

RESEARCH ARTICLE

Available Online at <http://www.aer-journal.info>

Assessment of Duckweed Supplement Diet to Fishmeal on the Growth Performance of *Oreochromis niloticus* Fingerlings

E. Wanderi¹ and R. Olendi^{1*}

¹University of Eldoret, Department of Fisheries

^{1*}University of Eldoret, Department of Fisheries; rjolendi@yahoo.com

Abstract

Oreochromis niloticus is the most cultured fish in tropical freshwater aquaculture systems and second most cultured fish after carps in the world. In Kenya, *Oreochromis niloticus* has potential in eradicating hunger and poverty but this is limited because of its low yield attributed to unavailability of quality, reliable and affordable farm-made feeds, and a problem that needs to be addressed. Initiatives geared towards improving *Oreochromis niloticus* production but main challenges still remain to be cost implication in the production of feeds. This study aims at addressing feed costs challenges by the use of an alternative locally available feeds to replace the expensive commercially produced feeds. The study was to study was conducted at Dominion farm situated in Siaya County along the shores of Lake Victoria in Western Kenya. The main objective was to assess the effects of locally available duckweed diet on growth performance of *O. niloticus* fingerlings. 450 experimental sexed reversed male fingerlings of mean weight 3.1 ± 0.10 and length of 17.44 ± 0.42 mm were randomly distributed in three concrete circular tanks of 500 litres capacity each with two replicates. In each tank, 50 fingerlings were stocked and fed with a food ration of 5% body weight for 72 days. The fingerlings were fed in the morning at 9.00 A.M. and evening 4.00 PM daily using a dry duckweed meal, fishmeal and control diet. Sampling was done biweekly where length and weight gain of the fingerlings were obtained using a measuring board and weighing scale respectively. Average weight at the end of the experiment for duckweed, 50% dry duckweed diet-50% fishmeal diet and control were 56.03 ± 1.15 , 59.54 ± 0.31 , 66.73 ± 1.79 , respectively. The dry duckweed diet influence on the growth parameters was less than fishmeal diets. However, at the ratio of 1:1 duckweed to fishmeal diet, the weight gain was significant. There was a significant difference in FCR, PER, AWG, and SR ($p < 0.05$) when fingerlings were fed with three diets. *Oreochromis niloticus* showed an increase in growth performance during the entire period. This result indicates that dry duckweed can be used to minimize the high cost of fishmeal without negatively affecting fish growth.

Keywords: Duckweed, Fishmeal, *Oreochromis niloticus*, fingerlings, growth

INTRODUCTION

Oreochromis niloticus, the Nile tilapia is one of the most widespread fish species in tropical freshwater aquaculture and second most cultured after carps in the world (Dagne *et al.*, 2013; Shelton & Popma, 2006). *Oreochromis niloticus* is cultured in

different systems from extensive, semi-intensive, and intensive aquaculture systems. Its ease to adoption to captivity attributed by good taste, high survival rate, ability to eat a wide variety of food and ability to reach sexual maturity very fast among many others (Dagne *et al.*, 2013;

Gupta & Acosta., 2001). In the world, *Oreochromis niloticus* productivity has been on an increase from 1,189,959 tons (t) in 2000 to 3,096,935 tons in 2009, and this statistic represents about 8.6 % of total farmed finfish (36,117,880 t) (FAO, 2010). In Kenya, *Oreochromis niloticus* production has been declining by approximately 19.8% between the year 2014 and 2016 despite the increment in the previous year from 2009 after the introduction of economic stimuli program (KMFRI, 2017). This declining trend in *Oreochromis niloticus* production has been attributed to unavailability of quality affordable feeds with most of the feed mills producing sinking pellets, poor water quality management, increasing demand of the fishmeal feeds for other use and expansion of the aquaculture systems (KMFRI, 2017; the Kenya Republic, 2013).

Feeding alone account for 30-70% of the total operation of the average fish farm and it profoundly influences the growth, productivity and in turn, the profitability of farmed fish (El-Sayed, 2004). The most critical issues appertaining to feeding is the cost of animal protein sources. Most animal protein sources such as fishmeal and fish oil are expensive, thus it has necessitated the need to identify economically viable and environmentally friendly alternatives, such as locally available plant protein (Glencross *et al.*, 2007) for the future development of aquaculture (Tacon *et al.*, 2006). In this case, locally available duckweed stands out as a one of plant protein to be incorporated into the fish diet locally as it can grow well in different climates (Leng *et al.*, 1995).

Duckweed is a small green floating flowering plant of the *Lemnaceae* family (Ahammad *et al.*, 2003). Its productivity varies between 10-30 tons dry matter/ha/year, depending on the species, climatic conditions, available surface area, amount of nutrient and management (Tavares *et al.*, 2008) hence adequate for fish growth. Duckweed has a high concentration of trace minerals, potassium, phosphorus and protein content of about 40-

43% dry weight (Leng *et al.*, 1995) with better amino acids profile than other vegetable protein (Hillman & Culley, 1978). Also, duckweed leaves contain less fibre of 5% in dry matter and highly digestible than other plants (Chaturvedi *et al.*, 2003). It produces vegetatively and hence it can be grown locally using nutrients rich wastewater from recirculation systems (Tavares *et al.*, 2008). Duckweed has also been widely used in other countries to curb high cost of protein source not only fish feed but also in cattle, poultry and swine feed showing favourable results (Skilicorn *et al.*, 1993). Thus, given these characteristics, duckweed stands to be among the protein-rich plant which may be used as a substitute for fishmeal diet in Kenya. Therefore, this study aims to investigate the effects of supplementing the commercial diet with duckweed diet on growth performance of *Oreochromis niloticus* reared in tanks.

MATERIALS AND METHODS

Study Area

The experiment was done in Dominion Farm located in Siaya County, on the reclaimed Yala swamps 28 km from Siaya Town and the farm lies between latitude 00° 02'N, 00° 02'S and longitude 34° 1' E 7'S. Agriculture activities carried out in Dominion farms include fish farming, rice farming, horticulture, dairy farming, poultry and sugarcane farming. The rice canals are enriched with aquatic plants such as azola and duckweed as a result of the presence of rich nutrients originating from the rice farms. The canal is also habited by *Oreochromis niloticus* which escapes from the fish ponds through the outlet during flashing of pond water. The *Oreochromis niloticus* in rice canal feed on the existing natural food such as duckweed and phytoplankton.

Experimental Fish

Four hundred and fifty sex-reversed experimental male *Oreochromis niloticus* fingerlings of mean weight of 0.44 g and length of 17.74 mm were transferred from

the hatchery to a holding tank for 48 hours. 50 fingerlings were taken into aerated experimental tanks of 500 litres capacity with two replicates and control and left for 24 hours to acclimatize prior to the experiment. The experimental tanks were labelled; tank 1 fishmeal, tank 2 duckweed-fishmeal, and tank 3 duckweed. Tank 1 fish were fed on fishmeal diet, tank 2 fish were fed with duckweed-fishmeal diet and tank 3 fish were fed with duckweed diet all at 5% body weight at 9.00 am and 4.00 pm on daily basis for 72 days. Weight and length were measured using weighing balance and fish measuring board respectively biweekly and recorded.

Diets

Commercial Diet (Fishmeal)

Fishmeal was obtained from Dominion fishmeal processing plant which had the following components: soya cake 25%, Lake Shrimp 20.28%, dried cassava 9.08%, maize bran 20.10%, rice bran 21.29% sunflower 3%, salt 1% and vitamin premixes 0.25%. These percentages were formulated by the Dominion Fish Feed Limited, a feed producer co company in Kenya using trial and error food formulation method using an excel software (KMFRI, 2017).

Duckweed-Fishmeal Diet

Using a weighing balance 50% dried duckweed diet and 50% fishmeal diet were determined. The diets were placed in a basin and mixed using a spatula.

Duckweed

Duckweed was collected using kick nets from the surface of canals located between rice fields in Dominion farm. It was drained and sundried on until it became crispy to touch. Completely dried duckweed was then crushed into powdery form. Proximate analysis was done according to (AOAC, 2000) to obtain their nutrient composition.

Measurement of Growth Parameters

Each fish was removed using a scoop net and placed in a tray and dried using the absorbent paper. Weighing balance and fish

measuring board were used to determine weight and length respectively. The fish was returned into another tray and at the end returned to the experimental tanks. This process was repeated until all fish were weighed. The experiment was repeated fortnightly until the end of the exercise. Food conversion ratios (FCR), specific growth rate (SGR) and percentage survival rate were determined according to (De Silva & Anderson, 1995) formula.

$$FCR = \frac{\text{Dry weight feed supplied}}{\text{Total weight gain by fish}}$$

$$SGR(\%) = \frac{\text{Ln}W_t - \text{Ln}W_o}{T(\text{days})} \times 100$$

$$S\% = \frac{\text{Initial fish count} - \text{dead fish count}}{\text{Initial fish count}} \times 100$$

$$\text{Average weight gain} = \frac{W_t - W_o}{T(\text{days})}$$

Where:

W_t = final body weight of fish in grams at the end of the experiment.

W_o = Initial body weight of fish in grams at the beginning of experiments.

Ln = Natural Logarithm of both final and initial body weight of fish in grams.

T = Duration (time) of the feeding trial in days.

N_o = Number of fingerlings alive at the end of the experiment

Protein Efficiency Ratio

Protein efficiency ratio (PER) is defined as the ratio between the weight gain of fish and the amount of protein fed (De Silva & Anderson, 1995)

$$PER = \frac{\text{Mean weight gain(g)}}{\text{Mean protein intake(mg)}}$$

Statistical Analysis

The data on length and weight were subjected to one-way analysis of Variance

(ANOVA) using the General Linear Model of SAS (2015) and where significance was indicated, Duncan's Multiple Range. Test option of the package was used to separate the means. Significance was determined at $P < 0.05$.

RESULTS

Effect of the Dietary Treatment on Food Conversion Ratios (FCR), Specific Growth Rate (SGR) and Percentage Survival Rate (%S), Protein Efficiency

Ratio (PER) and Mean Weight Gain (MWG)

The *Oreochromis niloticus* fingerlings showed a significant difference in term of FCR, PER, SGR, and MWG when fed with the three diets (Table 1), with fishmeal diet having the highest values followed by a fishmeal-duckweed meal and duckweed meal. Highest survival was recorded in fingerlings fed with duckweed meal followed by fishmeal and fishmeal duckweed combination.

Table 1: Growth Parameters of *Oreochromis niloticus*

Parameters	Fishmeal Diet	Ducked-Fishmeal Diet	Duckweed Diet
Initial weight gain(grams)	3.1±0.10	3.1±0.10	3.1±0.10
Final weight gain (grams)	66.73±1.79	59.54±0.15	56.03±0.31
Initial length (mm)	17.44±0.42	17.44±0.42	17.44±0.42
Final length(mm)	36.49±1.32	34.01±0.98	29.43±1.27
MWG	20.53 ^a	18.21 ^b	17.01 ^c
SGR	1.18 ^a	0.96 ^b	0.92 ^c
PER	1.31 ^a	1.32 ^b	1.26 ^c
FCR	2.10 ^a	1.93 ^b	1.77 ^c
%Survival	93	82	96

Values are mean ± SE for three replicates. Means bearing different superscripts along the same row were significantly different ($p < 0.05$)

DISCUSSION

The possibility of using duckweed as a source of protein and energy in place of fishmeal is quite prominent in *Oreochromis niloticus* feeds. Fasakin *et al.* (2001) observed that the inclusion of up to 30% duckweed meal in tilapia diets promoted adequate growth. In this study, the inclusion of dry duckweed diet at 100% (duckweed alone), 50% (equal proportion of duckweed and fishmeal diet) and 0% (control, without duckweed) was done to determine its effect on the growth of *Oreochromis niloticus*. The mean weight gain by *O. niloticus* fingerling was the same when fed with the three-diets $p < 0.05$. The use of dry duckweed alone showed the poorest performance, a similar result was also obtained by several authors (Hassan & Edwards, 1992; Tavares *et al.*, 2008) when using fresh duckweed. This result indicates that both dried and fresh duckweed may

negatively affect fingerlings growth. This scenario may be justified by the fact that fresh duckweed contains high moisture content (96%) and air pockets in the leaves which facilitate floating thus decrease its palatability. While the dry duckweed nutrient content may vary depending on where it was cultured, that is nutrient-rich systems or in a system with low nutrients which may either hinder or promote growth performance of *O. niloticus* growth.

Food conversion ratio, specific growth rate, protein efficiency, and weight gain were significantly different when the *Oreochromis niloticus* were fed with the three diets, $p < 0.05$. Fishmeal showed the highest performance in SGR (1.18), MWG (20.53) and PER (1.31) as compared to the other two diets which may be attributed to the ingredients used during the processing of fish diets and its palatability. In addition, fishmeal had a high percentage of crude fat

and crude protein than duckweed. While pure dry duckweed had the poorest performance an indication that duckweed should be used as a supplement to fishmeal but not a complete diet. The 50% supplemented feed also showed a positive impact on fish growth thus an indication that duckweed may be utilized without hindering the growth performance. Also, despite the less crude fibre of 5.13% in a dry matter which enhances its digestibility, it could be less palatable than the fishmeal (6.4%) (Chaturvedi *et al.*, 2003)

Food Conversion Rate (FCR) for *Oreochromis niloticus* was within the expected ratio as suggested by different authors i.e. 2-4 (Granoth & Porath, 1983; Hassan & Edwards, 1992). The lowest FCR was reported in *Oreochromis niloticus* fed by pure dry duckweed inclusion may have been caused by decrease palatability, or imbalances in amino acids. This is contrary to the case that duckweed has better amino acids profile than other vegetable protein (Hillman & Culley, 1978). Although amino acids profile may vary with the productivity of the environment it grows (Leng *et al.*, 1995)

CONCLUSION AND RECOMMENDATIONS

The crude protein was 30% within the expected ranges 28-30% which compares favourably with fishmeal crude protein content of 30%. Considering that fishmeal duckweed diet had a positive influence on growth performance of *Oreochromis niloticus*, it should be used as an alternative protein source to reduce the cost of fish feed in aquaculture enterprise. Further research should be done on a cost-benefit analysis of duckweed as a fish diet and protein source to ensure its full potential use.

ACKNOWLEDGEMENT

The researchers thank the Dominion Farm management for financial support and necessary facilities during the study period.

REFERENCES

- Ahammad, M. U., Swapon, M. S. , Yeasmin, T. U., Raham, M. S. & Ali, S. M. (2003). Replacement of Sesame oil cake by Duckweed (Lemna minor) in Broiler Diet.Pakistan. *Journal of Biological Science*, 6(16), 1450–1453.
- AOAC (2000). Approved methods of the American Association chemist. In *Association chemist* (12th Ed.). MN USA: AOAC, and St. Paul.
- Chaturvedi, K. M., Langote, D. S. & Asolekar, R. S. (2003). Duckweed-fed fisheries for treatment of low strength community waste water. *WWWTM Newsletter*. India: Asian Institute of Technology.
- Dagne, A., Degefu, F. & Lakew, A. (2013). Comparative growth performance of mono-sex and mixed-sex Nile tilapia (*Oreochromis niloticus* L.) in pond culture system at Sebeta. *Ethiopia International Journal of Aquaculture*, 3, 30–34.
- De Silva, S. S. & Anderson, T. A. (1995). *Fish nutrition in aquaculture*. London, UK: Chapman and Hall.
- El-Sayed, A.F. M. (2004). Protein Nutrition of Farmed Tilapia: Searching for Unconventional Sources. In R.B. Bolivar, G. C. Mair, & K. Fitzsimmons (Eds.), *New Dimensions on Farmed Tilapia' Proceedings of the Sixth International Symposium on Tilapia in Aquaculture 12-16 September 2004* (pp. 12–16). Manila, Philippines: ISTA Publications.
- FAO. (2010). *The State of World Fisheries and Aquaculture 2010*. FAO, Rome.
- Fasakin, E. A., Balogun, A. M. & Fagbenro, O. A. (2001). Evaluation of sun dried water fern *Azolla Africana* and duckweed, *Spirodellapolyrrhiza*, in practical diets for Nile Tilapia, *Oreochromis niloticus* fingerlings. *Journal of Applied Aquaculture*, 11(4), 83–92.
- Glencross, B. D., Booth, M. & Allan, G. L. (2007). A feed is only as good as its ingredients - A review of ingredient evaluation strategies for aquaculture feeds. *Aquaculture Nutrition*, 13(1), 17–34.
- Granoth, R. & Porath, D. (1983). An attempt to optimize feed utilization by tilapia in flow-through aquaculture. *International Symposium of Tilapia in Aquaculture, Tel Aviv, Israel*, 550-558.

- Gupta, M. M. & Acosta., B. O. (2001). Development of global partnerships for fish genetics research - A success story. *Paper presented at the Technical Workshop on Methodologies, Organization and Management of Global Partnership Programmes*, (pp. 9–10). Rome, Italy.
- Hassan, M. S. & Edwards, P. (1992). Evaluation of duckweed (*L. Perpusilla* and *Spirodela polyrriza*) as feed for Nile tilapia (*Oreochromis niloticus*). *Aquaculture*, *104*, 315-326.
- Hillman, W. & Culley, D. D. (1978). The use of duckweed. *American Scientist*, *66*, 442-451.
- KMFRI (2017). Kenya's Aquaculture Brief (2017). Status, Trends, Challenges and Future Outlook. Kenya Marine and Fisheries Research Institute, Mombasa, Kenya., 12.
- Leng, R. A., Stambolie, J. H. & Bell, R. (1995). Duckweed a potential high protein feed resource' for domestic animals and fish. *Livestock Research for Rural Development*, *7*(1).
- SAS, I. (2015). *Discovering JMP 12®*. SAS Inst (13th ed.). SAS Institute Inc, Cary, NC, USA.
- Shelton, W. L. & Popma, T. J. (2006). Biology. In Tilapia: Biology, Culture, and Nutrition. In C.E. Lim & C. D. Webster (Eds.), *In Tilapia: Biology, Culture, and Nutrition* (pp. 1–49). Binghamton, NY, USA: Haworth Press:
- Skilicorn, P. W., Spira, W. & Journey, W. (1993). Duckweed aquaculture: a new aquatic farming for developing countries., 15-25.
- Tacon, A. G. J., Hasan, M. R. & Subasinghe, R. P. (2006). *Use of fishery resources as feed inputs for aquaculture development: trends and policy implications*. *FAO Fisheries Circular. No.1018* (Vol. 99). Rome: FAO.
- Tavares, F. A., J., B., Rodrigues, R., Fracalossi, D. M., Esquivel, J. & R., R. (2008). Dried duckweed and commercial feed promote adequate growth performance of tilapia fingerlings. *Biotemas*, *21*(3), 91–97.