RESEARCH ARTICLE

Evaluation of Growth Response and Food Utilization Efficiency in Tilapia, *Oreochromis mossambicus* (Peters), Fingerlings Fed Supplemented Dietary Protein Levels with Varying Feeding Rates in Concrete Tanks

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Evaluation of Growth Response and Food Utilization Efficiency in Tilapia, *Oreochromis mossambicus* (Peters), Fingerlings Fed Supplemented Dietary Protein Levels with Varying Feeding Rates in Concrete Tanks

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Abstract
A four weeks laboratory feeding trial was conducted to assess the effect of dietary crude protein levels of 32.68% as basal protein diet (BPD) and 22.40% as low protein diet (LPD) fed at different feeding rates on growth performance, feed and nutrient utilization of tilapia, *Oreochromis mossambicus*. Fish were reared utilizing outdoor concrete tanks of $1 \times 1 \times 1$ m. The results showed that growth performance of tilapia fingerlings was significantly ($p < 0.05$) increased at the higher dietary protein levels. Feed efficiency was significantly ($p < 0.05$) reduced in terms of protein efficiency ratio (PER) and specific growth rate (SGR) at the LPD tested. Further, the results clearly showed that fish growth was best at the BPD level tested. Furthermore, in term of percentage weight gain and daily weight gain, there was a progressive improvement in the growth responses with increasing dietary feeding rates at LPD levels, while weight increment in fish fed with BPD achieved a mean final weight of 41.11 g, LPD at 6% body weight of 29.55 g, LPD at 8% body weight of 31.50 g and LPD at 10% body weight of 33.02 g, respectively. Protein, lipid and moisture content were influenced significantly by dietary protein levels. There was a significant increase in muscle protein and a decrease in lipid content with increasing dietary protein. The growth performance of *O. mossambicus* fingerlings was monitored under laboratory conditions.

Keywords: Basal and low protein diets; proximate composition; growth performance; *O. mossambicus*.

1. Introduction

Tilapia is one among the most successful largely cultured finfish species in the world, because of their fast growth rate and ability to feed low on the aquatic food chain. Moreover, tilapia are easy to reproduce and handling are having good resistance to disease and tolerance to wide range of environmental conditions. These are being found in over 100 countries [1].

With the intensification of culture methods for tilapia species during recent years, it has become necessary to provide complete rations to meet their dietary nutrient requirements. Numerous studies have been conducted so as to ascertain the dietary protein requirements of tilapia, *Oreochromis niloticus* with reported dietary protein requirements ranging from 30% crude protein in the case of pond reared fish and juveniles [2, 3] to over 45% crude protein in the case of fry and fingerlings reared within indoor aquaria [2, 4]. In Tilapia production, feed cost is the major part of the variable costs and protein is the most expensive component of the feed. Thus, reducing the amount of protein in tilapia feed is one of the most important interests of aquaculture investigators.

If insufficient energy is available or if there is an excess amount of protein in relation to the concentration of dietary energy, the extra protein will be used as a source of energy [5, 6]. The nutritional requirements of tilapia are very similar to other warm water fishes. The diet of fishes must be balanced and should contain the primary or basic food components such as proteins, carbohydrates and lipids. Protein is the most expensive macronutrient in fish diet. The dietary protein requirement for fish fry is high and ranges from 35% to 56% [7].

Furthermore, dietary protein requirements decreased with increasing fish size and age [4, 8, 9]. Based on various studies, fry of tilapia of size <1 g requires diet with 35–50% protein, 1–5 g requires diet with 30–40% protein and 5–25 g requires diet with 25–35% protein [10].

As the culture of tilapia becomes more intensive, strategies for supplementary feeding associated with different protein levels will have to be assessed to reach maximum economic returns. Feeding frequency and feeding rates are one of the important considerations as it can affect growth and the efficiency of feed utilization. Feeding at the optimum rate can result in tremendous decrease in feeding costs. Taking the above considerations, the main objective of the study was designed to evaluate the effect of basal protein diet (BPD) and low protein diet (LPD) fed at varying feeding rates on growth performance, feed and nutrient utilization of tilapia *Oreochromis mossambicus* fingerlings cultured in pure seawater utilizing outdoor concrete tanks system.

2. Methods

2.1. Experimental animals

All male tilapia fingerlings with average body weight ranged from 2.99 to 3.75 ± 0.76 g was utilized for the feeding experiment at Brackishwater Aquaculture Center, Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao, iloilo, Philippines. Experimental facilities were located at Leganes, Iloilo, Philippines. Fingerlings were conditioned in a fiberglass tank in pure seawater wherein they fed with a commercial diet containing 30% protein for one week as an acclimation period to the laboratory conditions supplied with sufficient aeration. Fingerlings were fed twice daily. Upon stocking, the initial body weight of the fish was measured using digital weighing scale. Weight measurement was done by applying the volumetric method to minimize stress into the experimental animals. Fifty fingerlings were stocked in each concrete tank of (1 × 1 × 1 m) hapa nets. All initial measurements were done on the same day and the fish were randomly stocked in the experimental units.

2.2. Diet preparation and water management

BPD and LPD were formulated, and the proximate composition was performed using Table 1 [11]. The stocks were fed to satiation BPD and three levels of 6%, 8% and 10% body weights of LPD, respectively. Feeding was done three times daily in 08:30, 12:30 and 16:30 h, respectively for a period of 8 weeks. Weight gain (WG) and increases in total weight of the fingerlings over 4 weeks culture period were estimated as well as the survival rate, protein efficiency ratio (PER), specific growth rate (SGR) and feed conversion ratio (FCR) upon termination. Moreover, physico-chemicals properties of the water were monitored weekly for ammonia and pH analysis by taking water samples from each tank in the laboratory. However, temperature, dissolved oxygen and salinity were done every week *in situ*. Stock sampling was done weekly. Water exchange of 50% of the total volume of the water was made weekly.

2.3. Statistical examination of the data

Data were analyzed by one-way analysis of variance (ANOVA). When differences were found among treatments, Duncan multiple test was used to compare means by SPSS Software (SPSS, USA). Differences were considered significant at $p < 0.05$.

Table 1: Composition and proximate analysis of the tested diets on dry weight basis.

Ingredients of the diets							
Dietary protein levels	Fish meal (g)	Soy beans meal (g)	Copra meal (g)	Rice bran (g)	Bread flour (g)	Minimum vitamin mix (g)	Total (g)
BPD	15.00	23.00	6.00	37.00	15.00	4.00	100
LPD	6.00	10.00	7.00	43.00	28.00	6.00	100

Experimental diets						
Dietary protein levels	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	NFE (%)
BPD	9.91	32.70	3.07	5.35	12.22	48.43
LPD	9.95	22.40	2.38	5.30	11.39	58.02

3. Results and Discussion

Physico-chemical analysis of seawater was performed weekly. Salinity range from 31.2 to 29.7 ppt and dissolved were taken *in situ* and ranged from 8.2 to 4 ppm. Samples of water in all tanks were taken between 08:00 and 09:00 h before water exchange for analysis. Total ammonia nitrogen (TAN) was measured using spectrophotometer and ranged from 0.114 to 0.030 ppm, while alkalinity was determined using pH meter which revealed to be from 8.70 to 7.48 ppm. Dissolved oxygen and temperature were measured using YSI oxygen meter, while salinity was measured using refract meter.

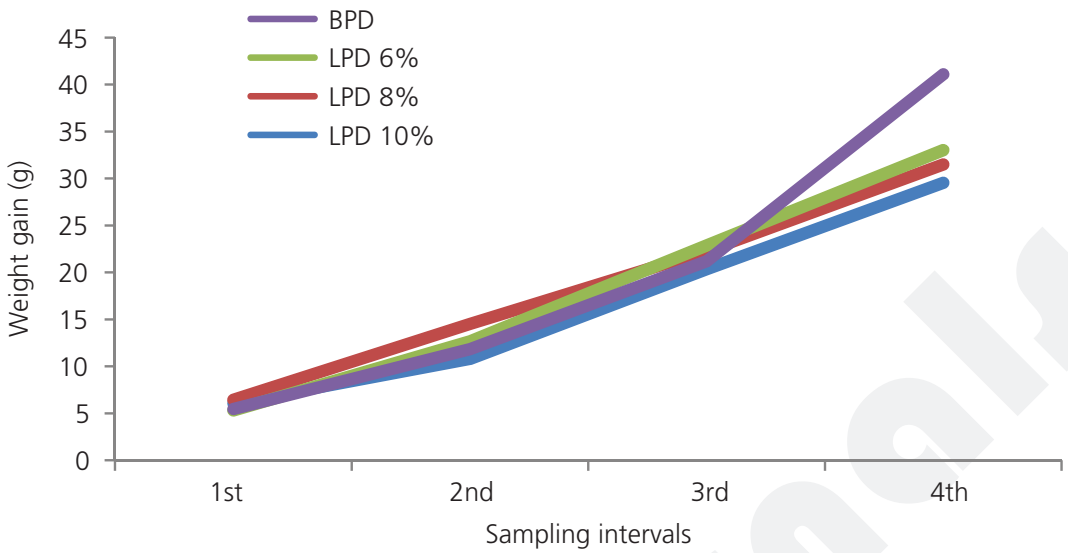
Growth performance parameters for tilapia *O. mossambicus* fingerlings after the feeding experiment were presented in Table 2. It was evident that there was a significant effect of dietary protein on growth performance of the experimental fish. WG and SGR increased significantly with increasing dietary protein levels from 22.40% to 32.70%. However, the differences between the growth values obtained by fish fed at 6% and 8% feeding rates of LPD were not significantly affected by the differences in feeding rates. Fish fed on 10% body weight of LPD thus exhibited comparable growth in terms of WG, average daily WG and SGR, respectively. Lower FCR was observed.

Growth performance of *O. mossambicus* fingerlings showed an increasing trend from the first to the final sampling (Figure 1). It was observed that treatment with BPD obtained a best mean final body weight of 41.11g, with LPD of 6% feeding rate which has final body weight of 29.55 g, with LPD of 8% feeding rate achieved 31.50 g and LPD of 10% feeding rate obtained 33.02 g, respectively. Values of growth parameters of the fingerlings fed diets at varying feeding rates over the experimental period were shown in Table 2.

Based on the % WG, there was an progressive improvement in the growth responses with increasing dietary protein level upon weight increment (in BPD) obtained a mean final weight of 41.11 g in BPD, 29.55 g LPD at 6% body weight, 31.50 g in LPD at 8% body weight and 33.02 g in LPD at 10% body weight. In contrast, similar observation reported [12] that the growth of *O. mossambicus* juveniles increased with dietary protein levels up to 38% and 40%, at different feeding regimes, respectively.

There was a remarkable increase in % WG and SGR in experimental groups compared with the BPD. Certainly, comparing % WG between the four treatments it was clear that fish fed at BPD and LPD of 10% body weight significantly obtained more % WG compared with the fish fed at LPD of 6% and 8% body weights. In feeding trial with different feeding scheme, there were significant differences in term of PER which revealed to be lower in higher protein diet, as well as FCR with slightly significant differences between BPD and LPD with different feeding rates treatments, but no significant difference among LPD different feeding rates.

Figure 1: Growth performance trend of O. mossambicus fry during 30 days culture period.



Better FCR was observed in fish fed on LPD at 8% body weight. Overall growth obtained from fish fed on LPD at 6%, 8% and 10% was lower comparing with fish fed on BPD. Thus, there were no significant differences in survival among fish groups (Table 2).

Table 2: Mean growth performance indices (mean ± SD) as compared between BPD and different levels of LPD fed to *O. mossambicus* for 30 days.

Treatments	Initial weight (g)	Final weight (g)	WG (%)	SGR (%)	PER	FCR	Survival rate (%)
BPD	3.65 ± 0.54^{a}	41.11 ± 2.48^{b}	1027.85^{a}	3.51^{a}	3.09 ± 0.97^{a}	1.80^{a}	90.00^{a}
LPD 6%	2.99 ± 0.17^{a}	29.55 ± 8.88^{a}	887.40^{b}	3.31^{a}	2.35 ± 0.93^{b}	1.74^{a}	92.33^{a}
LPD 8%	3.51 ± 0.42^{a}	31.50 ± 2.51^{a}	797.44^{c}	3.18^{b}	3.53 ± 0.16^{a}	1.70^{a}	87.25^{a}
LPD 10%	3.76 ± 0.25^{a}	33.02 ± 11.85^{a}	779.36^{c}	3.15^{b}	4.22 ± 0.36^{a}	1.58^{b}	88.00^{a}

^{a,b}Means within columns without a common superscript are significantly different ($p < 0.05$).

Biochemical analysis of fish carcass (Table 3) reveals that protein, lipid and moisture content were significantly influenced by dietary protein level. There was a significant increase in muscle protein and a decrease in lipid content with increasing dietary protein. Fish fed 32.70% protein diet had higher content of protein

Table 3: Biochemical analysis of *O. mossambicus* carcass fed different levels of dietary protein.

Sample	Moisture (%)	Percent dry basis				
		Ash (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	NFE (%)
Initial sample	60.28	15.63	53.51	19.80	1.07	9.99
BPD	72.32^{b}	14.73^{a}	56.673^{a}	20.40^{b}	0.63^{b}	9.11^{b}
LPD 6%	71.35^{b}	15.49^{a}	55.13^{a}	16.20^{c}	1.27^{a}	10.37^{a}
LPD 8%	71.59^{b}	16.31^{a}	54.70^{b}	18.98^{b}	1.00^{a}	9.01^{b}
LPD 10%	74.20^{b}	16.27^{a}	53.13^{a}	22.01^{a}	0.80^{b}	7.79^{c}

^{a,b}Means within columns without a common superscript are significantly different ($p < 0.05$).

than fish fed at 6%, 8% or 10% body weight of LPD as 22.40% protein. This relationship was also noted on mozambique tilapia, *Sarotherodon mossambicus* [12], on grass carp, *Ctenopharyngodon idella* [13], on guppy, *Poecilia reticulata* [14], on hybrid tilapia, *O. niloticus* and *O. aureus* [15] and on Nile tilapia, *O. niloticus* [16–19].

The increase in muscle protein and decrease in lipid content with increasing dietary protein levels may be attributed to the high carbohydrate and low protein content in the diet of low protein levels (Table 1). The excess carbohydrate in the diet may be converted into body fat for storage [14]. Ash content was unaffected by dietary protein level. This result is similar to that obtained in *O. niloticus* collected from fish ponds [19, 20].

4. Conclusion

The results from the present study showed a marked increase in growth performance, especially % WG, PER and SGR of *O. mossambicus*. A better and slight enhancement in FCR and body composition in diets containing 32.68% protein compared with 22.40% protein inclusion reared in concrete flow-through tanks system were observed. Further, these findings might reveal that a diet containing 32.68% protein fed at 10% feeding rate appears to be economical and suitable for *O. mossambicus* fingerlings reared in pure seawater conditions.

Competing Interests

The author declares that he has no competing interests.

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