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## COMPENSATORY GROWTH OF *Oreochromis niloticus* SELECTED STRAIN FROM BOGOR, WEST JAVA

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### ABSTRACT

Inefficient feed management strategy in aquaculture will increase the fish production cost. One of the most effective strategies to solve this problem is through a better understanding of the compensatory growth of cultured fish. *O. niloticus* BEST tilapia strain (total length:  $7.23 \pm 0.11$  cm mean  $\pm$  SD; Body weight:  $7.04 \pm 0.08$  g mean  $\pm$  SD) were reared in aquariums at  $26.3 \pm 1.4^\circ\text{C}$  for 10 weeks. During the experiment, the control group was fed twice a day. The other two groups were deprived of food for one and two weeks and then fed twice a day during refeeding period. At the end of the experiment, the fish deprived for one week had a body weight, biomass and specific growth rate that were not significantly different from the control group. The body weight, biomass and specific growth rate of fish deprived for two weeks were significantly lower than the other groups. This study revealed that concentrations of ash and lower concentrations of protein and lipid on the deprived groups were higher compared to those without feed deprivation. Mortality of fish was lower than 9% and not significantly different among the treatments. Fish aggressive behavior was the main reason for injuries and death. Given the results, BEST tilapia strain was only able to reach complete growth compensation not longer than one week deprivation period. The results of the present study could be applied as basic information for further research on feeding management of BEST tilapia strain.

**KEYWORDS:** *Oreochromis niloticus*; compensatory growth; feed deprivation; mortality

### INTRODUCTION

An increase in feed prices often has a profound impact on aquaculture. Feed accounts for over 70 percent of the production cost. Fish farmers must have detailed knowledge of nutritional requirements & optimal feeding practices to anticipate higher feed price. Inefficient feeding management will lead to higher fish production cost. One of the effective strategies to reduce production cost in aquaculture is by understanding the compensatory growth of cultured fish species (Jobling, 2010). Compensatory growth is defined as the phase of exceptionally rapid growth, following a period of nutritional deficiencies (Hayward *et al.*, 1997; Ali *et al.*, 2001).

Previous studies on the compensatory growth of fish have been successfully conducted on both cold water and warm water fish species (Wang *et al.*, 2000; Stefansson *et al.*, 2009; Jiwyam, 2010; Peres *et al.*, 2011; Urbinati *et al.*, 2014). Compensatory growth response has been reported in many fish species following feed deprivation (Xie *et al.*, 2001; Wang *et al.*, 2005; Cho *et al.*, 2006; Ribeiro & Tsuzuki, 2010; Mohanta *et al.*, 2016).

Nile tilapia *Oreochromis niloticus* is a warm water, euryhaline, omnivorous fish species. The species is globally the most popular and produced in high quantity. This species has become one of the most common culture species in Indonesia whose production continues to grow. One of Nile tilapia strains available in Indonesia is BEST (Bogor Enhanced Strain Tilapia) strain. BEST tilapia strain is a genetically selected strain with the excellent trait in growth performance. This strain was produced through a selective breeding conducted by a research team from the Institute of Freshwater Aquaculture Research and

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Development, Bogor (Gustiano, 2009). BEST tilapia strain has several advantages over its predecessor (Red NIFI, Nirwana, and GESIT). For examples, in general: it has better growth performance, disease resistance, and environmental tolerance. Specifically, BEST tilapia strain is 140% disease resistance to *Streptococcus* compared to other existing tilapia varieties in Indonesia (Gustiano, 2009).

Hayward *et al.* (1997) stated that the compensatory growth can be used as a management tool to improve growth, feed efficiency, and also reduce the cost of feed. According to Hitchcock (2013), using compensatory growth, farmers can reduce costs by using less amount of feed than usual without reducing the yields. However, the information of compensatory growth specifically on BEST tilapia strain has not yet available. Therefore, the objective of the present study was to investigate whether compensatory growth occurs in BEST tilapia strain in order to improve its aquaculture management.

## MATERIALS AND METHODS

The experiment was carried out from January to February 2016 at the Institute for Freshwater Aquaculture Research and Fisheries Extension, Bogor. This study used BEST tilapia, *Oreochromis niloticus*, strain from Bogor as the experimental fish.

A total of 180 fish were stocked in nine aquariums (50 cm x 40 cm x 40 cm; water level: 30 cm) with the density of 20 fish per aquaria. The fish were fed twice a day using a commercial pellet feed containing 31% crude protein and 3.0% crude lipid (Hi-Pro-Vite 781-1).

Initially, the fish (Mean total length:  $7.23 \pm 0.11$  cm; Mean body weight:  $7.04 \pm 0.08$  g) were starved 24 h prior stocking into the aquariums with the stocking density of 20 fish per aquaria. A completely randomized design (CRD) was used in this experiment with three feeding regimes and three replications. Three fish from each treatment were sampled at the beginning and the end of the experiment for the analysis of initial body composition (moisture, protein, lipid, and ash).

The experiment lasted for 8 weeks and was divided into two periods, a feed deprivation period weeks one to two, and a refeeding period (weeks three to eight). Fish in the control treatment were fed to satiation twice a day throughout the eight-week period. The fish in the other three treatment groups were starved for one and two weeks during the feed deprivation period and then fed to satiation twice a day (07:00 and 15:00 h) during the refeeding

period. The fish in each tank were batch-weighed at the end of the feed deprivation period and at the end of the experiment, following feed deprivation for 24 h.

Chemical composition was analyzed from three fish which randomly caught from each tank so that 17 fish remained in each tank at the beginning of the refeeding period. At the end of the experiment, five fish from each tank were taken and pooled, autoclaved, homogenized, and dried to a constant weight at 105°C (Cui *et al.*, 1997). Protein, lipid, and ash concentrations were determined for the fish samples from each tank using the methods described by Cui *et al.* (1997) to observe the effect of feed deprivation on protein, lipid, and ash concentrations of fish. During the experiment, water temperature was maintained at  $26.3 \pm 1.4^\circ\text{C}$  and photoperiod was conducted at 12:12-h light-dark (12L/12D). Specific growth rates of wet weight, protein, and lipid were calculated (Fu *et al.*, 1998):

$$\text{Specific growth rate of wet weight} = \frac{100(\ln W_t - \ln W_0)}{t}$$

$$\text{Specific growth rate of protein} = \frac{100(\ln W_{pt} - \ln W_{p0})}{t}$$

$$\text{Specific growth rate of lipid} = \frac{100(\ln W_{lt} - \ln W_{l0})}{t}$$

where  $W_t$  is the final and  $W_0$  the initial wet weight of the fish,  $W_{pt}$  is final and  $W_{p0}$  the initial weight of the body protein,  $W_{lt}$  is the final and  $W_{l0}$  the initial weight of body lipid, and  $t$  is the duration of the experiment.

One-way analysis of variance (ANOVA) was performed to test the treatment effects, and Tukey's procedure was applied for multiple comparisons. P value was used as an indication of significant differences. It was considered significant when  $P < 0.05$ .

## RESULTS AND DISCUSSION

Based on the weight gain comparison, the highest weight gain since refeeding period started was found on one-week deprived group. At the end of the experiment, the average weight of one week deprived group was not significantly different from those without deprivation ( $P > 0.05$ ). On the contrary, the average of final weight from two weeks deprived group was significantly lower than other groups ( $P < 0.05$ ) (Table 1).

After feed deprivation period, significant differences were found in the average fish biomass at different feed deprivation treatments. The final

Table 1. Weight gain comparison of tilapia based on duration of feed deprivation

Duration of feed deprivation (week)	Initial weight (g)	Weight after feed deprivation (g)	Final weight (g)
0	7.04 ± 0.01	9.53 ± 1.15 <sup>a</sup>	26.11 ± 1.48 <sup>a</sup>
1	7.02 ± 0.15	7.28 ± 0.35 <sup>b</sup>	26.41 ± 2.59 <sup>a</sup>
2	7.05 ± 0.04	6.18 ± 0.38 <sup>c</sup>	20.97 ± 1.09 <sup>b</sup>

Description: Different superscript letters indicate significant difference between treatments

average biomass at the end of the experiment showed that fish biomass of treatment one-week deprivation was higher than those without deprivation. On the other hand, the biomass of the fish that were deprived for two weeks was significantly lower than the other treatments (Table 2).

Based on the results, a complete compensation was found after one-week feed deprivation. Compensatory growth may be an internal adjustment mechanism for animals to adapt to often dramatically varied environments. The animals that withstand a period of nutrition restriction could return to a normal growth trajectory (Ali *et al.*, 2001). No significant difference in body weights and biomass was found between one-week deprived group and the group without feed deprivation. Similar effects of feed deprivation on growth and body composition were also reported in previous studies (Oh *et al.*, 2007; Morshedi *et al.*, 2013; Yengkokpam *et al.*, 2014; Pang *et al.*, 2016). The present study showed that tilapia were unable to compensate weight losses during two weeks of feed deprivation period, which resulted in significantly lower body weight and biomass compared to the other groups at the end of the experiment. In line with Dharma & Suhenda (1986), several factors in the food transformation affected the growth performance such as the amount of feed consumed, digestibility, digestion rate, feeding frequency, food

absorption, as well as feed efficiency and feed conversion. One week feed deprivation on tilapia caused a faster response to food transformation into body tissue, which related to its growth.

Compensatory growth occurred as a response to hyperphagia (Ali & Wootton, 2003), which contributed to energy restoration from the starvation period and catch up the weight loss by greater growth if fish had eaten without restriction. The magnitude of compensatory growth was depending on how severe fish experienced the undernutrition conditions (Fu *et al.*, 1998). Hyperphagia in fish is known as a response to a reduction in feeding frequency accompanied by an increase in gastric capacity which results in body mass increase (Fabry, 1969; Jobling, 1982). In the present study, hyperphagia appeared on the deprived fish groups. Results of this study showed that one-week deprived fish consumed feed above normal during refeeding period and grew faster ( $0.46 \pm 0.06$  g/day) than control ( $0.39 \pm 0.04$  g/day). Meanwhile, two-week deprived fish grew slower than the control during refeeding period ( $0.35 \pm 0.03$  g/day). It means that duration and frequency of feeding during refeeding was important for compensatory growth.

The present study showed lower mortality rate (<9%) in all treatments. The aggressive behavior of fish which resulted in injuries was the major cause of mortality. Meanwhile, specific growth rates accord-

Table 2. Biomass gain comparison of tilapia based on duration of feed deprivation

Duration of feed deprivation (week)	Initial biomass (g)	Total biomass after feed deprivation (g)	Final biomass (g)
0	140.79 ± 0.27	190.68 ± 23.01 <sup>a</sup>	486.79 ± 13.59 <sup>a</sup>
1	140.37 ± 3.03	145.59 ± 6.94 <sup>b</sup>	491.97 ± 32.28 <sup>a</sup>
2	141.07 ± 0.72	123.69 ± 7.54 <sup>c</sup>	383.96 ± 8.23 <sup>b</sup>

Description: Different superscript letters indicate significant difference between treatments

ing to wet weight, protein, and lipid were not significantly different between one-week deprivation treatment and those treatments without deprivation ( $P > 0.05$ ). However, the specific growth rates of both groups were significantly higher than that of the two weeks deprivation group ( $P < 0.05$ ) (Table 3).

Improvement in the specific growth rate of wet weight, protein, and lipid in tilapia deprived for one week indicated that tilapia have the ability to compensate for weight losses up to one week of feed deprivation. This result was similar to the results of Cho (2005) who found specific growth rate improvement during compensatory growth observation of juvenile flounder (*Paralichthys olivaceus*). However, Wang *et al.* (2009) reported that cyclical feed deprivation and refeeding failed to enhance compensatory growth in Nile tilapia *Oreochromis niloticus* L.

At the end of the experiment, the highest moisture and ash concentration was found in fish deprived for two weeks. However, statistical analysis indicated that the difference was not significantly different among the treatments. The moisture concentration was only found in the one week deprived group treatment (Table 4). Meanwhile, the highest protein and lipid concentrations were found in fish without deprivation. Protein and lipid concentrations of the deprived groups were significantly lower than those without deprivation ( $P < 0.05$ ). On the other hand,

higher concentrations of ash were found at the deprived groups compared with the group without feed deprivation.

Lower concentrations of lipid and protein in the fish body were found in feed-deprived groups. According to Fu *et al.*, (1998) the variation of lipid and protein concentrations highly dependent on fish species and size, water temperature, and duration of feed deprivation. The depletion of protein and lipid concentrations due to feeding deprivation was also reported by Wang *et al.* (2000) and Wang *et al.* (2009). This study indicates that the fish suffered from feed deprivation exhibited lower body protein and lipid concentration than the control group at the end of the experiment. Fish used their protein and lipid for metabolic energy during feed deprivation period (Navarro & Gutierrez, 1995; Fu *et al.*, 1998).

**CONCLUSION**

A complete growth compensation regarding feeding deprivation of *Oreochromis niloticus* BEST tilapia strain only occurred no longer than one week deprivation period. A much longer period of feed deprivation would result in a lower growth performance. The results of the present study could be applied as a basic information for future research to determine the effective and efficient feeding strategies for culturing BEST tilapia strain.

Table 3. Specific growth rates of wet weight, protein, and lipid comparison of tilapia based on duration of feed deprivation

Duration of feed deprivation (week)	Specific growth rate of wet weight (%)	Specific growth rate of protein (%)	Specific growth rate of lipid (%)	Survival rate (%)
0	2.34 ± 0.10 <sup>a</sup>	1.75 ± 0.07 <sup>a</sup>	2.12 ± 0.07 <sup>a</sup>	93.33 ± 2.89 <sup>a</sup>
1	2.36 ± 0.15 <sup>a</sup>	1.74 ± 0.11 <sup>a</sup>	2.01 ± 0.11 <sup>a</sup>	93.33 ± 2.89 <sup>a</sup>
2	1.94 ± 0.09 <sup>b</sup>	1.44 ± 0.09 <sup>b</sup>	1.74 ± 0.07 <sup>b</sup>	91.67 ± 2.89 <sup>a</sup>

Description: Different superscript letters indicate significant difference between treatments

Table 4. Body composition of tilapia before and after feed deprivation treatments

Duration of feed deprivation (week)	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Initial	77.10 ± 0.27	51.41 ± 0.06	17.71 ± 0.06	19.35 ± 0.08
Final : 0	74.59 ± 0.38 <sup>a</sup>	52.41 ± 0.08 <sup>a</sup>	23.89 ± 0.13 <sup>a</sup>	16.08 ± 0.10 <sup>b</sup>
Final : 1	73.50 ± 0.44 <sup>b</sup>	51.46 ± 0.01 <sup>b</sup>	21.68 ± 0.12 <sup>c</sup>	17.40 ± 0.06 <sup>a</sup>
Final : 2	75.04 ± 0.31 <sup>a</sup>	51.30 ± 1.07 <sup>b</sup>	22.30 ± 0.07 <sup>b</sup>	17.51 ± 0.04 <sup>a</sup>

Description: Different superscript letters indicate significant difference between treatments

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