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Impacts of Feeding Restriction Regimes on Economic and Productive Performance of Nile Tilapia Fish

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ABSTRACT

This study investigated the effect of feeding restriction regimes on economic and productive performance of Nile tilapia *Oreochromis niloticus*. Sixty Nile tilapia fish were randomly classified into three groups (n=10/group) with similar initial body weight. Group I (Control group) was fed three times daily for 32 days. Group II was deprived for 4 days and then re-fed for 16 days, while Group III was deprived for 8 days and then re-fed for 32 days. The experiment was terminated after 10 weeks. All groups were fed on commercial diet at 2% of body mass. Indicate parameters measured were weight gain, feed efficiency, feed conversion ratio, economic conversion ratio and water quality. The above parameters were measured every 2 weeks. The results revealed that, after 64 days, Fishes which exposed to long starvation periods (8F:32R) consumed significantly (P= .01) more feed compared to other the restricted group (4F:16R). The highest feed efficiency was observed in fish exposed to 4F:16R. However, this group showed less feed intake than the 8F:32R and control groups. Moreover, cost benefit analysis under restriction indicated that, the highest return observed in control group and restricted fish for 4 days and the lowest in restricted fish for 8 days (P= .05). On the other hand, parameters of water quality (pH, Dissolved oxygen, Turbidity and Ammonia) were significantly (P= .01) affected by feed restriction regimes. Turbidity and ammonia levels were more in control group than the restricted groups.

Keywords: *Cost-benefit analysis, Economic and productive performance, Nile tilapia fish.*

INTRODUCTION

Feed prices in the world markets continue to rise; this has made it difficult to convert the benefits of higher biological production associated with commercial feed into economic gains when fed fish are presented traditionally. Feed costs in tilapia (*Oreochromis niloticus*) farming represent 60-70% of the total production costs (Borski *et al.*, 2011). Egyptian aquaculture currently provides almost 79 % of the country's fish needs, with almost all the output coming from small and medium sized privately-owned farms. Egypt's aquaculture industry ranks number 10 worldwide and number two in tilapia production behind only China (Ahmed, 2016).

Fish farmers have adopted various feed management strategies in an effort to maximize the profits from aquaculture such as reducing feed input (Cuvin-Aralar *et al.*, 2012),
Reduce problems of water quality and labor costs (Blanquet and Oliva-Teles, 2010).
Some of these strategies include mixed feeding such as alternative commercial pellets with farmmade feed and restricted feeding such as body weight feeding or feeding deprivation and refreshment cycles, with fish normally fed for satiation during the refeeding period (Ali *et al.*, 2003).
Restriction of feed is a strategy for feed management that has attracted broad interest in aquaculture (Ren et al., 2015).
This approach is supposed to take benefit of a phenomenon called compensatory growth, defined as an accelerated growth rate arising from

adequate refeeding of the fish after a period of limitation of feed or exposure to unfavorable c onditions such as low temperature and low oxygen (Ali et al., 2003). Starvation and re-feeding strategy may aid to reducing feeding time and obtaining even higher output than continuous feeding strategy (Xiao et al., 2013).

The aim of this study was to investigate the effect of short-term cycles of feed deprivation and re-feeding on economic and productive performance of Nile tilapia fish *(Oreochromis niloticus).*

MATERIALS AND METHODS

Area of study

This study was carried out in Aquatic Lab at the Department of Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, University of Sadat City, from September 2017 untill November 2018. All fish-handling, collection and disposal procedures were according to the regulations of Institutional Animal Care and Use Committee (IACUC) (Approval number: VUSC-004-2-16).

Experimental Units

Six glass aquaria were used in the experiments. Dimensions of each aquarium were 100 cm length x 30 cm width x 40 cm height with capacity of 80 liters of water.

For each aquarium, the followings tools were supplied (Figure 1):

- Floating glass aquarium thermometer with suction cup and aquarium thermometer stick were used for measuring the daily water temperature.
- Heater with thermostat (Risheng Electrical Heater RS 308C - 150 W, China) was required to keep aquarium water at optimum temperature for fish.
- Aquarium filter and pump (BAOLAI, BL 1001F, China): it is mechanical filter that was used for the removal organic waste matter from the aquarium.
- Electrical aquarium air pump (Shark RS-610, China) was used for distribution of oxygen to every two aquariums by using hoses ended by air stones.
- Aquarium fish net (Nylon fishing nets with plastic handle) for fish handling and transport.

Fish, feed, and experimental design

Sixty fingerling Nile tilapias (*Oreochromis niloticus*) were obtained from a fish breeding farm in Beheira Governorate and acclimatized to laboratory conditions for 2 days before starting the experiment. Fingerlings were acclimatized to temperature of aquarium water for 20 minutes before it is released to avoid stress. Acclimatization occurred by partial replacement of bags water by aquarium water and then fish released into aquarium. Fingerling were randomly sampled and divided into three groups (10 fish per aquarium) with two replicates per treatment with initial mean body weight 29.4 ± 3.41g according to Azodi et al. (2016). The experiment lasted for 64 days.

The first group (control group): fish were fed three times daily through the experimental period.

The second group (R1): fish were deprived for 4 days and then re-fed for 16 days that achieved 4 cycles of depriving and re-feeding throughout the experimental period.

The third group (R2): fish were deprived for 8 days and then re-fed for 32 days to achieve 2 cycles of depriving and re-feeding throughout the experiment period.

All fish of three groups were fed on commercial diet at 2% of body mass. Fish were fed floating crumbles Tilapia ration from (Aller Aqua Company – Egypt) which contains 32% crude protein 17.2% ration total energy, 3% fiber and 5% crude fat. Water in aquarium was recurrently changed once a week and the amount of replaced water was ranged between 25 and 50% from the whole amount depending on the condition of water in aquarium. During experimental period, fish were reared under a photoperiod of 12 h light: 12 h dark.

Data recording

All experimental fish were weighed individually at the start of the experiment and every 2weeks until the end of the experiment. The fish were starved 12 h prior to weighing. According to method of Chris *et al.,* (2011), the following items were calculated at the end of experiment:

Weight gain (WG) = Final weight (Wt) – Initial weight (W0) (g)

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

Feed efficiency (FE) = (Wt - W0)/I

Economic conversion ratio (ECR) = Feed conversion ratio (FCR) x Price of ration (EGP)

Average feed cost (AFC) = Average feed intake (FI) x Price kg of ration (EGP)

Water Cost (WC) = Amount water used x Price liter of water (EGP)

Total Cost (TC) = Feed + Water cost (EGP)

Benefit/cost ratio (B/C) = Total return / Total cost

Where:

W0 and Wt are fish initial and final weights (g),
t is the feeding period (days), and I is total feed consumption (g).

Water quality parameters

Water quality parameters were measured twice weekly for each aquarium throughout the experiment [pH, Dissolved oxygen (D.O), Turbidity and Ammonia].

Statistical analysis

Data were analyzed using SAS system (2002) in Statute Inc, Cary, NC, USA, using one-way NOVA and correlation

RESULTS AND DISCUSSION

Productive performance analysis

Table 1 revealed that, the weight gain of restricted fish for 4 days (R1) and control group was higher than restricted fish for 8 days (R2) (45.55±4.56, 39.69±4.84 and 27.18±4.84 g respectively, P=0.01). Moreover, feed efficiency of fish restricted for (R1) was higher than restricted fish for (R2) and fish in control group throughout experiment period (0.20±0.02, 0.09±0.02 and 0.10 ± 0.02 g respectively, P=0.001). Nile tilapia had a high ability to grow sufficiently to fully compensate for weight loss during starvation, and the compensatory response was depending on the length of feed deprivation as well as the number of cycles of starvation.

Total feed intake was affected by duration of restriction. Fish of control and 8 days restriction groups showed higher feed intake than 4 days restriction group (2.70±0.21, 2.55±0.21 and 1.65±0.20 % day respectively, P=0.01). Feed conversion ratio was significantly better in restricted fish 4 days and 8 days groups than control group (4.70±0.30, 4.18±0.23 and 6.17±0.61g respectively, P=0.05). Also, economic conversion ratio was significantly superior in restricted groups (4 and 8 days) than control fish (140.17±9.81, 123.41±7.55 and 453.86±19.62 respectively, P= 0.001). However, feed conversion ratio and economic conversion ratio were not significantly differed between restricted groups as shown in Table (1).

Tilapia fish exposed to only two cycles of restriction had less weight gain than 4 cycles of restriction and control groups that were significantly similar. Although the duration of starvation was the same (16 days totally) in both 2 and 4 cycles groups, the fish exposed to 8 days fasting and 32 days re-feeding through 2 cycles showed the worst growth rate compared to fish in group of 4 days fasting and 16 days re-feeding through 4 cycles. Therefore, the long term of feed deprivation within few cycles may explain why tilapia fish in two cycles of restriction group showed partial compensation.

In relation to starvation period, fish that exposed to fasting for 8 days and 32 days re-feeding (8F:32R) may be more stressed than fish fasting for 4 days and 16 days re-feeding (4F:16R). Indeed, exposure to stress may be considered one of the main causes for reducing appetite and thus growth rate (Wendelaar, 1997). Accordingly, less foraging activities and feed efficiency and thus reducing body weight that observed in group fasted for 8 days may be attributed by long starvation stress.

These results were in close agreement with Eroldoğan et al. (2008) who reported that, in sea breams, the economic conversion ratio values of the fishes fed in 2 days starvation / 2 days starvation were lower than those of control group.

2. Economic performance analysis

There was a significant difference due to repeating cycles of deprivation and re-feeding regime on feed and water cost, where the highest mean in feed cost was related to control group (14.9±1.16 EGP) while the lowest feed cost was observed in restricted fish for 4 days (8.6±1.1 EGP) (P=0.05) as shown in Table (2). Moreover, water cost was lower in restricted fish for 8 days and 4 days in order and the highest water cost was control group (1.8, 2.1 and 2.4 EGP respectively, P=0.05).

Cost benefit analysis under feed restriction of tilapia fish indicated that, the highest return showing in control group and restricted fish for 4 days (989.2±29.52 and 977.4±31.86 EGP, respectively) and the lowest return in restricted fish for 8 days (815.8±31.5 EGP, P=0.05). Furthermore, benefit cost ratio appeared higher in restricted fish group for 4 days (91.3). This may be attributed to long starvation period and low number of cycles in fish fasted for 8 days. These results might be due to decrease feed and water cost in this group. Abdel-Hakim et al. (2009) who reported that, in the cost benefit analysis of feeding regime the results suggest to reducing feeding costs via deprived food slightly at one or two days which have the same growth and good performance with reducing costs. But severe deprivation had worst results.

3. Water quality parameters

Results in Table (3) illustrated that, repeating cycles of deprivation and re-feeding regimes had a significant effect on some parameters of water quality. The dissolved oxygen of restricted groups (4 and 8 days) was significantly more than dissolved oxygen in control group (5.70±0.31, 5.92±0.34 and 4.69±0.31 ppm respectively, P=0.01). Furthermore, water pH of restricted (4 and 8 days) groups was high in compared with water pH of un-restricted group (8.05±0.04, 8.07±0.04 and 7.93±0.04 respectively, P=0.01). However, turbidity of water in restricted fish group for 8 days was significantly lower than turbidity of water of control group (11.59±4.14 and 27.50±3.75 NTUs respectively, P=0.01).

In addition, ammonia of water of restricted fish group for 8 days was significantly lower than in control group (2.84±0.50 and 4.92±0.45 mg/L respectively, P=0.01). However, temperature of water did not significant affected by repeating cycles of deprivation and re-feeding system (P>0.05). These support Marty and Donald (2003) who reported that, feeding restriction reduce levels of harmful parameters of water quality.

Results in Table (4) denoted that, under feed deprivation the dissolved oxygen was positively correlated with pH and negatively correlated with turbidity and ammonia. Additionally, when water turbidity increased the level of ammonia of water increased and water pH decreased.

CONCLUSION

Fishes which exposed to long starvation periods (8F:32R) consumed more feed during re-feeding phases compared to other restricted group (4F:16R). The highest feed efficiency was observed in fish exposed to 4F:16R. On contrary, this group showed less feed intake than 8F:32R and control groups. Although the fish had improved feed efficiency without increased feed intake, this may be indicated effective digestibility that reflected on growth. Moreover, cost benefit analysis under restriction of Nile tilapia fish indicated that, the highest return showing in control group and restricted fish for 4 days and the lowest in restricted fish for 8 days. Furthermore, benefit cost ratio appeared higher in restricted fish group for 4 days. Although the highest feed cost and water cost was related to control group and the lowest feed cost and water cost was related to restricted fish for 4 days. Restricted fish for 4 days showed higher return than restricted fish for 8 days. On the other hand, parameters of water quality were significantly affected by feed restriction regimes. Both 4 days and 8 days fasting groups improved dissolved oxygen as well as water pH in comparison with control group. On contrary, turbidity and ammonia levels were more in control group than both restricted groups.

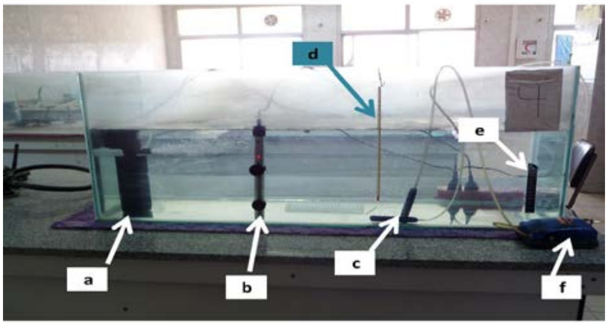

Fig. (1): Aquarium tools (a: Aquarium filter and pump, b: Heater with thermostat, c: air stone, d: Aquatic thermometer, e: Sticker thermometer and f: Electrical aquarium air pumps).

Table 1. Effect of repeating cycles of deprivation and re-feeding on performance of tilapia fish

Growth parameter	**Treatment**			***P- value***
	Control	**R1 (4 days)**	**R2 (8 days)**	
WG (g)	39.69 ±4.84^a	45.55±4.56^a	27.18±4.84^b	**
FE	0.10± 0.02^b	0.20±0.02^a	0.09±0.02^b	***
FI (g)	2.70±0.21^a	1.65±0.20^b	2.55±0.21^a	**
FCR	6.17±0.61^a	4.70±0.30^b	4.18±0.23^b	*
ECR	453.86±19.62^a	140.17±9.81^b	123.41±7.55^b	***

R1: 4 day fasting and 16 day re-feeding; R2: 8 day fasting and 32 day re-feeding.

*significant at 0.05, **significant at 0.01, ***significant at 0.001. $^{a-b}$: Means carrying different superscripts at the raw are significantly differed WG: weight gain, SGR:specific growth rate, FE: feed efficiency, FI: feed intake,

FCR: feed conversion ratio, ECR: economic conversion ratio.

Table 2. Cost benefits analysis under repeating cycles of deprivation and re-feeding of tilapia fish

Treatment	**Cost (EGP)**		**Total cost**	**Return (EGP)***	**B/C ratio****
	Feed	**Water**			
Con	14.9±1.16^a	2.4^a	17.3^a	989.2±29.52^a	57.2
R1	8.6±1.1^c	2.1 ^{a}	10.7^c	977.4±31.86^a	91.3
R2	14±1.16^b	1.8^b	15.8^b	815.8±31.5^b	51.6

Con: control group, R1: 4 day fasting and 16 day re-feeding; R2: 8 day fasting and 32 day re- feeding.

*Return calculated according to weight. **B/C ratio: Benefit cost ratio. $^{a-b}$: Means carrying different superscripts at the column are significantly differed at 0.05.

Table 3. Effect of repeating cycles of deprivation and re-feeding on overall water quality parameters

Water quality parameters	**Treatment**			***P- value***
	Control	**R1**	**R2**	
DO (PPm)	4.69±0.31^b	5.70±0.31 ^{a}	5.92±0.34^a	**
pH	7.93±0.04^b	8.05±0.04^a	8.07±0.04^a	**
Temperature (°C)	27.22±0.40	27.29±0.41	27.33±0.45	NS
Turbidity (NTUs)	27.50±3.75^a	20.22±3.83^{ab}	11.59±4.14^b	**
Ammonia (mg/l)	4.92±0.45^a	3.85±0.47^{ab}	2.85±0.50^b	**

R1: 4 day fasting and 16-day re-feeding; R2: 8 day fasting and 32-day re-feeding DO: dissolved oxygen

Ns: non-significant, ** significant at 0.01. $^{a-b}$: Means carrying different superscripts at the raw are significantly differed.

Table 4. Correlation coefficient between dissolved oxygen (D.O), pH, turbidity, ammonia under effect of repeating cycles of deprivation and re-feeding in tilapia fish

	pH	Turbidity	Ammonia
D.O	0.73***	-0.62***	-0.43***
Ammonia	-0.33**	0.51***	
Turbidity	-0.49***		

Significant at 0.01, * Significant at 0.001.

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