Selection response and heritability in growth trait of first generation (G1) of djambal catfish population (*Pangasius djambal*)

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Abstract. Djambal catfish (*Pangasius djambal*) is a freshwater fish species native to Indonesia. It can be found especially in Sumatera and Kalimantan rivers. An effort to increase productivity of djambal catfish in aquaculture can be done through the use of superior broodstock that can be obtained from a breeding program. This study implemented a breeding program to obtain the population of first generation (G1) with faster growth compared to previous generation. The selection method was within family selection. Breeding candidates were created by half-sib mating of broodstocks with male to female ratio of 2:1 Ten families resulting from the spawning were reared in indoor area until they reached juvenile size. The juvenile were then grown in net cage sizing of 3 × 5 × 1.5 m suspended in an earthen pond at the density of 10 fish m^{-2} for five months. Fish selection was done on the basis of body weight. The observed parameters were growth rate, coefficient of variance, differential selection, selection response, and heritability. This study showed that G1 population of djambal catfish has faster growth rate than the G0 population. The average absolute weight of G1 population was 701.85±118.92 g; control population was 564.70±74.52 g; and selected population was 889.56±61.97 g. The value of coefficient of variation, selection response, differential selection, and heritability were 16.94%, 137.15 g (24.29%), 187.71 g (26.74%) and 0.33, respectively. The implementation of within family selection method in catfish has proved effective to obtain next generation with faster growth than previous generation.
Key Words: djambal catfish, within family selection, selection response, heritability.

Introduction. Djambal catfish (*Pangasius djambal*) is a native catfish species to Indonesia. In 1998, this fish was successfully bred by induced breeding method (Legendre et al 2008). Djambal catfish flesh is white in colour, has creamy texture and savory taste that are favored by consumers. To date, Vietnam has dominated the supply of white fleshed catfish to several catfish consuming countries such as United States of America (USA), Japan, and some countries in Europe. However, there are still some export opportunities for djambal catfish due to larger demand, so that the opportunity should be fulfilled by the increase of fish productivity. The increase of this fish productivity can be done by using superior broodstock. The improvement of genetic quality to obtain a superior broodstock can be done through breeding program which included three strategies, i.e. selection, hybridization, and chromosome manipulation (Farias et al 2017).

The utilization of superior broodstock, that is resulted from a selection program has shown to increase productivity and profit in some fish farming such as tilapia (*Oreochromis niloticus*) (Nugroho et al 2013), catfish (*Pangasianodon hypophthalmus*) (Tahapari et al 2018), catfish (*Clarias gariepinus*) (Dewi et al 2016), silver barb (*Barbodes gonionotus*) (Khan & Huda 2012), crab (*Portunus pelagicus*) (Fujaya et al 2016), tiger prawn (*Macrobrachium rosenbergii*) (Khasani et al 2018), and common carp (*Cyprinus carpio*) (Vandeputte 2003).

Before starting of a selection program, the aim of the program should be clearly determined. In most of fish species, the important characters are growth rate, feed conversion efficiency, fish resistance against disease, flesh quality, and age as it reaches gonad maturity (Gjedrem 1983). Selection technique is a technique to improve quantitative characters (Ponzoni et al 2005). The fundamental principle from this technique is exploitation of additive characteristic alleles in all loci that control quantitative characters to improve the population (Gjedrem 2005). This selection program is based on the principle that most of variation performance is caused by genotype factor and can be derived from parent to offspring (Lutz 2006). The selection program based on family selection was started in 1975. In 2010, it was reported that only 8.2% of aquaculture product was produced from genetic improvement (Gjedrem & Robinson 2014; Farias et al 2017).

This study was conducted to evaluate genetic improvement of djambal catfish on growth performance under within-family selection program (Figure 1). The selection criterium was the deviation of growth value of each individual from its family average. The implementation of within-family selection method is beneficial when the variance of environment component has considerable effect on individuals in the same family (Ponzoni et al 2005). The aim of this study was to obtain first generation (G1) of djambal catfish population with faster growth compared to the previous generation. The coefficient of variation value, differential selection, selection response, and heritability were used to determine genetic improvement between selected and control populations.

Material and Method

Breeding design and family production. This research was conducted from January to December 2018 at the Research Institute for Fish Breeding, Sukamandi (West Java, Indonesia). The initial broodstock population came from Indragiri River (Riau Province, Indonesia). Fish were reared in a 200 m^2 concrete pond with soil at the bottom. The total initial population consisted of 35 male and 20 female, with average weight of 3.0-4.0 kg. This initial population was used as a founder population or a base population. In this study, the base population (G0) broodstock were about 2.5 years old with 2.5 to 3.5 kg of body weight, five females and ten males have been selected to produce 10 families of G1 populations.

The sexually mature gonad female were characterized by their egg diameter, i.e. ≥ 1.2 mm, meanwhile the sexually mature gonad male were characterized by cement secretion containing sperm when their abdomen was massaged to urogenital. The mature female was injected with human chorionic gonadotropin (HCG) and ovaprim which served to synchronize the maturity of the egg and stimulated ovulation. The dosage of HCG hormone applied for injection was 500 IU kg^{-1} fish and the dosage of ovaprim hormone was 0.6 mL kg^{-1}. The ovaprim dosage for male fish was 0.2 mL kg^{-1}. The artificial fertilization was started with mixing the eggs and sperm in plastic bowl. Egg fertilization used paternal half-sib, where one female fish was fertilized with two male fish. The fertilized eggs were then incubated in hatching funnel. The hatching and rearing of fish larvae were done separately for each family. In rearing phase, seven families out of 10 families were used because other three families experienced mortality.

Within-family selection was performed on growth character by using body weight parameter. The selection was performed when the fish reached consumption size (more than 700 g). The rearing process and fish selection were shown in Figure 1. Fish with average weight of population were used as control population, meanwhile the selected population were used as next generation.

Fish were reared in a floating net sized of 3×5×1.5 m that was installed in 6000 m^2 of earthen pond. Fish density was 150 fish/net. During rearing period fish were fed with commercial pellet containing 32% of crude protein with feeding rate of 3-5% biomass and given two times per day.

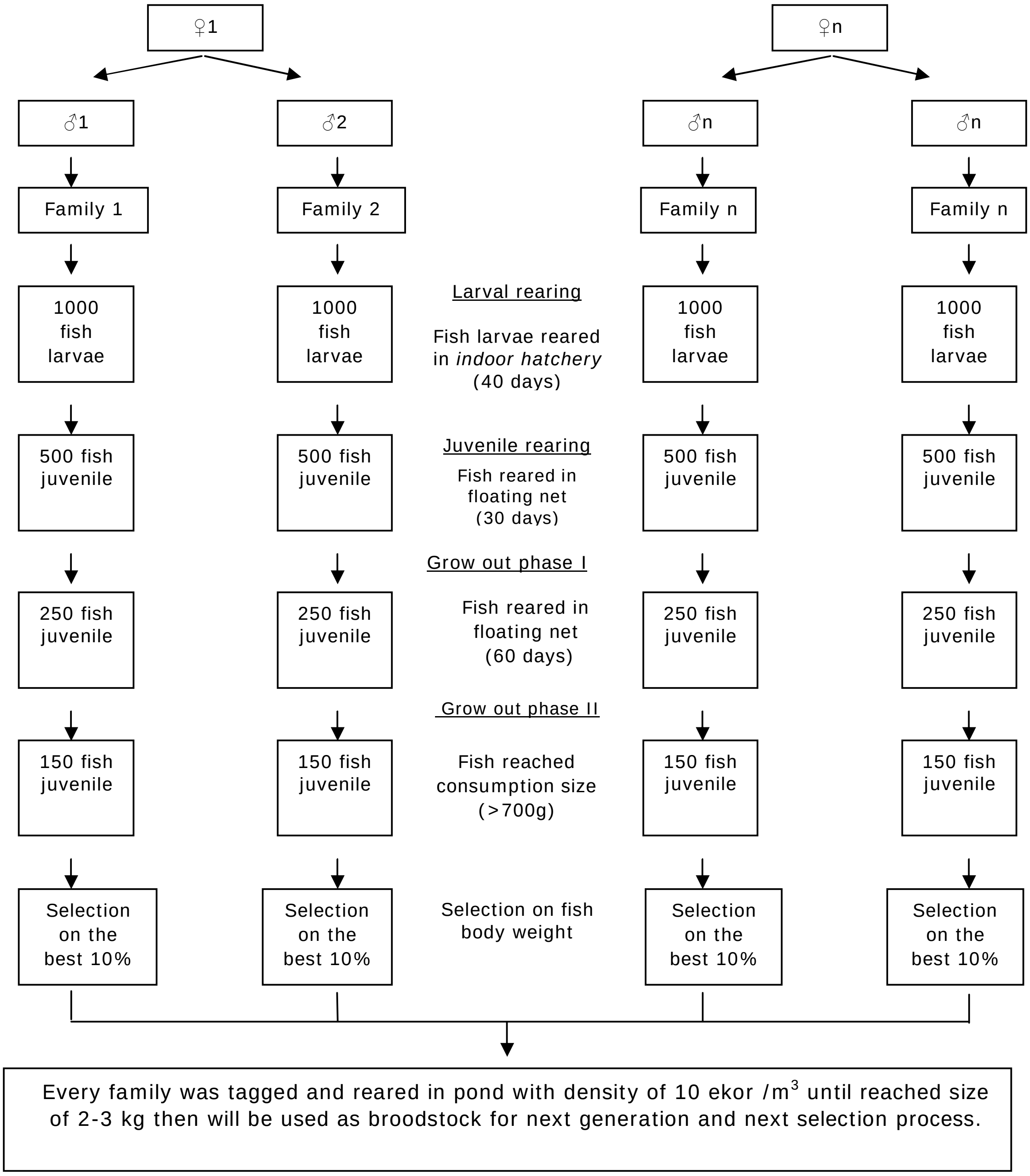

Figure 1. The selection procedure of within-family selection of djambal catfish.

Parameters. The observed parameters included growth rate (weight and length), coefficient of variation (CV), differential selection, and heritability. The observation on growth rate was performed on the initial and end of this study by measuring fish weight and length for each family. The parameter of selection response, coefficient of variation, and heritability were calculated following the formula of Gjedrem & Baransky (2009).

Coefficient of variation (CV) performed by the following formula:

$$CV(\%) = (SD / X)*100$$

where: SD = standard deviation;

X = the average of population.

Differential selection value (S) was performed according to average weight of initial population and average weight of selected population. Differential selection value was calculated by following formula:

$$dS = Xs – X$$

where: dS = differential selection;

Xs = average weight of selected population (g);

X = average weight of initial population/control (g).

Selection response (R) was the average improvement of weight of next generation from previous population as the effect of selection or it measured according to average mean value of offspring with average population of control. Selection response was performed by this following formula:

$$R= P_{selected\ population} - P_{control\ population}$$

And, the percentage of selection response was performed by following formula:

$$R(\%) = (R / WT)*100$$

where: R (%) = percentage of selection response;

R = selection response;

WT = average population of control.

Heritability value (h^2) was measured by proportion of improved selected parameter from two populations and it has been shown by differential selection. Tave (1993) and Falconer (1981) stated that h^2 as quantitative character in fish consisted of three levels, i.e low (0-0.1), moderate (0.1-0.3) and high (0.3-1.0). Heritability value was measured by the following formula:

$$h^2 = R / dS$$

where: h^2 = heritability;

R = average mean of the offspring and the broodstock;

dS = differential selection, phenotype average of selected population with initial selection.

Results and Discussion. The CV showed how far a value of fish length and weight in one family spreads out from their average value. In initial population of djambal catfish (G0), the CV value for total length, standard length, and weight were 79.91%, 93.22%, and 28.10%, respectively (Table 1). In G1 population, the coefficient of variation for standard length character and weight were 7.54% and 16.94% (Table 2). The broodstock which came from G0 population was used as control, meanwhile the broodstock from selected average was used to obtain heritability and selection response (Table 1).

Table 1

The average, of length, weight, coefficient of variation, and diferential selection of G0 population of djambal catfish

Parameters	*Selected population G0*			*Initial population G0*		
	Standard length (cm)	*Total length (cm)*	*Weight (g)*	*Standard length (cm)*	*Total length (cm)*	*Weight (g)*
Average	36.08	42.76	871.42	34.15	39.73	502.16
Stdv	1.64	1.55	125.67	31.84	31.75	141.11
Coefficient of variation (%)	4.56	3.62	14.42	93.22	79.91	28.10
Differential selection (ds)	1.92	3.03	369.26			
Differential selection (ds) (%)	5.63	7.62	73.53			

Table 2
The average, and coefficient of variation of length and weight of control, initial, and selected population of first generation (G1) of djambal catfish

Parameters	*Control population*		*Initial population*		*Selected population*	
	Standard length (cm)	*Weight (g)*	*Standard length(cm)*	*Weight (g)*	*Standard length (cm)*	*Weight (g)*
Average	32.50	564.70	33.56	701.85	37.06	889.56
Stdv	2.,13	74.52	2.53	118.92	1.58	61.97
Coefficient of variance (%)	7.28	19.53	7.54	16.94	4.25	6.97

According to differential selection of djambal catfish in G0 population and G1 population, fish weight was higher than fish total length and standard length (Table 1 and 3). High value of differential selection in population led to higher value of selection response. The selection response on weight was 24.29%, whereas on the standard length was 3.25% and total length was 4.32% (Table 3).

The heritability value was used to obtain how genetic impacts the variance level of a certain character. In djambal catfish, the heritability of total length, standard length, and weight were 0.58; 0.57 and 0.33, respectively (Table 3). The distribution of weight of djambal catfish resulting from selection process was shown in Figure 2.

Table 3
The differential selection value, selection response, and heritability of first generation population (G1) of Djambal catfish

Parameters	*Standard length (cm)*	*Total length (cm)*	*Weight (g)*
Differential selection (ds)	3.50	1.78	187.71
Differential selection (%)	10.43	3.99	26.74
Selection response (RS)	1.06	1.85	137.15
Selection response (%)	3.25	4.32	24.29
Heritability (h^2)	0.58	0.57	0.33

A phenotype is a quantitative character which is expressed by fish, as example the length and weight. The phenotype depends on the interaction of gene and optimal environment interaction. In this study, the CV of weight in G0 generation was 28.10%, whereas in G1 population was 16.94%. Gjedrem (2005) stated that the value of CV in fish was about 17-29%. Tave (1993) stated that a population with 25% of CV would have higher successful opportunity in selection program compared to the lower CV value by the same range. The higher the CV value in a population might show larger variance of size in a population. High value of CV in G0 population provides higher opportunity for successful selection process to obtain fastest growing population. In selection program of djambal catfish, the selected fish from G0 population was sorted by the fish weight, therefore the superior individual is selected. This superior individual will be a broodstock for next generation. This selection has proven effective in resulting G1 population with faster growing (Figure 2).

The value of selection response of djambal catfish on fish weight reached 24.29%, or higher than tilapia (*O. niloticus*) that was about 10-17% (Gustiano et al 2013; Nugroho et al 2017). The selection response on commonly cultured fish range from 5-15%. The heritability value affects the genetic gain obtained from selection program. The selection program has proven to be effective to obtain broodstock with faster growth i.e common carp (Dong et al 2015), Atlantic salmon (*Salmo salar*) (Gjedrem 2016; Thodesen et al 1999), tilapia (*O. niloticus*) (Gustiano et al 2013; Nugroho et al 2017). In this study, the heritability value of djambal catfish in its weight character was 0.33. Heritability values of more than 0.3 indicate that selection in djambal catfish is effective, so genetic factors are more dominant in the appearance of fish phenotypes. If the heritability value was lower in selected character, the selection was relatively less effective due to the phenotype performance is affected by environmental factors rather than the genetic factor. The environmental factors that affected the phenotype were location, fish feed, management, and fish disease.

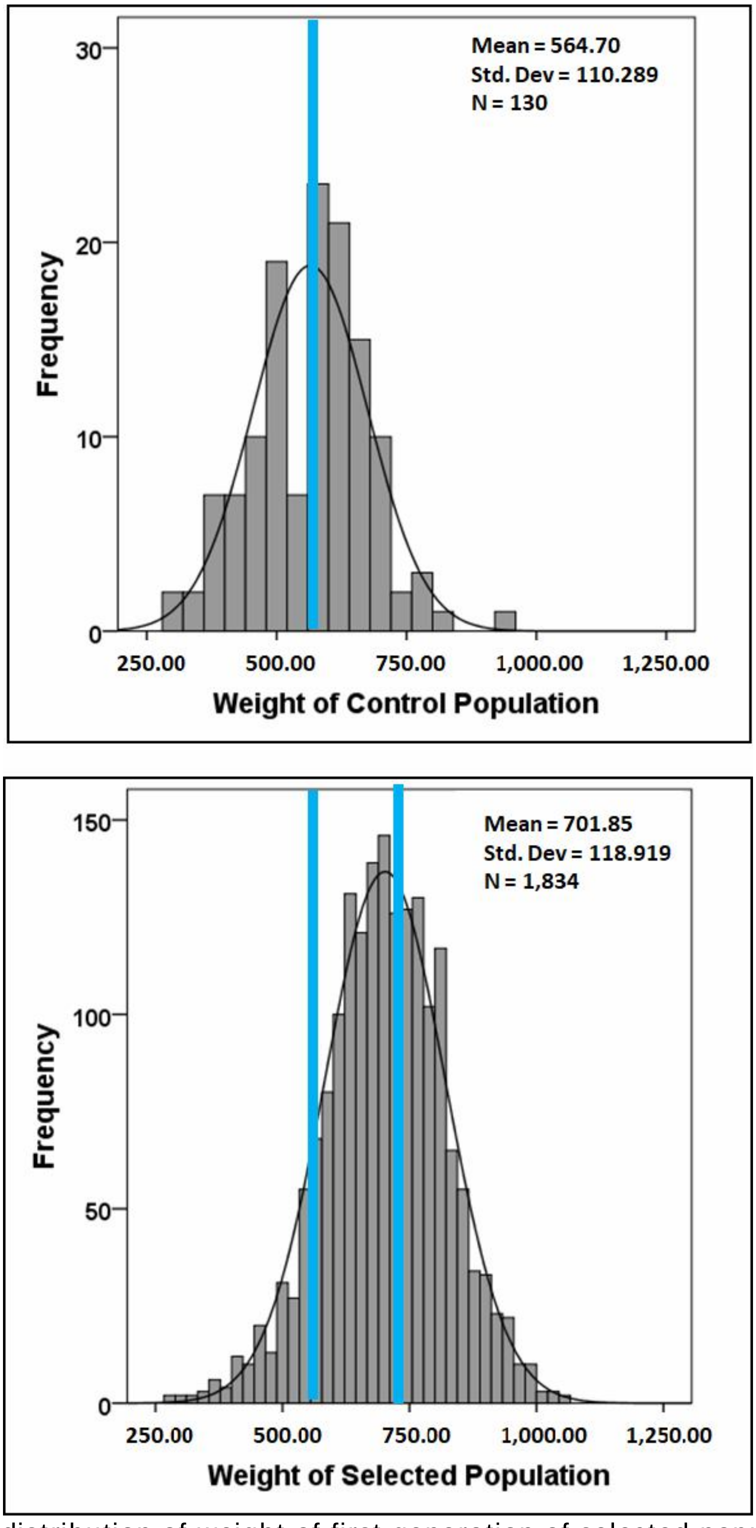

Figure 2. The distribution of weight of first generation of selected population (G1) of djambal catfish at the end of fish rearing.

The use of within-family selection method in djambal catfish to get a generation that grows faster than the previous generation was proven to be effective. The use of this method has previously been recommended for countries in Southeast Asia (Uraiwan & Doyle 1986).

The use of within-family selection methods can also increase the growth rate of tilapia (*O. niloticus*) as practiced by the Freshwater Aquaculture Center (FAC) of Central Luzon State University, Philippines.

Conclusions. The family selection of djambal catfish to obtain faster growth of next generation has proven effective. The heritability value of weight character and length was more than 0.3. It showed that genetic factor was more dominant than environmental factor affecting growth of first generation of djambal catfish. The increase of growth due to the selection program reached 24.29%.

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