Genetic improvement of growth trait in Siamese catfish (*Pangasianodon hypophthalmus* (Sauvage, 1878)) through family selection

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Abstract. In the case of catfish culture in Indonesia, the availability of superior seeds with favorable rapid growth is still an obstacle in the community. Siamese catfish (*Pangasianodon hypophthalmus*) breeding activity by applying family selection program has been done at Research Institute for Fish Breeding (RIFB) Sukamandi, Indonesia. Selection is one of the efforts to produce superior broodstock in order to improve the productivity of catfish culture. The improved character is expected to be inherited in the next generation. This study aimed to evaluate the selection response, selection differential and heritability of second-generation Siamese catfish. The formation of second generation of Siamese catfish (G2) was done through family selection on growth character using the size parameter of body weight by half-sib method. Selection response test was conducted on selected fish from the first generation Siamese catfish breeder (G1) selected. The spawning resulted in 20 families and they were kept separately for eleven months in the 20 net cage of 3m x 5m x 1.5m, placed in an earthen pond. The results showed that response to selection, selection differential and real heritability in the second generation population were 18.54% (125.97 g), 29.95% (241.19 g) and 0.48, respectively. Siamese catfish second generation of the selection results are expected to play a role in increasing the productivity of national catfish culture fishery and can improve the welfare of the farmers community. The selection process still need to be continued to the next generation to obtain a superior generation.
Key Words: growth, selection, genetics, Siamese catfish, response to selection.

Introduction. In Indonesia, Siamese catfish (*Pangasianodon hypophthalmus* (Sauvage, 1878) is a fish species introduced from Thailand in 1972 (Hardjamulia et al 1981). Siamese catfish in Indonesia are found in the aquaculture environment, such as floating net cages, but they also exist in natural big rivers in Java (e.g. Citarum) and Sumatra (e.g. Batanghari) which are areas of Siamese catfish production centers (Pouyaud et al 1998). In addition, Siamese catfish populations which are found in nature are also the result of the development of restocking, such as in Wonogiri Reservoir (Kartamihardja et al 2011) and Malahayu Reservoir (Andriyanto et al 2012). In addition to Indonesia, catfish are also found in Asia such as Vietnam, Thailand and China. According to Gustiano (2009), there are 14 of 28 species of catfish in Indonesia. In Indonesia, catfish is an economically important fish because of the favorable meat flavor, relatively affordable price, easy aquaculture technique and has a relatively wide tolerance to the aquaculture environment.

Currently, the seed source used in commercial catfish growth out in the community comes from the Community Seed Producing Unit, owned by fish breeders, as well as from the Government Fish Seed Producing Hall, whose growth performance is relatively variable, indicating the deterioration of fish genetic quality. According to Gustiano & Pouyaud (2007) in the case of tilapia the last few years there was a tendency of genetic quality decline due to lack of proper management. This decline in genetic quality decreased growth rate causing a decrease in production and productivity, and also fish farmer income. Efforts to increase Siamese catfish production have been done with various approaches, such as through improved aquaculture technology and genetic improvement. Improvements in the aspects of aquaculture (seeding and grow out) are done by using the latest technology, such as the use of quality feed, containers and controlled aquaculture system. Improvement in the aspec of genetic is generally done through a selective breeding program which is an activity to select individuals which have good genetic qualities to be used and developed further for the next generation.

The basis of selection is breeding value. Two factors that determine the phenotype are genotype and environment (Hadie et al 2008). The selective breeding program has been shown to be effective in increasing the growth of several species of aquaculture fish. The selective breeding program was generally able to increase the growth of 6-7% per generation in most of the cultivated fish. However, in some species such as Atlantic salmon (*Salmo salar*), coho salmon (*Oncorhynchus kisutch*), channel catfish (*Ictalurus punctatus*), *Labeo rohita,* and Nile tilapia (*Oreochromis niloticus*), selective breeding programs using individual and family selection increased growth of 11-14% per generation (Dunham et al 2001). In the case of catfish culture in Indonesia, the availability of superior seeds with favorable rapid growth is still a constraint in the community. Based on this background, improving the genetic quality of Siamese catfish to get superior seed which grow fast in order to increase production and productivity of aquaculture fishery in the future is needed. This study aims to evaluate the selection response, selection differential and heritability of second-generation of Siamese catfish in RIFB.

Material and Method. The study was conducted from January to December 2017 at Research Institute for Fish Breeding (RIFB), Sukamandi, Indonesia. The test fish were obtained from induced spawning using HCG and ovaprim hormones (Tahapari et al 2007). HCG was injected to dam with a dose of 500 IU kg^{-1} of fish, while ovaprim was injected with a dose of 0.6 mL kg^{-1} for dam and 0.2 mL kg^{-1} for sire. Parent used was Siamese catfish G1 selection that was about 2.5 years with the weight of 3-4 kg. Selection of mature gonad was done by canulation to know the size of egg diameter ready for breeding.

The stripping process was done in the same day as injection. The fertilized egg was hatched in a hatching funnel container. Spawning and rearing activities of larvae/test fish seeds were done separately. The cross applied half-sib pattern in which one female parent was fertilized by two male parents, forming 20 families. The selection of the family was performed on the growth character using the weight size parameter by the method of within-family selection using 20 families per generation. Selection was performed for 10% of the population of each family at the time the test fish reached the consumption size with an average body weight of ≥ 750 g (Figure 1). The parents of the population average were used as a control, while the selected were used to determine heritability and the response of the selection performed.

Grow-out phase of fish was carried out for eleven months in a 6000 m^2 earthen pond using 20 net cage, sized of 3m x 5m x 1.5m, with stocking density of 150 fish $cage^{-1}$. Fish were fed floating feed containing 30-33% of protein level with 3-5% feeding rate and twice daily frequency.

The observed parameters included body weight and total length, from which coefficient of variation (CV), selection response, genetic gain, differential selection and real heritability value were analyzed. Observation of fish growth was done every month by measuring length and weight of 30 fishes of each population. The growth rate of body weight and length were calculated based on the formula according to Effendie (1979) and Murtidjo (2001), while the selection response parameters, the diversity coefficient, and heritability were calculated based on the formula according to Gjedrem (2005).

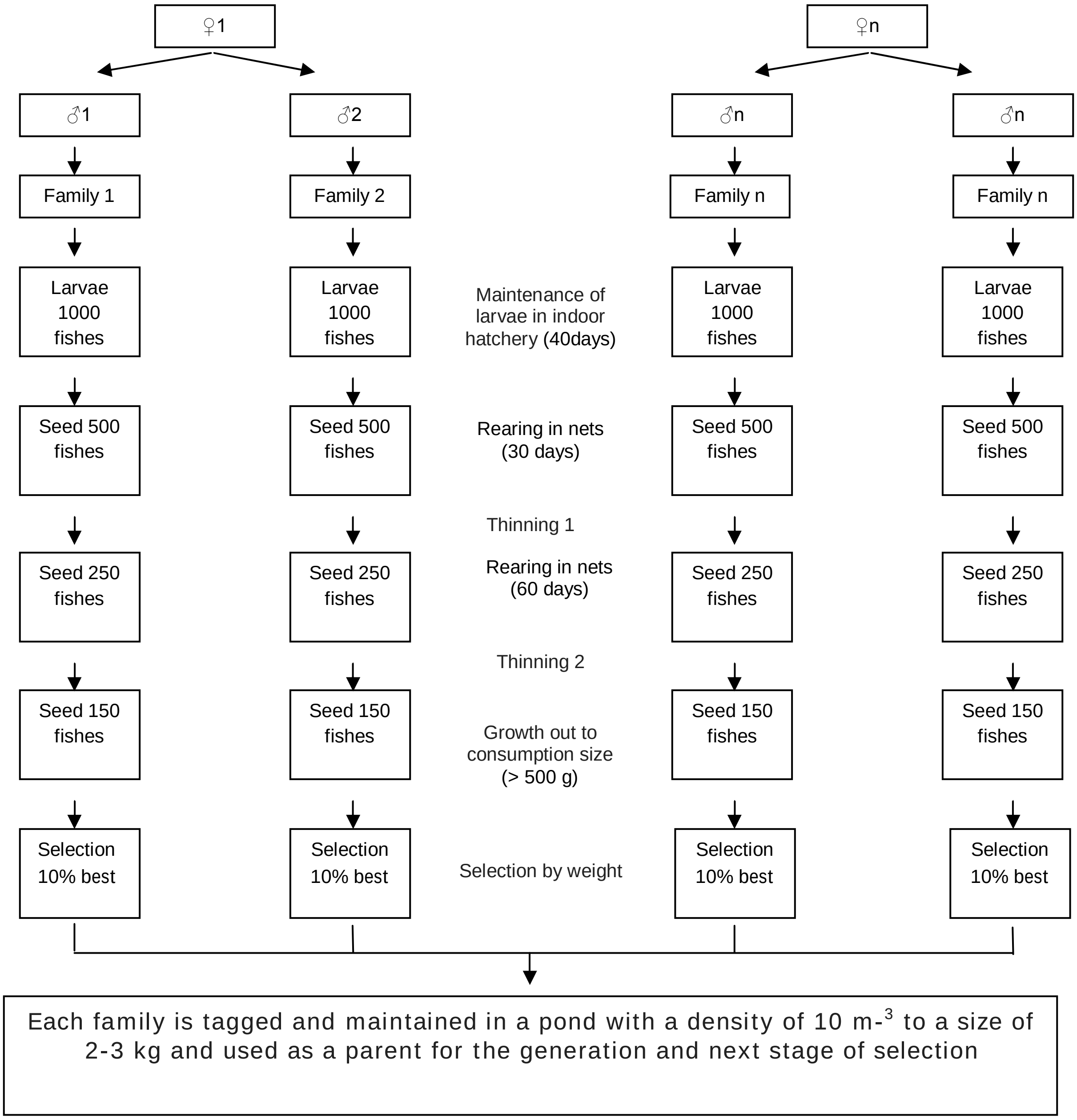

Figure 1. Procedure of selection response test and second generation siamese catfish population formation.

Results and Discussion. The results of observation on weight parameters in the second generation population resulted in average values of coefficient of variation (CV), selection response (R), genetic gain (ΔG), differential selection (S) and real heritability (h2) of; 26.78%, 18.54%, 125.97 g, 241.19 g and 0.48 respectively. The value of CV shows the diversity value of the measured population, where a high CV value indicates that the measured population has a wide or more heterogeneous diversity, where as the low value of CV means that the measured population has a narrow or more homogeneous diversity (Ninh et al 2011; Suwoyo et al 2014). In this research, CV value in second generation population on the weight parameter is 26.78% (Table 1).

Table 1

The performance of the second generation population (G2) and control population at the end of the growth out stage

Parameter	*Second generation of breeding population (G2)*	*Control population*	*Second generation of selected population (G2)*
Final weight (g)	805.33±215.67	679.36±176.52	1046.52±127.92
Variation coefficient (%)	26.78	25.98	-
Survival rate (%)	90.2	91.7	-
Feed conversion ratio (FCR)	1.2	1.23	-
Selection response (%)(g)	18.54% (125.97 g)		-
Real heritability	0.48		-
Differential selection (g)		241.19	

Tampake et al (1992) stated that to determine the diversity of a character the following criteria are used: low if CV (0-20%), medium (20-50%) and high (> 50%). The value of the CV shows the value of the phenotypic diversity of the measured population, where the higher the CV the greater the diversity possessed or more heterogeneous. So that selection will be more effective in populations that have high diversity values. In this study, the CV values on the weight character appear to be wider (Table 1) than in the length characters (Table 2). With higher CV values on character weights, this character is used for selection parameters to provide an opportunity for successful selection program. According to Tave (1993), CV provides a picture of the diversity of phenotypes that will support the success of a selection program. The higher the value of the CV in a population then the more it shows the diversity of individual sizes in the population and makes the population for the candidates to be selected or as the population for the next selection.

Table 2

Final length, coefficient of variation, selection response, selection differential and heritability of second generation of Siamese catfish population

Parameters	*Second generation of breeding population (G2)*	*Control population*	*Second generation of selected population (G2)*
Final length (cm)	35.55±2.70	34.01±2.44	38.63±1.83
Variation coefficient (%)	7.59	7.17	-
Selection response (%) (cm)	4.53 (1.54)		-
Real heritability	0.56		-
Selection differential (cm)		3.08	

The value of the CV is more influenced by generation and environment (Ninh et al 2011). Phenotypic diversity is directly proportional to genetic diversity. According to Dunham (2004), the genetic variety is important for long-term sustainability of a species or population to enable its ability to adapt to change. Further stated, if the range of phenotype is very narrow, it will find obstacles in the selection process. Selection can increase the genetic quality quantitatively with the ultimate goal of obtaining superior breeds as elders (Warwick et al 1995; Gjedrem et al 2012).

The result of data evaluation showed that the selection response in second generation population (G2) on the fish weight character has a relatively high value, namely 17.95% with genetic progress value (ΔG) of 124.96 g (Table 1). These results show the progress of genetic improvement that is good enough for one generation and better than some species such as Atlantic salmon, coho salmon, channel catfish (*Ictalurus punctatus*), *Labeo rohita* and *Hypoplectrus indigo*, selective breeding programs using individual and family selection can increase growth 11-14% per generation (Dunham et al 2001). A similar study was reported by Gustiano et al (2013) that selection performed on Nile tilapia showed a selection response in the third generation of 15.73% for males and 10.62% for females and realized heritability value was 0.39 for male and 0.29 for female. Then the selection at the phase of the indigenous F-3 of blue tilapia (*Oreochromis aureus*) seed obtanied the selection response of 22.74% and the heritability of 0.81 (Gunadi et al 2015). Similarly, Iswanto et al (2015) found that the individual selection program in catfish (*Clarias gariepinus*) up to third generation has resulted in genetic quality improvement with a cumulative selection response of 52.64%. The use of superior catfish seeds Mutiara strain (*Clarias gariepinus*) from the selection program was able to produce higher weight gain, survival, and harvest biomass ($p < 0.1$), and was more efficient in using feed compared to the local strains indicated by lower FCR value. The faster growth of the Mutiara strain was also supported by the higher level of RNA/DNA ratio compared to the local strains (Dewi & Tahapari 2017).

According to Gjedrem (2000) estimates of genetic progress or selection responses for each generation for aquatic organisms range from 10 to 20%. The success of selection can be measured from the value of genetic progress (genetic gain) of the resulting selection response. The genetic progress or selection response expected per year due to selection is highly dependent on the intensity of selection, genetic diversity, phenotypic diversity and generational intervals (Hardjosubroto 1994; Warwick et al 1995). The optimal combination of these factors should be sought to achieve optimal genetic progress (Hardjosubroto 1994; Warwick et al 1995). Then Winarlin & Gustiano (2007) reported that the selected tilapia had 200% more growth than the fish used by the community. Similarly, Taufik et al (2008) reported that the selected fish had better resistance to *Streptococcus* at 140% compared to fish used by the community. The information obtained in the above test provides an explanation that the selected fish have advantages compared to the fish used by the farmer community. Asih et al (2011) reported that selection activities in carp (*Cyprinus carpio*) for two generations (F2) showed a heritability value of 0.29 and a selection response of 43.36%. Then in the next generation (F3) the genetic gain was about 14.20 g or 51% (Radona et al 2016). The high phenotype variation is positively correlated with genetic variation (Tave 1999; Noor 2000), genotype variation may provide an increased chance of growth in organisms.

Our result explains that selection can improve the genetic gain (better genetic gain) and the increase depends on the proportion of genetic variation on the heritability of the phenotypic variety (Table 1). The exact proportion of heritability can be determined through continuous selection of generations (Falconer & Mackay 1981; Kapuscinski & Jacobson 1987; Warwick et al 1995). However the results of research reported by Marnis et al (2018) that genetic diversity in second and first generation Siamese catfish shows that the average of observed heterozygosity of the G-1 population (0.420) was lower than the G-2 population (0.495). Inbreeding level showed that the G-1 population was more inbred than the G-2 population. The study also found that both striped catfish populations had relatively low genetic variation. Selection response values are influenced by several factors, including the heritability of selected characters and differential selection (Falconer & Mackay 1981). Selection response value obtained in this study amounted to 18.54% with a real heritability value of 0.48. This result is a very significant improvement in catfish aquaculture system. The heritability value indicates a positive response value from the selection program (Gjedrem 2005; Nielsen et al 2010). According to Tave (1999), heritability is classified into three, namely low (< 0.2); moderate (0.2-0.4); and high (> 0.4). In this study a relatively high heritability value is expected and positively correlated to the selection response to be obtained in the next generation (Vandeputte et al 2008; Ninh et al 2013).

Growth is one of the targeted characters in the selective breeding program. The purpose of selective breeding based on the character of growth is to increase production. The distribution pattern or the distribution of individual weights in the population of selection and control population is presented in Figure 2. The pattern of distribution of the weight of the second-generation population shows higher growth than the control population. The distribution of fish population data is on the right of the control population data distribution, indicating that the selection process can improve the genetic quality of the fish. The results of this study are similar to those of M'balaka et al (2012) on tilapia (*Oreochromis shiranus*) indicating that the growth of tilapia is higher than non tilapia. Faster growth in fish can be obtained by selection, individual selection or family selection (Gustiano & Pouyaud 2008; Yuniarti et al 2009). According to Lind et al (2012), improving genetic quality in animals or plants can increase productivity.

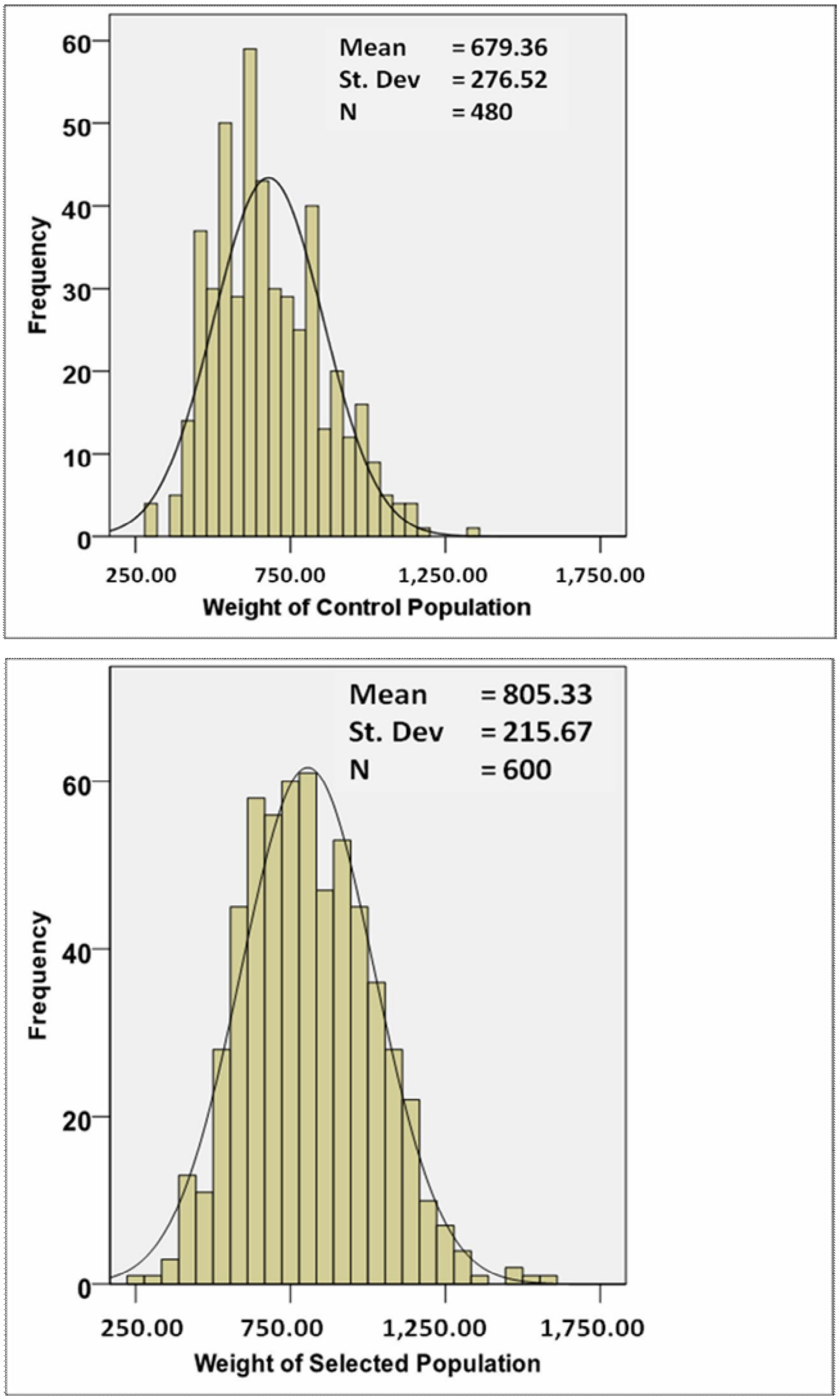

Figure 2. The distribution of the size of the second generation population weight (G2) of Siamese fish selection and control at the end of the growth out stage.

In the selection activity the selection response was obtined. It was the difference in weights between the selected and the average populations. According to Hardjosubroto (1994), the differential selection (selection differential) is the difference between the average performance of the selected population and the average population performance before selection. The value of differential selection is one of the important factors in determining the success of the selection activity. The higher the value of differential selection will result in a higher selection response value with the assumption that the heritability value is fixed. The average of the selected differential values obtained by the selected Siamese catfish G2 was 242.19 g (Table 1), which means that the mean of the selection population weight increased by 29.95%. This may provide an opportunity to increase the weight of the average Siamese catfish in the next generation in response to the selection performed.

The results of observation on the average length of fish population in second generation of selection (G2) resulted in average value of CV of 7.59%, this value slightly higher than the CV in control population of 7.17% (Table 2), but the value of this CV is small (< 20%), so it has a narrow or homogeneous diversity. Likewise, the response value of selection of length characters has a relatively small average value of 4.53%. The average CV value based on the length character indicates a smaller value than the weight of the fish. So in this study the character of body weight is used as a selection parameter for genetic improvement. Character of body weight more describes the value of biomass productivity in fish consumption size. Previous research on long-term relationship on catfish was reported by Darmawan et al (2015) that the long-term relationship of Siamese catfish showed a positive allometric growth pattern (b>3) which means that Siamese catfish growth length increase is not as fast as weight gain. So in this study the character of the fish weight was used as a selected parameter. Selection based on the fish weight character has been shown to be effective in some fish species such as in Nile tilapia (*Oreochromis niloticus*) (Nguyen et al 2010).

Conclusions. The second generation Siamese catfish population had better growth performance compared to the control population. In term of weight trait, the heritability value was 0.48, differential selection value was 241.19 g and response to selection value was 18.54%. The second generation of Siamese catfish are expected to increase fisheries productivity in aquaculture and farmers welfare. The selection program can still be continued to get a superior generation.

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