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The utilization of *Vallisneria aethiopica*, *Brassica oleracea* and *Pennisetum clandestinum* by *Tilapia rendalli*

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ABSTRACT

A common lawn grass; kikuyu grass, an abundant vegetable; cabbage and vallisneria a common macrophyte were tested for utilisation by two size classes of a herbivorous fish, *Tilapia rendalli* held in glass aquarium tanks. The test feeds were given to sub-adult *T. rendalli* for 133 days at 8% body weight and juvenile fish for 84 days at 15% body weight. Sub-adult and juvenile fish fed kikuyu grass attained a higher specific growth rate, higher protein efficiency ratio and better food conversion ratio than those fed cabbage and vallisneria. This is explained by the differences in the protein content, higher levels of lysine and the sulphur-containing amino acid, methionine in kikuyu grass. Palatability studies of the juveniles also showed that kikuyu was most preferred. However, sub-adults preferred vallisneria, kikuyu and cabbage respectively. The possible reasons for the selection are discussed.

1. Introduction

Despite numerous efforts from governments and the donor community, aquaculture production in Africa has remained miniscule. The aquaculture infrastructure built in the 1970s and 1980s is in a state of disrepair in most African countries (FAO, 2004). One of the major reasons that led to the collapse of the of many aquaculture enterprises is the cost of formulated feed. Fish feeds represent over 50% of the total variable production costs (El-Sayed, 2006). Furthermore, many locals lacked the requisite fish husbandry practices associated with intensive fish culture systems. It may now be necessary to look at semi-intensive culture systems that will use readily available natural food.

In South Africa warm water aquaculture is beset by technical and environmental factors. Tilapia production, mainly from small scale operations was 210 tonnes in 2003 (Department of Water Affairs, 2005). Most of this production was based on *Oreochromis mossambicus*. There is very little farming of the macrophagous *Tilapia rendalli* in South Africa. The herbivorous feeding nature of *T. rendalli* makes it a suitable candidate for semi-intensive aquaculture.

The basic biology of *T. rendalli* is well documented (Le Roux, 1955; Munro, 1967; Wager, 1968; Gaigher, 1969; Potgieter, 1974; Batchelor, 1978; Caulton, 1978, 1982; Chifamba, 1990). The major limitation in the culture of *T. rendalli* appears to be its slower growth rate when compared to *Oreochromis niloticus* and *O. mossambicus* (Chifamba, 1995). The slow growth rate of *T. rendalli* has also been reported by Pauly et al. (1988). The ability of *T. rendalli* to efficiently utilise plant diets because of its macrophagous feeding nature may be the solution to the development of semi-intensive aquaculture industry. Although *O. spp* may exhibit higher growth rate, their ability to utilise plant based diets is limited. There is very little information on its aquaculture potential of *T. rendalli*. The paucity of information on a species that can potentially play an important role in semi-intensive aquaculture systems prompted this study. In this study *T. rendalli* was fed on readily available plant diets, vallisneria, kikuyu grass and cabbage. It is therefore imperative that the utilisation of these readily available diets by *T. rendalli* be investigated.

2. Materials and methods

The experiment was conducted in indoor aquarium tanks, at the Aquaculture Research Unit at the University of Limpopo, Limpopo Province, South Africa.

Vallisneria and kikuyu grass were harvested fresh each morning and cabbage was bought fresh from a local market. A completely randomised design with two replications for the test plants: vallisneria, kikuyu grass and cabbage was setup. One hundred and eighty litre aquarium glass tanks, equipped with bio-filters were randomly stocked with eight mixed-sex *T. rendalli* sub-adults. Individual mean body weights were 44.6 g. The experiment lasted for 133 days. The second part of the study was conducted using juvenile *T. rendalli* where 20 l rectangular aquarium glass tanks were randomly stocked with five mixed-sex juvenile *T. rendalli* of 7 g

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average weight and the experiment lasted for 83 days. The fish were acclimatised to the experimental environment for 2 weeks prior to the start of the experiment. During this period the fish were offered the different test diets to ensure acceptability.

Each morning prior to feeding, the plants were chopped into small pieces (1 cm for the sub adults and 0.5 cm for juveniles) using a kitchen knife. The test feeds were weighed and offered to the fish three times a day at 8% body weight per day, for the sub-adults and 15% body weight for the juveniles. All fish from each tank were weighed every 30 days for growth monitoring.

Thermostatic immersion heaters were used to maintain the water temperature in all tanks at 30 °C for the duration of the experiment. Dissolved oxygen (DO) and pH were measured fortnightly using a handheld YSI (556 MPS) multiparameter. The mean weight was calculated and the growth indices determined using specific growth rate (SGR) which was calculated according to Winberg (1956). Food conversion ratio (FCR) was determined by the dividing the food consumed with the weight gained and protein efficiency ratio (PER) as the increase in body weight (g) per gram protein consumed.

3. Proximate analysis of feeds

Samples of the feeds were analysed for protein, amino acid composition, energy, carbohydrates, fibre, fat, ash and moisture following the procedures stipulated by the Association of Official Analytical Chemists (AOAC, 1995). Dry matter was determined by freeze-drying each sample for 72 h. Nitrogen content of the dry matter of the feed was determined using a LECO FP2000 Nitrogen Analyser using the Dumas combustion with protein content calculated as % nitrogen × 6.25. Crude fat content was assessed by Soxhlet extraction of the freeze-dried samples with petroleum ether at 40–60 °C. Fibre was determined using the Fibretec system Method (AOAC, 1995). Carbohydrates were calculated by difference and Energy by calculations as described in AOAC (1995).

The test feeds were investigated for palatability. A mixture of these plants was offered in equal proportions in glass aquarium tanks to sub adults and juvenile *T. rendalli*. The number of uneaten pieces was counted every 15 min.

Results on SGR, FCR and PER were subjected to one-way ANOVA and significant means were separated using Tukey's test. *T*-test was used to determine utilisation between the sub-adult and juvenile groups. Chi-square test was used to determine if the test diets were in equal proportions at the end of the experiment. Manly's (1974) alpha was used to measure food preference.

4. Results

The pH ranged from 7.6 to 9.0, dissolved oxygen was from 7.5 to 8.3 mg/l and temperature was maintained at 30 °C. All these parameters fall within the acceptable limits for *T. rendalli*.

Proximate composition of the plants used in these experiments (Table 1a), show a considerable difference in protein content and amino acid composition (Table 1b). Kikuyu grass had the highest protein level of 24.91% and vallisneria had the lowest protein level of 8.03%.

Table 1a
Proximate composition of the experimental diets.

Feed type	Moisture	Ash	Fat	Fibre	Protein
Kikuyu	1.53	10.58	2.81	19.47	24.91
Vallisneria	7.14	13.67	1.07	11.26	8.03
Cabbage	1.45	20.54	5.62	22.85	22.86

Table 1b
Amino acid composition of the experimental diets (% protein).

	Kikuyu	Vallisneria	Cabbage
Cystine and cysteine	0.43	0.64	0.43
Methionine[a]	0.45	0.15	0.16
Aspartic	2.23	1.61	1.05
Threonine[a]	0.93	0.41	0.39
Serine	0.95	0.54	0.43
Glutamine	2.65	1.15	1.64
Proline	1.35	0.56	0.52
Glycine	1.37	0.85	0.54
Alanine	2.00	0.69	0.82
Valine[a]	1.56	0.65	0.68
Iso leucine[a]	1.12	0.47	0.42
Leucine[a]	2.33	0.93	0.75
Tyrosine	0.80	0.21	0.26
Phenyl alanine[a]	1.34	0.62	0.43
Lysine[a]	1.42	0.69	0.70
Ammonia	2.20	1.06	0.97
Histidine[a]	0.51	0.28	0.29
Arginine[a]	1.44	0.73	0.61

[a] Essential amino acid.

There was a significant difference in the SGR, FCR and PER of sub-adult *T. rendalli* fed the different test feeds ($P < 0.05$, ANOVA). Kikuyu gave the highest values followed by cabbage and *T. rendalli* fed on vallisneria lost weight, hence the SGR, FCR and PER were negative (Table 2a). SGR, FCR and PER values were also significantly different among the test feeds in juvenile *T. rendalli* ($P < 0.05$, ANOVA). As in sub-adults, kikuyu gave the best growth performance in juveniles followed by cabbage (Table 2b). Juveniles fed on vallisneria also lost weight.

Sub-adult and juveniles fed kikuyu attained the same SGR (Tables 2a and 2b). However, there was a significant difference in the SGR of juvenile and sub-adults fed cabbage ($P < 0.05$, *T*-test). Juveniles utilised cabbage better than sub-adults. Utilisation of vallisneria by both sub-adult and juveniles was poor (Tables 2a and 2b).

The palatability experiments showed that the test diets were no longer in equal proportions after 15 min (Tables 3a and 3b), in both sub-adult and juveniles ($P < 0.05$, Chi^2). This scenario was maintained up to the end of each experiment. Manly's α showed that juveniles preferred kikuyu grass, cabbage and vallisneria respectively (Table 3a). These results were in agreement with the growth performance experiments. In sub-adults palatability experiments contradicted the growth performance experiments as Manly's α showed that there was preference for vallisneria, kikuyu and cabbage respectively (Table 3a).

5. Discussion

Many studies have shown the importance of *T. rendalli* in the control of aquatic weeds (Junor, 1969; Caulton, 1977). However no evaluation of the use of these plants in the culture of *T. rendalli* has been undertaken. In this study, the fastest growth was

Table 2a
Performance of sub adult *Tilapia rendalli* fed on different diets.

	Treatment		
	Vallisneria	Kikuyu grass	Cabbage
Initial weight (g)	39.3	36.1	50.8
Final weight (g)	35.6	56.3	55.6
Weight gain (g)	-2.7^a	25.4^b	8.0^c
PER	-0.09^a	0.21^b	0.06^c
SGR	-0.024^a	0.181^b	0.050^c
FCR	-143.6^a	19.1^b	69.6^c

NB: Figures in the same row with different superscripts are significantly different.

Table 2b
Growth performance of juvenile *Tilapia rendalli* fed on different diets.

	Vallisneria	Kikuyu grass	Cabbage
Initial weight (g)	6.9	4.6	4.8
Final weight (g)	5.8	6.5	5.9
Weight gain (g)	−1.1	1.9	1.1
PER	-0.19^{a}	0.11^{b}	0.07^{c}
SGR	-0.901^{a}	0.181^{b}	0.108^{c}
FCR	-65.6^{a}	37.03^{b}	59.86^{c}

NB: figures in the same row with different superscripts are significantly different.

Table 3a
Macrophyte preference by sub-adult *T. rendalli* when given equal proportions; 1:1:1, (tabulated $X^2 = 5.991$) $\alpha = 0.05$.

	Vallisneria	Kikuyu	Cabbage
No. stocked	100	100	100
% After 15 min	34	71	90
% After 30 min	33	51	83
% After 35 min	25	36	82
% After 40 min	17	26	76
% Remaining	17	26	76
α_i	0.143	0.218	0.638

Table 3b
Macrophyte preference by juvenile *T. rendalli* when given equal proportions; 1:1:1.

	Vallisneria	Kikuyu	Cabbage
No. stocked	40	40	40
% After 15 min	85	25	65
% After 30 min	77.5	15	50
% Remaining	70	7.5	37.5
α_i	0.609	0.069	0.328

observed in fish given kikuyu grass followed by fish fed cabbage whilst those given vallisneria lost weight, and this pattern was observed in both sub-adult and juvenile fish. The FCR values in this study confirm the growth indices observed, with the lowest FCR obtained where kikuyu grass was given, followed by cabbage and negative values were obtained for vallisneria. The high FCR values obtained for the plants used in this study may be a result of the below borderline levels of some important amino acids and the presence of anti-nutritional factors. According to Santiago and Lovell (1988), tilapia require 5.12% lysine; 2.68% methionine and 4.20% arginine in their protein for optimum growth. No plant protein can on its own support good growth of fish due to deficiency in at least one essential amino acid (Jauncey and Ross, 1982). However, utilization may be feasible in semi-intensive production systems, where autotrophic and heterotrophic food material may supply the deficient amino acids (Li and Yakupitiyage, 2003).

The high values of PER in fish fed kikuyu are probably a direct result of the high protein content of the grass and its high protein digestibility. This may also be due to the higher levels of the essential amino acids in kikuyu grass e.g., 1.42%, and 0.45% protein for lysine and methionine respectively. Vallisneria, had the lowest level of both lysine (0.69% protein) and methionine (0.15% protein). The poor performance of *T. rendalli* fed cabbage and vallisneria compared to fish fed kikuyu grass may be explained by a lower level of lysine and methionine in these diets. The minimum requirement for lysine is 4.6 g/100 g of protein, all the plant diets had borderline lower levels of lysine and methionine, growth improved with increasing amount of protein in this diets. In experiments by Yang et al. (2010) juvenile grass carp demonstrated that the final weight, weight gain and protein retention and condition factor of fish fed diet with supplemental lysine and methionine were significantly higher, while the Feed Conversion Ratio (FCR) were significantly lower in comparison with fish fed the control diet.

The negative values obtained for SGR, FCR and PER in *T. rendalli* given vallisneria may be due to the restricted feeding regime adopted in this study. Vallisneria is an aquatic plant that has a higher moisture content than the other plants. A large part of the feed weight was therefore water.

Palatability experiments showed that juveniles preferred kikuyu over the other plants. The choice of kikuyu is probably explained by the grass' high protein content and its high amino acid composition. Fasakin et al. (1999) also noted that juvenile fish prefer plants with high protein content. The sub-adults preferred vallisneria. Size related dietary shifts are common in cichlids (Moyo and Fernado, 1999). However, it is not immediately obvious as to why the sub-adults preferred vallisneria. The optimal foraging theory assumes that organisms feed in a way that maximizes their net rate energy intake per unit time (Pyke et al., 1977). Herbivous organisms like *T. rendalli* commonly behave as energy maximizers (Belovisky, 1986) and accomplish their maximizing behaviour by choosing food that is of high quality and has low search and low handling time (Pyke et al., 1977).Kikuyu was a better quality diet and it was expected that the sub-adults would show preference for it. Chifamba (1990) fed *T. rendalli* sub-adults with *Ceratophyllum dermersum*, *Lagarosiphon ilicifolius*, *Vallisneria aethiopica* and *Najas pectinata*. The fish showed preference for the macrophyte that had the highest protein content which was *V. aethiopica*. In this study vallisneria had the least protein content and the sub-adults showed preference for it. It is possible that factors such as the amount of structural material and polyphenolic compounds affected the selection. The findings of this study also indicate that the ability of *T. rendalli* to control aquatic weeds may be limited as palatability studies reflect feeding selectivity. Therefore, it may not be always effective in the weed management in rivers. More research is recommended to elucidate the underlying factors behind the choice, of vallisneria by sub-adult *T. rendalli*.

6. Conclusion

Fish fed on vallisneria lost weight indicating that it is not a suitable diet for *T. rendalli*. Kikuyu grass gave better growth indices than the other plants. It is envisioned that better growth performance would be obtained in semi-intensive pond culture because of the availability of natural food. However, it is recommended that further studies be undertaken on how kikuyu can be improved to provide better growth rates. Amino acid supplementation of kikuyu may give better results.

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