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RESPONSE TO SELECTION FOR BODY WEIGHT IN THE THIRD GENERATION OF MASS SELECTION OF THE AFRICAN CATFISH (*Clarias gariepinus*) AT RESEARCH INSTITUTE FOR FISH BREEDING SUKAMANDI

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ABSTRACT

Genetic improvement of the African catfish (*Clarias gariepinus*) in Indonesia for increasing growth performance has been conducted by Research Institute for Fish Breeding at Sukamandi through mass selection. Collection and characterizations of the founder populations, building the synthetic base population, first generation and second generation through mass selection were conducted during 2010-2013. Later, in 2014 it was followed by building the third generation. The present study aimed to find out the genetic gain in the third generation in term of response to selection for body weight. Fifty pairs of the selected (fast growing) individuals from the second generation were mated to produce the third generation. As a comparison, five pairs of average-sized individuals were mated to produce the control population, as a second generation representative. Larval rearing, nursery and grow-out phases were respectively held for 25 days in the aquaria, 30 days in the concrete tanks and 60 days in the concrete ponds. At the end of each phase, individual samplings of body weight were undertaken. The results showed that mean body weight of the third generation was higher than that of control population at the end of larval rearing phase (0.21 ± 0.26 g versus 0.20 ± 0.15 g), nursery phase (6.12 ± 2.93 g versus 5.80 ± 3.50 g) and grow-out phase (198.67 ± 82.82 g versus 165.22 ± 71.09 g). Those results revealed that response to selection for body weight of the third generation was positive, i.e. about 20.24% (33.45 g).

KEYWORDS: African catfish (*Clarias gariepinus*); body weight; mass selection; response to selection; third generation

INTRODUCTION

Introduced African catfish (*Clarias gariepinus* Burchell 1822) recently becomes a great economically important species in Indonesian aquaculture. It has been cultured vastly throughout Indonesia, mainly in Java, Sumatra, and Kalimantan. African catfish has been several times introduced into Indonesia for aquaculture, either directly from Africa or via other countries. All of those introduced strains exhibited superior growth performance at the beginning of their introductions. Unfortunately, their growth performances were then decreasing. Therefore, genetic improvement program for increasing the growth performance of the African catfish in Indonesia should be carried out in order to increase its productivity in aquaculture industry.

Genetic improvement program in establishing a new fast growing strain of the African catfish has been conducted by Research Institute for Fish Breeding at Sukamandi since 2010. The genetic improvement program was conducted using mass selection for the growth rate, in term of body weight. Collections and characterizations of the founder populations were conducted in 2010 (Imron *et al.*, 2010; 2011), for which four strains have been collected, namely Paiton, Sangkuriang, Dumbo, and the Egyptian strains. Then, in 2011 it was followed by building the synthetic (composite) base population through diallele crossing of four strains of the founder populations (Iswanto *et al.*, 2012). In 2012, the first generation was established with response to selection of 20.59% for body weight (Iswanto *et al.*, 2014a). Later, building the second generation was conducted in 2013 resulted in response to selection of 11.80% for body weight (Iswanto *et al.*, 2014b). Finally, in 2014 it was followed by building the third generation to test the growth performance compared to the second generation. The present study aimed to

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find out the genetic gain resulted in the third generation in term of response to selection (selection response) for body weight.

MATERIALS AND METHOD

The test of response to selection for body weight in the third generation of African catfish compared to the control population was held in May to September 2014 at Research Institute for Fish Breeding (RIFB) Sukamandi. Fifty pairs of the selected (fast growing, in term of body weight) individuals (breeders) of the second generation were mated to produce the third generation. As a comparison, five pairs of average-sized individuals were mated to produce the control population, as a second generation representative. These mating processes were done artificially using ovaprim (Syndel Laboratories Ltd., Canada) to induce final maturation (ovulation and spermiation). The eggs were obtained through stripping, while the sperm were collected through partial gonadectomy techniques. Approximately 100 g eggs obtained from each female breeder were fertilized by pooled sperm from all male breeders, then were incubated in separated 1 m x 1 m tray made from happa placed within indoor concrete tanks with circulated water.

A thousand of two days old larvae obtained from each fertilization process were reared for 25 days within 55 indoor aquaria (60 cm x 40 cm x 20 cm), *i.e.* 50 aquaria for the third generation and five aquaria for control population. Brine shrimp (*Artemia* sp.) nauplii was given as first feed during two days of rearing period, then, in the third day it was partially replaced with chopped silkworms (*Tubifex* sp.). Within following until fifteenth days of larval rearing period, life silkworms was used as natural feed, which was gradually replaced with commercial fish larval feed contained 40% crude protein (HI-PRO-VITE PS-P, PT Central Proteinaprima, Mojokerto). This commercial fish larval feed was given until 25th day, partially combined with commercial shrimp larval feed contained 40% crude protein (BINTANG 581, PT Central Proteinaprima). Those feed were given *ad libitum* (until apparent satiation) five times daily (at 06:00, 10:00, 14:00, 18:00, and 22:00). At the end of rearing period, individual samplings of body weight of 2% (from initial stock) juveniles from each aquarium were undertaken. Then, juveniles from all aquaria for each third generation and control population were pooled and were graded into < 2 cm, 2-3 cm, 3-4 cm, and > 4 cm size class groups.

Juveniles of each size class group were then stocked into five outdoor concrete tanks (3 m x 5 m x 0.5 m) filled with irrigation water for 30 days (one

month) of nursery phase with stocking density of 580 fishes/m² (equal to 8,700 juveniles/tank). Separation of each size class group juveniles stocked within a same tank (either for the third generation or control populations) was facilitated by net screen. Small crumble sized (BINTANG 581) and crude crumble sized (BINTANG 582) commercial shrimp larval feed with 40% crude protein content were respectively given for small (< 2 cm and 2-3 cm size class groups) and larger (3-4 cm and > 4 cm size class groups) juveniles. These feeds were given *ad libitum* four times daily (at 08:00, 12:00, 16:00, and 21:00) during first ten days or nursery period. Those feed were then gradually replaced with commercial small sized (0.5-1.2 mm of diameter) floating fish feed contained 40% crude protein (PRIMAFEED PF 800 and PF 1000, PT Matahari Sakti, Surabaya) given *ad libitum* thrice daily (at 08:00, 12:00 and 16:00) during 10th-30th days of rearing period. At 15th day, all of juveniles from each the third generation and control populations were pooled and regrouped via grading into < 3 cm, 3-4 cm, 4-5 cm, 5-6 cm, and > 6 cm size class groups. These groups were then restocked into their concrete tanks (separation of each size class group juveniles stocked within a same tank was facilitated by net screen). At the end of nursery phase, individual body weight samplings of 2% population (from initial stock of each the third generation and control populations) were undertaken. Then, the juveniles from all tanks of each the third generation and control populations were pooled and graded into < 3 cm, 3-5 cm, 5-7 cm, 7-9 cm, 9-11 cm, and > 11 cm size class groups.

Juveniles of each size class group were then stocked into nine outdoor concrete ponds (2 m x 10 m x 0.8 m) filled with irrigation water for grow-out phase of 60 days (two months), using stocking density of 200 fishes/m² (equal to 4,000 juveniles/pond). Separation of each size class group juveniles stocked within a same pond (either for the third generation or control populations) was facilitated by net screen. Small sized floating fish feed of 30% crude protein content with \pm 2 mm (HI-PRO-VITE 781-1, PT Centralpangan Pertiwi, Karawang) and \pm 3 mm (HI-PRO-VITE 781-2) of diameter were respectively given for small (< 3 cm, 3-5 cm and 5-7 cm size class groups) and larger (7-9 cm, 9-11 cm, and > 9cm size class groups) juveniles. Those feeds were given *ad libitum* thrice daily (at 08:00, 12:00, and 16:00) during first ten days of grow-out period. Then, within subsequent ten days of grow-out period, the small size class groups of juveniles were fed with \pm 3 mm floating fish feed (HI-PRO-VITE 781-2) and the larger ones with \pm 4 mm floating fish feed (HI-PRO-VITE 781). Those feeds were given *ad libitum* twice daily (at 08:00 and

16:00). Within following days of grow-out period, all of the juveniles were fed with \pm 4 mm floating fish feed (HI-PRO-VITE 781), given *ad libitum* twice daily (at 08:00 and 16:00). During sixty days of grow-out period, individual body weight samplings of 2% population (from initial stock of each the third generation and control populations) were conducted every twenty days.

At the end of grow-out period, individual body weight samplings of 20% population (from initial stock) from each the third generation and control populations were undertaken. Thus, realized heritability and response to selection (Gjedrem & Baranski, 2009) of the third generation could be determined. Response to selection (R) of the third generation was determined as $R = (\text{mean body weight of the third generation} - \text{mean body weight of control population})$. While, realized heritability (h^2) was determined as $h^2 = (\text{response to selection of the third generation} : \text{selection differential of the second generation})$, with the selection differential of the (previous) second generation was about 179.35% (Iswanto *et al.*, 2014b).

During larval rearing, nursery and grow-out phases of the third and control population of the African catfish held at RIFB Sukamandi, water quality parameters, including water temperature, pH, dissolved oxygen, ammonia and nitrite were recorded at the beginning of the each rearing phase followed by subsequent twice a week recordings. Recordings of water temperature, pH and dissolved oxygen using digital wa-

ter quality checker (TOA DKK WQC-22A, DKK TOA Corporation, Japan) and the concentration of ammonia and nitrite using spectrophotometer (Hitachi UV/Vis Spectrophotometer U-1500, Hitachi Instruments Inc., USA) were carried out twice daily, in the early morning (at 06:00) and the afternoon (at 14:00).

RESULTS AND DISCUSSION

Growth performances of the third generation and control population of the African catfish (*C. gariepinus*) based on individual samplings of body weight at the end of 25 days of larval rearing phase, 30 days of nursery phase and every 20 days during 60 days of grow-out phase were presented in Figure 1. Those results showed that the third generation attained table-size for commonly Indonesian consumers (about 100-150 g) at 95 days old or 40 days of grow-out period, while the control population attained it at less than two months of grow-out period. Compared to grow-out phase commonly practiced by African catfish farmers in Indonesia, which were commonly carried out for 2-3 months, those growth performances were comparable.

At the end of larval rearing phase, nursery phase and grow-out phase, mean body weight of the third generation was higher than that of control population (Figure 1). Those results suggested that genetic improvement program in term of increasing the growth performance of the African catfish conducted at the RIFB Sukamandi during three generations of

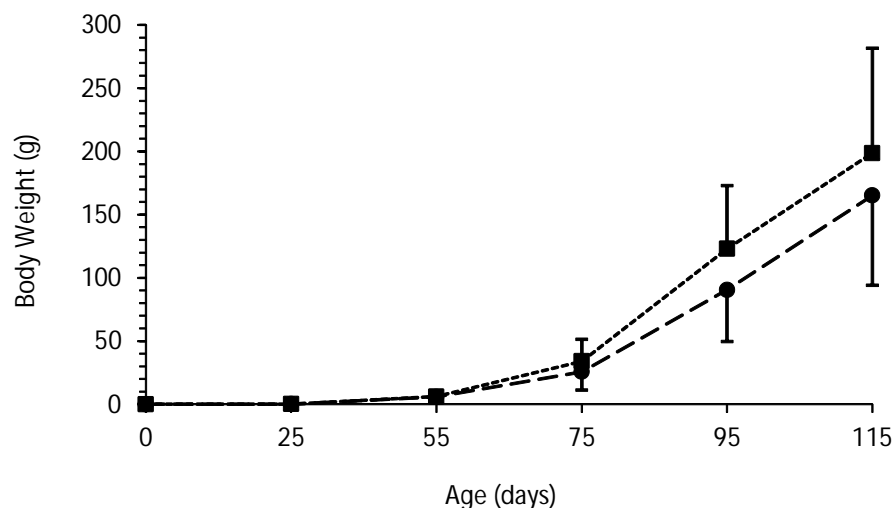


Figure 1. Growth performances based on body weight during 25 days of larval rearing phase, 30 days of nursery phase and 60 days of grow-out phase (based on samplings of 2% populations) of the third generation (■) and control population (●) of the African catfish (*Clarias gariepinus*) genetic improvement program held at Research Institute for Fish Breeding, Sukamandi. Vertical lines represent its each standard deviation

mass selection has gained positive results. Response to selection and final mean body weight of the third generation compared to the control population at the end of larval rearing, nursery, and grow-out phases were presented in Table 1.

Based on those growth performances, final response to selection for body weight in the third generation of mass selection of the African catfish at RIFB Sukamandi was about 20.24% (33.45 g). This response to selection was similar to that of the first generation, which attained 20.59% (Iswanto *et al.*, 2014a), but was much higher than that of the second generation, which only attained 11.80% (Iswanto *et al.*, 2014b). Thus, cumulative response to selection for body weight during three generations of mass selection of the African catfish at RIFB Sukamandi attained 52.63%.

The success of genetic improvement programs for increasing the growth performance using mass selection were also reported in several other cultured fish species. Genetic improvement for growth performance of *Salmo trutta fario* through four generations of enhanced methods of mass selection in France resulted in maximal response to selection for body weight, which attained 130% (Chevassus *et al.*, 2004). Mass selection for improving the growth performance of *Ictalurus punctatus* conducted in United States of America resulted in 12% and 18% response to selection for body weight in respectively Kansas and Marion strains (Dunham & Smitherman, 1983). Then, three generations of the mass selection yielded in cumulative response to selection for body weight of 29% and 21% in respectively Kansas and Marion strains (Rezk *et al.*, 2003). In *Clarias macrocephalus*, improving the growth performance through three generations of mass selection conducted in Thailand resulted in 11.8% response to selection for body weight (Na-Nakorn, 1993). Genetic improvement program for increasing the growth performance of *Megalobrama amblycephala* conducted in China through five generations of mass selection yielded in 29%

response to selection for body weight (Li & Cai, 2003). Three generations of mass selection for improving the growth performance of *Barbodes gonionotus* in Bangladesh resulted in cumulative response to selection of 21.9% (Hussain *et al.*, 2002).

Genetic improvement program to increase the growth performance using mass selections in the past years, however, were reported to be unsuccessful in *Cyprinus carpio* (Moav & Wohlfarth, 1976) and *Oreochromis niloticus* (Hulata *et al.*, 1986; Huang & Liao, 1990). Those failed genetic improvement programs by applying the mass selection were, however, caused mainly by low genetic variation in the base populations due to limited number of broodstocks used to produce the offsprings, increasing the inbreeding level and the influence of maternal effects since the use of mass spawnings (Huang & Liao, 1990; Lutz, 2001; Chevassus *et al.*, 2004; Gjedrem & Baranski, 2009).

Based on the response to selection for body weight in the third generation of 20.24% and selection differential for body weight in the establishing the second generation of 179.35% (Iswanto *et al.*, 2014b), realized heritability for body weight at the end of grow-out phase in the third generation of mass selection of African catfish at RIFB Sukamandi was about 0.12. This realized heritability was relatively similar to that of the first generation of about 0.10 (Iswanto *et al.*, 2014a), and somewhat higher than that of the second generation of about 0.08 (Iswanto *et al.*, 2014b). Applying the mass selection for improving performance would be effective and produced positive response to selection when heritability of respective trait was high and/or the population size was large, thus high selection differential could be applied (Kapusinski & Miller, 2007; Beaumont *et al.*, 2010). Although realized heritability in three generations of mass selection of African catfish at RIFB Sukamandi were low, however, selection differential in establishing the base population (Iswanto *et al.*, 2012), the first (Iswanto *et al.*, 2014a) and second (Iswanto *et al.*, 2014b) generations were high (respectively

Table 1. Response to selection and final mean body weight of the third generation compared to the control population of the African catfish *Clarias gariepinus* at the end of larval rearing, nursery and grow-out phases

Phases	Periods (days)	Final mean body weight (g)		Response to selection	
		Third generation	Control	Gram (g)	Percentage (%)
Larval rearing	25	0.19 ± 0.10	0.19 ± 0.07	-	-
Nursery	30	6.12 ± 2.93	5.80 ± 3.50	-	-
Grow-out	60	198.67 ± 82.82	165.22 ± 71.09	33.45	20.24

Table 2. Water quality during 25 days of larval rearing phase, thirty days of nursery phase and sixty days of grow-out phase of the third generation and control population of the African catfish (*Clarias gariepinus*) genetic improvement program held at Research Institute for Fish Breeding (RIFB), Sukamandi

Parameters	Phases		
	Larval rearing	Nursery	Grow-out
Temperature (°C)	27.4-28.9	25.5-33.9	28.0-31.5
pH	7.61-8.02	6.10-7.54	5.06-6.98
Dissolved oxygen (mg/L)	5.00-5.80	0.40-11.40	0.44-3.69
Ammonia (mg/L)	0.0320-0.0522	0.1055-0.3753	0.1688-3.8953
Nitrite (mg/L)	0.0178-0.0671	0.0103-0.1728	0.0032-0.1321

180.40%, 179.35%, and 167.50%), therefore still always produced positive response to selection. Mass selection in improving growth performance of *O. niloticus* at Sukabumi produced 2.3% response to selection for total length, while its realized heritability was 0.12 (Brzeski & Doyle, 1995). Similar results was also reported for mass selection in improving growth performance of *O. niloticus* in the Philippines, which produced 8% response to selection for total length, while its realized heritability was 0.16 (Basaiao *et al.*, 2005). The successful genetic improvement program for *O. niloticus* through combined family selection namely GIFT (Genetic Improvement of Farmed Tilapias) project conducted in the Philippines resulted in improved growth performance with cumulative response to selection of 85% for body weight during five generations, while its heritability were respectively 0.18, 0.25, 0.18, 0.07, 0.13, and 0.09 (Eknath & Acosta, 1998).

Survival rates of the third generation and control population of African catfish during 25 days of larval rearing phase and 30 days of nursery phase carried out at RIFB Sukamandi were quite high, respectively $80.14 \pm 10.76\%$ and $70.58 \pm 11.37\%$ in the larval rearing phase and respectively 83.16% and 77.39% in the nursery phase. Whereas, survival rates during 60 days of grow-out phase were lower, *i.e.* 68.19% for the third generation and 66.09% for the control population.

Those slightly low survival rates in the grow-out phase were caused by relatively high ammonia concentration in the water, which almost reached 4 mg/L. Ammonia concentration over 0.34 mg/L was not recommended for grow-out phase of the African catfish, even though the threshold concentration was 2.5 mg/L (Schram *et al.*, 2010). Except for high con-

centration of ammonia in the grow-out phase, other water quality parameters during 25 days of larval rearing phase, 30 days of nursery phase and 60 days of grow-out phase in both third generation and control population of the African catfish at RIFB Sukamandi were still in the acceptable ranges required for optimum survival and growth of the African catfish (Table 2), as were recommended by several authors. Recommended optimum water temperature for larval rearing and nursery phases of African catfish ranged 27.5°C-32.5°C (Britz & Hecht, 1987), while for grow-out phase ranged 27°C-30°C (Degani *et al.*, 1988). Well oxygenated water was recommended for larval rearing phase (Britz & Hecht, 1988), while for nursery and grow-out phases it was not necessary, since African catfish is an air breathing fish that used direct aerial respiration (Teugels, 1986). Median lethal pH water for African catfish juveniles was reported at 4.3 and 9.2 (Ndubuisi *et al.*, 2015). For nitrite, median lethal concentration for the African catfish was reported at 0.2 mg/L (Ajani & Adeyemo, 2012).

CONCLUSION

Growth performance of the third generation of mass selection of the African catfish (*Clarias gariepinus*) during 25 days of larval rearing phase, 30 days of nursery phase and 60 days of grow-out phase conducted at RIFB Sukamandi was higher than that of control population, resulted in a positive response to selection for body weight.

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