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ESTABLISHING A BASE POPULATION OF INDIVIDUAL SELECTION FOR LOW MAINTENANCE REQUIREMENTS IN TERM OF DIETARY PROTEIN LEVEL IN THE AFRICAN CATFISH (*Clarias gariepinus*)

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ABSTRACT

The farming industry of the African catfish (*Clarias gariepinus*) in Indonesia is affected by a high feed cost during the grow-out phase resulting in low economic return. Selective breeding to produce new strains with low maintenance requirements is one of the potential solutions to overcome the problem. The present study aimed to identify and study the performance of the base population of African catfish treated with feed low in dietary protein during the grow-out phase. Out of 100 broodstock pairs, 96 pairs had produced successful hatching. Approximately 1,000 larvae from each pair were reared separately to reach seven-week-old juveniles. Then, 50 individuals from each pair were selected to form the base population. The base population was reared for four months and fed with commercial feed containing 12% crude protein resulting in final mean body weight of 82.04 ± 34.66 g, a specific growth rate of 2.02%/day, a feed conversion ratio of 4.23, and survival rate of 25.15%. At the end of the grow-out phase, the size variation among treated fish was relatively high (variation coefficient of 42.31%). The subsequent individual selection stage had identified that 325 individuals (equal to 26.93% of the total population) had the best performances with a mean body weight of 128.80 ± 22.80 g, selection differential of 46.80 g, and selection intensity of 1.35. These results suggested the potency of the selected base population be used in the forming of the next generation.

KEYWORDS: **African catfish (*Clarias gariepinus*); base population; body weight; dietary protein level; individual selection**

INTRODUCTION

African catfish (Clarias gariepinus) is one of important freshwater aquaculture fish species in Indonesia. Currently, it has been widely cultured by fish farmers throughout the Indonesian region despite the low economic return (5%-20%) in grow-out phase due to high feed expenses (Kurniawan & Triyanti, 2011; Lindawati *et al*., 2013; Muhammad & Andriyanto, 2013; Jatnika *et al*., 2014). Fortunately, a genetic improvement program, mainly through selective breeding to establish the new strains with superior performance on important economic traits, *e.g.* growth, survival, and feed efficiency might offer a solution to overcome this problem.

Genetic improvement through selective breeding in aquaculture mainly focuses on fish growth performance which is considered the most important economic trait (Gjedrem *et al*., 2012; Gjedrem & Rye, 2016). The African catfish is considered to have a highly efficient metabolism (Machiels & Henken, 1986). Therefore, a selective breeding program to increase its growth performance using high-quality feed (high dietary protein level) during a grow-out phase can be considered inessential. Thus, Van Weerd (1995) suggested that selective breeding of the African catfish should focus more on the aspect of minimum maintenance requirements. In Indonesia, a selective breeding program to establish a new strain of the African catfish capable to grow in minimum maintenance conditions such as low dietary protein intake is highly preferred in order to reduce the high cost of commercial feed used in the grow-out phase. If such strain could be mass produced, the operational cost of the African catfish culture can be re-

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duced which in turn increase the economic viability of the farming activity.

In general, selective breeding to improve an important economic trait consists of establishing the base population from which selection can be initiated followed by producing the next generations via selection (Gjedrem & Baranski, 2009; Nguyen, 2016). The present study aimed to identify and study the performance of the base population (based on growth, condition factor, survival, and feed efficiency) of African catfish treated with feed low in dietary protein during the grow-out phase.

MATERIALS AND METHODS

The present study was conducted at the Research Institute for Fish Breeding (RIFB) Sukamandi lasted for seven months from August 2017 to February 2018. The strain of the African catfish used to produce the base population was an improved stock called Mutiara strain which previously had undergone rapid growth selection for three generations (Iswanto *et al.*, 2016a). A total of 100 pairs of Mutiara strain broodstock were artificially spawned. The hatched larvae reared to juvenile stage (the base population) to be used, later on, in the grow-out phase. A floating type of commercial feed containing 12%crude protein (MS PREO 890, PT Matahari Sakti, Surabaya) was used as the feed during the grow-out phase.

The selected mature broodstocks of Mutiara strain (3.2-4.4 kg of body weight) were artificially bred using ovaprim hormonal treatment (ovaprim, Syndel Laboratories Inc., Canada). The eggs were obtained through stripping, while the sperms were collected using partial gonadectomy technique. Approximately 40-60 g eggs obtained from each female broodstock were fertilized and incubated in separated happas (1 m x 0.5 m x 0.5 m) placed within indoor concrete tanks equipped with a circulating water system.

Approximately, 1,000 larvae from each pair were reared within separated aquaria (60 cm x 40 cm x 40 cm) for three weeks. During this larval rearing period, *Artemia* sp. nauplii were given for the initial three days. Afterward, it was replaced with a commercial feed sized 100-200 μm containing 65% crude protein (Nori, BERNAQUA, Belgium) for the next seven days followed by a change to a commercial feed sized 200-300 μm containing 60% crude protein (MeM, BERNAQUA) for the subsequent ten days. Those feeds were given four times (08:00, 12:00, 16:00, 20:00) daily until apparent satiation. At the end of larval rearing period, juveniles from each aquarium were graded into < 1 cm, 1-2 cm, 2-3 cm, 3-4 cm, and > 4 cm size classes.

In total, 300 juveniles from each dominant size class (1-2 cm, 2-3 cm, and 3-4 cm size classes, proportionally based on their percentage) from each aquarium were then transferred into separated happas (1 m x 1 m x 1 m) constructed in an earthen pond (400 m^2). These juveniles were reared for four weeks (nursery phase). A crumble sinking commercial feed sized 200-400 μm containing 40% crude protein (FENG LI 1, PT Matahari Sakti) were given four times (08:00, 12:00, 16:00, 20:00) daily until apparent satiation for the first five days, then it was replaced with the feed sized 300-600 μm (FENG LI 2, PT Matahari Sakti) for the subsequent five days. For another next five days rearing period, a floating commercial feed sized 500-700 μm containing 40% crude protein (PRIMAFEED PF 500, PT Matahari Sakti) was given to the juveniles and then replaced with the feed sized 800-1,000 μm (PRIMA FEED PF 800, PT Matahari Sakti) for the subsequent five days. Finally, the latter was replaced with the feed sized 1,000-1,200 μm (PRIMA FEED PF 1000, PT Matahari Sakti) for the last eight days rearing period. These floating type feeds were given three times daily (08:00, 14:00, 20:00) until apparent satiation. At the end of the nursery phase, juveniles from each happa were graded into < 3 cm, 3-5 cm, 5-7 cm, 7-9 cm, and > 9 cm size classes.

In total, 50 juveniles from each dominant size class (5-7 cm and 7-9 cm size classes, proportionally based on their percentage) from each happa were reared communally within a concrete tank (7 m x 7 m x 1 m) for four months (grow-out phase). During this grow-out period, the juveniles were given a floating commercial feed with low crude protein content of 12%sized 2-3 mm (MS PREO 890 no. 2, PT Matahari Sakti) for the first two weeks and sized 3-4 mm (MS PREO 890 no. 3) for the remaining period to apparent satiation twice daily (08:00 and 16:00). Within the period, monthly samplings were undertaken to measure the individual total length, standard length, and body weight of the fish samples. The total of commercial feed consumed by the base population during the grow-out period was recorded to determine the feed conversion ratio (FCR= total feed consumed/biomass gain). All of the remaining fishes at the end of the grow-out period were counted to determine the survival rate (SR= number of survivor/number of stocking x 100). The total length and body weight were measured to determine the specific growth rate (SGR= (log-e final weight – log-e initial weight)/days of grow-out period x 100), size variation in term of body weight's coefficient of variation (CV= standard deviation of body weight/mean body weight x 100), and individual condition factor (K= body weight/cube of the total length).

At the end of the grow-out period, individual fish were selected from the base population based on the individual final body weight, *i.e.* individual fish whose final body weight more than 100 g (reaching the table-size at harvest) were selected. These selected individual fishes will serve as the selected base population that will be used in future selection research. Furthermore, about 50 individual fish whose final body weights were more or less similar to the final mean body weight of the former were also selected as broodstock representatives of a control population in future selection research.

The mean body weight of the selected base population was calculated to determine the selection differential (S= mean body weight of the selected base population – mean final body weight of the base population) and selection intensity (i = selection differential of body weight / standard deviation of final body weight). All individuals of the selected base population and control population were then individually tagged using PIT (passive integrated transponder) tags, and communally stocked within a concrete tank (4 m x 3 m x 1 m) for grow-out phase. A floating commercial feed containing 30% crude protein (PRIMA FEED LP 3, PT Matahari Sakti) were offered to satiation twice (08:00 and 16:00) daily.

RESULTS AND DISCUSSION

Performances of the Base Population

Successful hatching rate of eggs (more than 50%) was produced by 96 out of 100 broodstock pairs. The remaining pairs had poor egg hatching rates (less than 20%) producing larvae with weak and/or abnormal (deformed) development and mostly died within two days post-hatching. Only larvae from the 96 pairs of broodstock were used to form the base population through subsequent larval rearing phase, nursery phase, grow-out phase and individual selection for low maintenance requirement. The total number of broodstock used was considered sufficient to form the base population despite the minimum recommended number of pairs to form a base population is 100 males and 100 females (Gjedrem & Baranski, 2009).

The growth performance and survival rate of the base population during larval rearing and nursery phases in the present study were relatively good. At the end of the three weeks of larval rearing phase and four weeks of nursery phase, the length averages of the base population ranged between 1-3 cm and 5-9 cm respectively, comparable to those reported for Mutiara strain of African catfish (Iswanto *et al.*, 2015). The survival rate of the base population during larval rearing phase within aquaria ranged 64.40%-89.30% (76.46 ± 6.32% on average), while during nursery phases within happas ranged 60.33%-98.67% (79.09 ± 10.07% on average).

The grow-out phase of the base population treated with commercial feed containing low dietary protein level (about 12% crude protein) in the present study was carried out for four months, before fully reaching the gonadal maturity stage. Since the gonadal mature stage of Mutiara strain was firstly attained within five months old (Iswanto *et al.*, 2016b), the grow-out period of the base population was also ended at around five months old.

The growth performance in term of monthly body weight of the base population fed with commercial feed containing low dietary protein level during the four months of the grow-out period is presented in Figure 1. The specific growth rate of the base population during the grow-out phase was accounted for 2.02%/day. Although this specific growth rate was low, it still falls within the range of specific growth rate reported by other studies for African catfish grow-out, which was around 2%-4%/day (See Degani *et al.*, 1989; Van Weerd, 1995; Ali & Jauncey, 2005). However, the growth performance of the base population was much lower compared to that of generally achieved in regular farming of the African catfish in Indonesia. In Indonesia regular farms, the African catfish could reach the minimum marketable size (> 100 g of body weight) within 2-4 months (Kurniawan & Triyanti, 2011; Lindawati *et al.*, 2013; Muhammad & Andriyanto 2013; Jatnika *et al.*, 2014; Iswanto *et al.*, 2015). This base population only reached a mean final body weight of 82.04 ± 34.66 g (Figure 1) after reared for four months. It was predicted that the mean harvest size of the base population would be achieved within five months of the grow-out period. This was almost doubled compared to the common grow-out periods of the African catfish cultured in Indonesia. This result suggested that lowering dietary protein level to 12% might reduce the final body weight down by one third within a normal grow-out period. Or, it will take about three times longer grow-out period to achieve normal marketable size. The dietary protein level in this study was only one third of the dietary protein level commonly used in the diet of African catfish (around 30%) in Indonesia (Amalia *et al.*, 2013; Abidin *et al.*, 2015; Khodijah *et al.*, 2015; Salamah *et al.*, 2015).

Besides its low growth performance, the use of low dietary protein level in this research had also resulted in very low survival rates of the base population. At the end of the grow-out period, the sur-

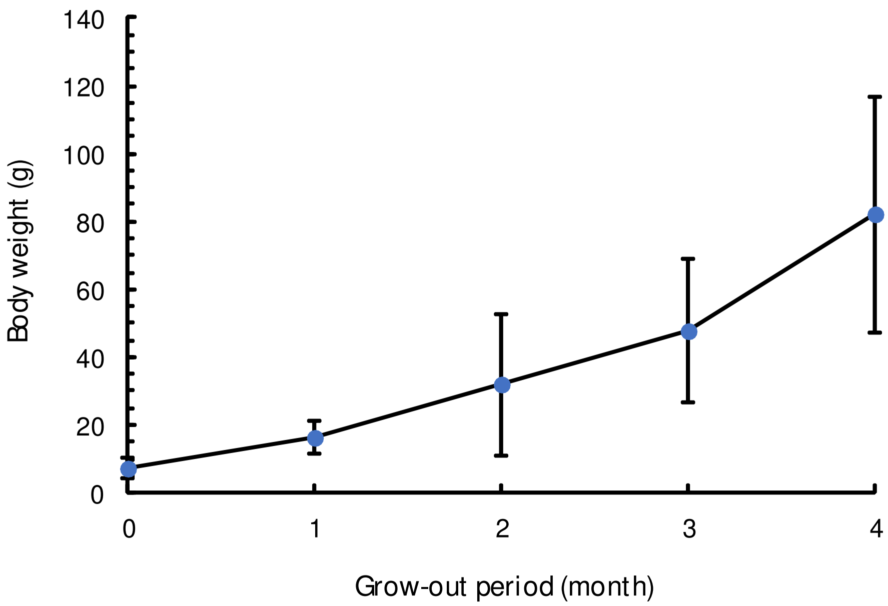

Figure 1. Growth performance in term of body weight of the base population of African catfish (*Clarias gariepinus*) fed with commercial feed with low dietary protein level (12%) during four months of grow-out phase.

vival rate of the base population was only 25.15%. This survival rate was much lower than those commonly obtained in the growth-out phase of the African catfish cultured in Indonesia's farms which usually ranged between 50%-90% (Kurniawan & Triyanti, 2011; Iswanto *et al*., 2015). The low survival rate of the base population was due to protein deficiency in individual fishes causing increased fish leanness, weakness, and mortality. The values of individual condition factors of the base population reflect this conclusion that ranged between 0.6-0.7 during the grow-out period. This value range indicates that the individual fish were lean (Froese, 2006), weak and prone to high risk of mortality. Mortalities were mainly observed within the first two months of the grow-out period. Only individual fish capable to sustain the low maintenance condition were alive until the end of the grow-out period.

The use of commercial feed with low dietary protein level during the grow-out period also affected the feed efficiency of the reared fish. Feed conversion ratio (FCR) of the base population during the grow-out period was 4.23. This high FCR was caused by the high mortalities occurred during the first two months of the grow-out period. This FCR was much higher than that of regular grow-out of the African catfish cultured in Indonesia which was around 1-1.2 (Muhammad & Andriyanto, 2013; Iswanto *et al*., 2015). The dietary protein level used in this study was too low compared to the dietary protein level recommended for the grow-out phase of the African catfish which was around 30%-40% (Machiels & Henken, 1985; Degani *et al*., 1989; Van Weerd, 1995; Ahmad, 2008). Thus, in order to compensate their dietary protein level requirements, individual fishes of the base population consumed a greater amount of feed given indicated by the high FCR value.

Despite the inferior grow-out performances (growth, condition factor, survival, and feed efficiency), the survived fish were capable to adapt to low dietary protein treatment. These individual fish were considered as fish with low maintenance requirement and have the potential to be used as broodstock in selective breeding. Interestingly, these survived fish exhibited high size variation at the end of the grow-out period. This size variation offers a possibility that the best performing fishes can be individually selected as a base population for future research.

Selection for Low Maintenance Requirement

Size distribution in terms of body weight of the survived fish at the end of grow-out period ranged between 18.10-242.30 g with a high variation coefficient of 42.31% (mean final body weight was 82.04 ± 34.66 g) (Figure 2). In general, the variation coefficients above 20% were considered high and corresponded to the large phenotypic variation existed

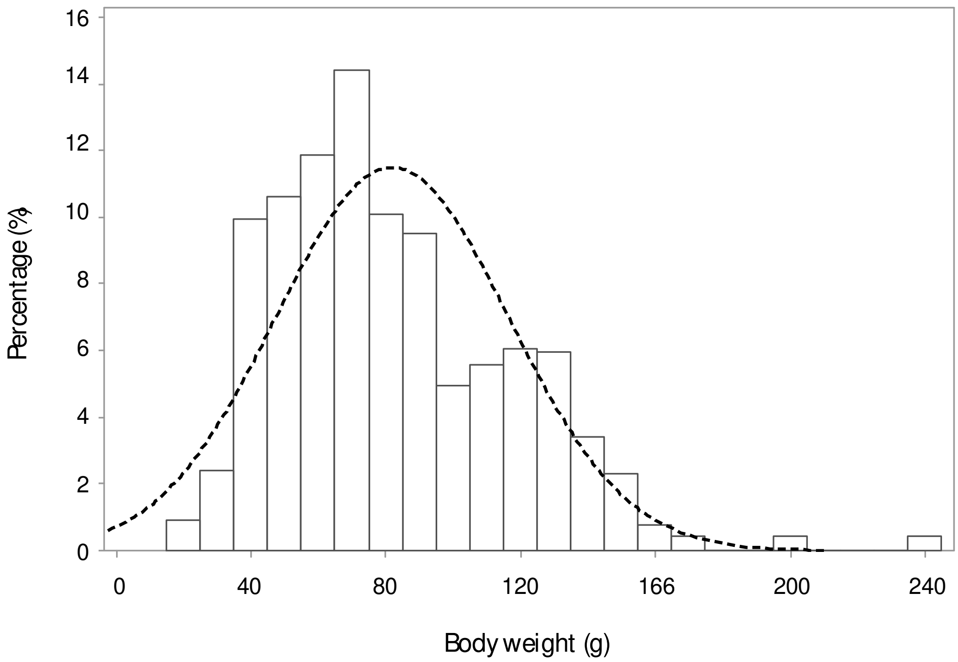

Figure 2. Individual size distribution in terms of body weight the African catfish (*Clarias gariepinus*) fed with commercial feed with low dietary protein level at the end of the grow-out phase.

(Gjedrem & Baranski, 2009). The high size (final body weight) variation of the base population suggested that there was a considerable variation amongst individual fish in responding to the low dietary protein level in the commercial feed given. Individual fish with a better response would gain higher body weight, which suggested its higher growth performance was due to its low maintenance requirement. These individual survivors with low maintenance requirement were the selection candidates to be selected for.

Selection of the individual survivors with final body weight more than 100 g (table-sized fishes) resulted in a total of 325 individual fish (26.93%) out of 1,207 survivors consisting of 147 males and 178 were females. The mean body weight of these selected individuals was 128.80 ± 22.80 g (ranged between 101.40-242.30 g). This individual selection resulted in a selection differential of 46.80 g or 57.05% higher than the average of final body weight of the base population with selection intensity of 1.35.

The individual selection to determine fish capable to adapt to low maintenance condition in this present study resulted in considerably low selection intensity. Selection intensity is one of three parameters determining the success of a selective breeding program besides heritability and standard deviation of the trait selected for (Gjedrem & Baranski, 2009). The success of a selective breeding program is determined by the response to selection (genetic gain). This means that higher selection intensity can lead to a higher response to selection. However, low selection intensity as used in this present study was recommended at the initial selection process in order to secure and maintain the broad genetic variation for future selections (Eknath *et al*., 2007; Gjedrem & Baranski, 2009).

Heritability indicates a portion of the selection differential that is heritable. The heritability for common economically important traits in most aquaculture species is within the range of 0.1-0.4 (Gjedrem & Baranski, 2009). The response to selection for low maintenance requirement in terms of the final body weight of grow-out phase in the next first generation was estimated to be between 4.7-18.7 g, equal to the increase of mean final body weight of 5.7% 22.8% compared to the base population. In general, 10% 20% responses to selection for growth performance were often obtained in most aquaculture species (Gjedrem & Baranski, 2009; Gjedrem & Rye, 2016).

CONCLUSION

Grow-out performances (growth, condition factor, survival, and feed efficiency) of the base population fed with commercial feed with low dietary protein level were much lower than those commonly obtained in the grow-out of the African catfish cultured in Indonesia. However, high size variation within the survived fish population suggested the study is able to identify fish capable to sustain low maintenance requirement. These fishes can be selected in order to produce fish population with much better performances via several generations of selection.

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