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EFFECTS OF VARYING DIETARY PROTEIN LEVELS ON DEVELOPMENT OF GONADS AND NUTRIENT RESERVES OF TANK RAISED *Tilapia rendalli* (BOULENGER, 1896)

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AUTHOR'S CONTRIBUTION
This work was carried out in collaboration between all authors. Author RM designed the study, wrote the protocol, designed and conducted experiment, interpreted the data, gathered the initial data, managed the literature searches, performed preliminary data analysis while authors FK, WS and HZ supervised the entire research work.

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ABSTRACT

This study was carried out to investigate the effects of varying dietary protein levels in feed on reproductive performance of *Tilapia rendalli*. One hundred and eighty (180) *Tilapia rendalli* fingerlings with an average body weight of 9.8±0.02 g were stocked into 12 experimental concrete tanks at 15fish per $3m^3$. The fish were subjected to four level crude protein (CP) diets - 30%, 35%, 40% and 45% for 90 days. High nutrition reserves was realised in the fish fed on 40% CP compared to those fed on 30%, 35% and 45% CP diets. Conversely, dietary protein level within the range of 30 to 45% did not significantly affect gonadosomatic index. The study recommends that *Tilapia rendalli* should be fed on a diet containing 40% protein level to achieve high reproductive performance.

Keywords: Gonadosomatic index; hepatosomatic index; dietary protein; *Tilapia rendalli.*

1. INTRODUCTION

Study has shown that protein is one of the most important and expensive macronutrient in fish diet [1]. Studies in bloodstock nutrition have been limited due to high production cost incurred to maintain prolonged experiment during the study period. Therefore the study of gonadosomatic index is very imperative and essential for massive production of fingerlings.

Study has further shown that although gonadosomatic index is the main parameter used to assess gonadal development, little attention is paid to nutrient reserves in the hepatopancreas using either hepatosomatic index (HIS) or biochemical composition [2]. Hepatosomatic index is an important parameter associated with energetic reserves and metabolic activities in the fish. The study of hepatosomatic index provides crucial information about the condition of liver and body and also impact of water pollution on the fish. It further

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provides an indication on status of energy reserve in fish which determines the development of the gonads.

Therefore, the main objective of the study was to assess the optimum economically viable dietary protein level that gives optimum gonadal development and nutritive reserves of *Tilapia rendalli*.

2. MATERIALS AND METHODS

The experiment was conducted at National Aquaculture Center in Domasi, Zomba Southern Malawi (15º17'0" South and 35º24'0" East). Experiment was conducted in $3m^2$ concrete tanks laid out in a completely randomised design (CRD) with four treatments replicated three times to match 12 experimental tanks. *Tilapia rendalli* fingerlings average body weights (9.8 g) were stocked into $3m^3$ experimental tanks at $5fish/m^3$. Fish in the four treatments were fed twice (10:00-15:00 hrs) with calculated at 5% live body weight and with an inclusion of 30% CP, 35% CP, 40% CP and 45% CP respectively for a period of 90 days. The four dietary protein feed were formulated using Linear Programming model as shown in Table 1. Prior to formulation, the tested diets from each treatment were chemically analyzed according to the standard methods of [3] for, protein, fat, fibre and ash as shown in Table 2.

2.1 Water Physio-Chemical Parameters

Water quality parameters that influence growth of fish [4] mainly dissolved oxygen (DO), temperature, pH and ammonia were measured every day at 10 am and 2 pm.

2.1.1 Sampling

Sampling was done for every 3weeks to determine new mean weights for various experimental units. A sample of 30 fish was obtained from each treatment (10 fish from each replicate).

2.2 Growth Performance Evaluation

After 90 days, fish were harvested and final weight, weight gain, Feed conversion ratio, protein efficiency ratio and mortality rate were determined. *Weight gain (g) = Final Weight of fish (g) - Initial weight of fish (g*); *Feed conversion ratio (FCR) = Total feed consumed by fish (g)/Weight gain by fish (g), Mortality (M) = (Number of fish at the start of the experiment – Number of fish at the end) × 100/ (Number of fish at the start of the experiment)*.

2.3 Organs Indices Evaluation

After 90 days, all fish were killed, and abdominal cavity was opened to remove liver and gonads. Each of them was weighed individually. Hepatosomatic index (HSI) and Gonadosomatic Index (GSI) were calculated as follows:

HIS =100 (liver weight (g)/body weight (g))
GSI =100(Gonads weigh (g))/(body weight (g))

Table 1. Feed formulation

Ingredients	Crude protein			
	30% CP	35% CP	40% CP	45% CP
Fishmeal	41	36.1	50.2	54.7
Soybean	47	39.4	24.9	14.7
Maize bran	11.4	23	24.3	30
Minerals	0.2	0.2	0.2	0.2
Vitamin	0.2	0.2	0.2	0.2
Binder	0.2	0.2	0.2	0.2
TOTAL	100	100	100	100

The ingredients were subjected to proximate analysis using standard methods according to (AOAC, 2003). Crude protein (CP), dry matters (DM), crude fibre (CF) and ash content were determined

Table 2. Chemical composition of the ingredients used to formulate three test diets on dry weight basis

Samples	Proximate composition			
	% Crude protein	% Crude fat	% Crude fibre	% Ash
Fish meal	64.63±0.36	4.1±0.02	4.4±0.01	14.7±0.03
soybean	45.3±0.45	18.1±0.23	0.23±0.01	7.4±0.4
Maize bran	10.81±0.02	4.2±0.32	10.7±0.03	3.78±0.24

2.4 Statistical Analysis

Data collected was entered into SPSS Statistical Software Program (version 16) and means for treatments: total weight, weight gain, FCR, survival rate, HIS and GSI were compared using two way analysis of variance (ANOVA) at 5% level of confidence. Duncan's Multiple Range Test (DMRT) was used to separate means for significance.

3. RESULTS AND DISCUSSION

3.1 Water Physio-Chemical Parameter

The water quality parameters in the tanks during experimental period were within the limit recommended for tilapia reproduction [5], since means of temperature (ºC), pH, dissolved oxygen (mg/l) and ammonia concentration (mg/l) were around 24.5ºC to 24.8ºC, dissolved oxygen from 7.5 to 7.5 mg/l and pH from 8.3 to 8.5 and ammonia (mg/l) from 0.14-0.23 respectively. The results for water quality parameters are presented in the Table 3.

3.2 Growth Performance Evaluation

The study revealed significantly ($P<0.05$) high growth performance and weight gain in the diet containing 40% CP. The results conform to the work of Tendulkar and Kulkarni, [6] who observed increase in fish growth with increase in dietary protein levels in feed. Similar trend was reported by Makwinja et al. [7] in *Tilapia rendalli* fed varying dietary protein levels. Conversely, the study revealed that further increase in dietary protein level reduces growth performance and protein efficiency ratio. This was evidenced in the diet containing 45% CP. Similarly, Jamabo and Alfred-Ockiya [8] reported that fish fed with diet containing 45% protein, nitrogen metabolism and protein efficiency ratio decreased showing the bad utilization of dietary protein. The study further agrees with Ahmad et al. [9] who reported highest growth rate in tilapia fed on 40% dietary protein level during the research period. Results from this study further explain that the decrease of growth beyond 40% can be due to the fact that the fish cannot use all of the available protein. Table 4 shows experimental *Tilapia rendalli* growth and Feed conversion ratio results.

3.3 Gonadosomatic and Hepatosomatic Evaluation

Gonadosomatic Index (GSI) has been proven to be a significant parameter for monitoring gametogenesis progression in teleost fish [10] The results from the study have revealed that dietary protein levels had no significant ($P>0.05$) influence over the male and female GSI. Therefore, it is more economical to give the broodstock the amount of protein in the diet just enough for fish growth and avoid wasteful of the excess protein in fish diets which may cause the diets to be unnecessarily expensive [11].

Conversely, significant ($p<0.05$) differences among treatments were observed in hepatosomatic index. The fish fed on 40% CP had significantly higher hepatosomatic index than the rest suggesting that increase in dietary protein levels result in significantly increase in nutritive reserves in the hepatopancreas. However, further increase in dietary protein level above 40% CP results into significantly decreases in hepatosomatic index. The study conforms to the findings of Rodrı´guez-Gonza´lez et al. [12] who tested different dietary protein levels on gonadal development and found that high protein levels resulted in increased protein and carbohydrates content in the hepatopancreas up to a certain point after which the HSI declines. Table 5 shows Gonadosomatic Index (GSI) and hepatosomatic index (HSI) analysis.

However, decrease in hepatosomatic index after 40% CP is in line with what has been previously reported by several researchers who observed the lowest hepatosomatic index in *C. carpio* fed on higher crude protein and lower carbohydrate diets [13-16].

Table 3. Water quality parameters measured in tanks stocked with *Tilapia rendalli* for 90 days (mean ± SE)

Parameter	Treatment			
	30%CP	**35%CP**	**40%CP**	**45%CP**
PH	8.5±0.1[a]	8.4±0.12[a]	8.7±0.23[a]	8.3±0.01[a]
DO(mg/l)	7.5±0.0.2[a]	7.3±0.2[a]	7.4±0.31[a]	7.3±0.03[a]
Temp(ºC)	24.25±0.1[a]	24.24±0.1[a]	24.3±0.03[a]	24.8±0.2[d]
Ammonia (mg/l)	0.14±0.03[a]	0.2±0.04[a]	0.13±0.01[a]	0.12±0.05[a]

Values with the same superscript in a row are not significantly different (P>0.05)

Table 4. Experimental *Tilapia rendalli* growth and feed conversion ratio results (mean ± SE)*

Parameter	Treatments				
	30%CP	35% CP	40%CP	45%CP	P value
Initial Weight (g)	9.77±0.02[a]	9.87±0.2[a]	9.53±0.23[a]	9.7±0.23[a]	0.783
Final weight (g)	46.6±0.49[a]	50.08±0.9[b]	53.93±0.93[c]	42.1±0.23[d]	0.000
Weight gain	36.9± 0.38[a]	40.5±0.8[b]	43 ±1.2[c]	32.4±0.76[d]	0.000
Feed conversion ratio	3.2±.0.03[a]	3.01±0.05[b]	2.9±0.05[c]	3.5±0.062[d]	0.000
Protein Efficiency ratio	0.7±0.04[a]	0.77±0.09[b]	0.72±0.1[c]	0.5±0.062[d]	0.000
Survival (%)	89±1.21[a]	92±0.15[b]	94±0.48[c]	93±0.02[d]	0.000
Condition factor(g/cm^{-3})	4.87±0.14[a]	5.02±0.15[b]	3.65±0.15[c]	0.19±0.008[d]	0.000
SGR(%day^{-1})	1.75±0.014[a]	1.83±0.027[b]	1.88±0.024[c]	1.64±0.016[d]	0.000

Values with the same superscript in a row are not significantly different (P >0.05

Table 5. Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) analysis (mean ± SE)*

Parameter	Test diets				
	30% CP	35% CP	40% CP	45% CP	P value
FHSI	0.85±0.13[a]	1.23±0.19[b]	1.53±0.13[c]	1.36±0.11[d]	0.033
FGSI	1.6±0.60[a]	2.4±0.52[a]	3.2±0.0.82[a]	1.15±0.76[a]	0.503
MHSI	0.86± 0.18[a]	1.25±0.06[b]	1.91 ±0.06[c]	1.4±0.05[d]	0.000
MGSI	0.14±.0.08[a]	0.17±0.06[b]	0.18±0.06[c]	0.14±0.038[d]	0.498

Values with the same superscripts in a row are significantly different (P<0.05)
Note: FGSI = Female Gonadosomatic index, FHSI = Female Histosomatic Index, MDSI = Male Gonadosomatic Index, MHSI = Male Histosomatic Index

4. CONCLUSION

The present study has demonstrated that further increase in dietary protein above 40% CP has no significant effect on the development of gonads. It is concluded therefore, that it is more economical to feed broodstock of *Tilapia rendalli* with diet containing 40% crude protein. Further increase in dietary protein will result into higher production cost while growth performance significantly declines.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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