heritability on total length of GFP. There were 0.47±0.18 in female population and 0.11±0.07 in male population. The greater heritability both on body weight and body length of female GFP was also reported by Pillai et al (2017).

Based on the difference on heritability value between male and female prawns, the prawn selection to improve their growth performance will be more effective when applied on female prawn population than male population. However, totally ignoring male population in the selection program will cause reducing effectiveness of breeding programs and potentially result small selection response (Hung et al 2013).

Conclusions. The selection response of GFP through mass selection of female population was higher than the male population. Heritability of both standard length and body weight of adult prawn were sexually dimorphic and their value was higher on female population. Breeding program for GFP to improve growth performance would be more effective if it is conducted on female population than male population.

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