

Note

Effect of stocking density on the growth and survival of improved (F₅ and F₆) and unimproved native strains of *Oreochromis shiranus* (Trewavas) raised in hapas

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ABSTRACT

Growth performance and survival rate of improved strains (F₅ and F₆) and unimproved native strain of *Oreochromis shiranus* was assessed. Three stocking densities (5, 7 and 9 fish m⁻³) were used to randomly allocate fingerlings, of mean weight 6±0.6 g, into 27 hapas. Hapas, measuring 9 m³ were fixed in a pond of 700 m². Stocking density significantly (p<0.05) affected the growth of the 3 strains though there was no significant difference between stocking density of 5 and 7 fish m⁻³. The highest final weight was noted at a stocking density of 5 fish m⁻³ with an average weight of F₆ being 28.1 g, followed by F₅ (24.9 g) and unimproved strain (24.0 g). F₆ strain had a higher final mean weight (23.41 g) followed by F₅ (21.84 g) and then unimproved strain (18.70 g), but there was no significant difference between the two improved strains (p>0.05). The apparent genetic gain due to selection was estimated to be 16.8 and 25.2% between the unimproved strain and F₅, F₆ strains, respectively. Based on the results, farmers can be encouraged to use F₆ strain at a stocking density of 5 fish m⁻³. The revelation that there was no difference between the improved strains has implications on the continuation of the selection program.

Keywords: Feed conversion ratio, Improved strain, Selection, Specific growth rate, Stocking density

Fish contributes about 72% of animal protein (Ecker and Qaim, 2011) thus signifying the importance of this resource to the food and economic security of Malawians. However, overfishing in the lakes and rivers, coupled with doubling of human population, per capita annual fish consumption has decreased from 14 kg in 1988 to half that figure in 1998 with a corresponding increase in price of fish (Jamu and Chimatiro, 2004). According to Wely (2003), the annual per capita consumption has decreased to about 5.8 kg in early 2000.

In Malawi, the most cultured fish species are tilapias as they have excellent aquaculture potential owing to their herbivorous/ omnivorous feeding habits, high tolerance to diseases and parasites (ICLARM, 1991). It is one of the easiest fish to farm, being exceptionally hardy, and is ideal for small farmers as well as industrial scale aquaculture. Aquaculture of tilapias is being recognised to be an important potential supplement not only for the nutritional value but also as an additional source of income for many local fish farmers. With limited land resources and high competition with agriculture for land, aquaculture needs to use high stocking densities to maximise production per unit space available. Pond aquaculture being the most common method of culturing fish in Malawi, faces many problems associated with water quality parameters, prolific

breeding. At low stocking densities adequate food is available for all members of the population and under such circumstances individual growth rates would be high and fish would be expected to mature and recruit to the spawning stock at a comparatively young age. On the other hand, at high stocking densities, competition for food may reduce growth rate as well as individual relative fecundities. The competition could also influence reproductive success via effects on egg quality which could result from reduced energetic investment in the yolk deposited in each egg.

Among the tilapia species being farmed in Malawi, *Oreochromis shiranus* is widely cultured by most farmers (over 90%) because of ease in reproduction relative to other tilapias. However, the major problem with *O. shiranus* is slow growth rate leading to stunting where females tend to become sexually mature and reproduce early at a small size. Having considered that this species is most preferred by farmers, a selective breeding program was established in 1996 in order to improve the growth rate of this valuable species. So far, the breeding program has gone up to F₆ generation. Since the breeding program was introduced, a lot of research on production parameters has been conducted but there is still no documented experimental result that has been done to determine the effect of stocking densities on the growth and survival of the improved *O.*

shiranus strains of F₅ and F₆ generations. It was therefore the main aim of this experiment to find out whether stocking density would affect the growth and survival of the improved *O. shiranus* strains comparing their performance with unimproved native strain.

The experiment was conducted at the Bunda fish farm in Lilongwe, Malawi in 9 m³ (3 m x 3 m x 1 m) hapas. The area was chosen because it has ponds suitable for the layout of the hapas and that the offspring of the improved strains and native unimproved strain of *O. shiranus* were readily available. Juveniles of the unimproved strain as well as F₅ and F₆ strains of *O. shiranus* were collected from concrete tanks at Bunda fish farm using a hand net. The juveniles of improved strains (F₅ and F₆) were collected from broodstock belonging to F₄ and F₅ respectively and were then kept in the tanks. The broodstock of the improved strain came from National Aquaculture Centre (NAC) in Domasi, in order to have a breeding nucleus for the improved strain in Bunda. These fingerlings with an average weight of 6±0.6 g were stocked in the hapas at densities of 5, 7 and 9 fish m⁻³. A completely randomised design (CRD) was used to allocate three treatments replicated three times at the three levels of stocking density (5, 7 and 9 fish m⁻³). A total of 1701 juveniles (567 from each treatment population) were randomly allocated to the 27 hapas for the experiment.

Fish were fed formulated feed of 29% crude protein to supplement the natural feed which was boosted by application of chicken manure at the rate of 500 kg ha⁻¹ week⁻¹ (Kang'ombe, 2008). The fish were fed at 5% body weight as per the recommendation by Lovell (1989) that tilapia ranging from 5-20 g be fed at 4-6% of its body weight. The fish were hand fed (twice a day) by broadcasting which despite being cumbersome, has an advantage over other methods of feeding like the use of automatic feeders and demand driven feeders in that it is relatively cheap and that the feeder can observe the fish while feeding. The fishes were sampled at fortnightly intervals and a sample size of 30% of the population was used. No feed was given 24 h prior to sampling, thus feeding was done for thirteen (13) days between sampling exercises. Fish were weighed using an electrical analytical balance calibrated to 0.01g. A stainless steel topped board, calibrated to the nearest mm was used to measure total length of the fish randomly selected from each hapa. Data on growth and survival of *O. shiranus* were collected every fortnight for a period of two and half months. The growth and survival of the fish were calculated as follows:

Body weight gain (bwg),

$$\%B\ WG = \frac{w_2 - w_1}{w_1} \times 100$$

where, W₁= initial mean weight, W₂= final mean weight

Specific growth rate (SGR),

$$\%SGR = \frac{\ln w_1 - \ln w_0}{t_1 - t_0} \times 100$$

where; W₁ = final mean weight (g) of fish; W₀ = initial mean weight (g) of fish at stocking time; t = time in days, ln = natural log

$$\text{survival rate (\%)} = \frac{\text{Number of fish at the end of the experiment}}{\text{Number of fish at the start of the experiment}} \times 100$$

Feed efficiency was analysed by calculating the apparent food conversion ratio (AFCR) using the formula:

$$AFCR = \text{Dry weight of feed given/Gain in weight}$$

Analysis of water quality parameters

Selected water quality parameters *viz.*, temperature, pH and ammonia were monitored at fortnightly intervals during the experimental period in order to maintain the levels within the limits required to sustain rapid growth of cultured fish (Boyd, 1990).

Data on growth and survival were analysed using two-way Analysis of variance (ANOVA) at 95% level of confidence. Genstat (12th edition) was used as a statistical package during analysis. Least significant difference (LSD) was used to separate the means among the fish strains and stocking densities.

The initial body weights of the three fish treatments ranged from 6.6±0.2 g to 6.9±0.2 g (Table 1 and Figs. 1, 2 and 3) and it was found that there was no significant difference (p = 0.640) in their initial weight and length (p = 0.066). Among the three different stocking densities, the least stocking density of 5 fish m⁻³ produced the highest weight followed by the density of 7 fish m⁻³ and the 9 fish m⁻³ being the least (Table 1 and Figs. 1, 2 and 3). This clearly shows that an increase in stocking density leads to a decrease in the growth performance of fish. Survival rate of fish was not significantly different (p=0.63, Table 1) among the fish treatments which was above 90%.

The final weight of fish differed significantly (p = 0.021, Table 1) among the treatments. F₆ generation had a significantly higher final mean weight (23.41 g) followed by F₅ (21.84 g) and native strain (18.70 g). Despite F₆ having higher weight compared to F₅, statistically, there was no significant difference (p = 0.100) in their final mean body weights. The difference which could be attributed to

Table 1. Initial and final mean weights, initial mean total length (TL₁), final mean total length (TL₂), specific growth rate (SGR), apparent feed conversion ratio (AFCR), increase in weight and survival rate of F₅, F₆ and unimproved strains

Parameter	F ₅ strain	F ₆ strain	Unimproved strain	p value
Initial mean weight (g)	6.6±0.2 ^a	6.7±0.2 ^a	6.9±0.2 ^a	0.640
Final mean weight (g)	21.84±0.5 ^a	23.41±0.4 ^a	18.70±0.6 ^b	0.021
Initial mean total length (TL ₁) (mm)	75±0.4 ^a	74±0.4 ^a	77±0.4 ^a	0.066
Final mean total length (TL ₂) (mm)	90.5±0.5 ^a	92.8±0.5 ^a	88.9±0.5 ^a	0.572
SGR (% per day)	0.424±0.1 ^a	0.558±0.1 ^c	0.336±0.1 ^b	0.043
AFCR	3.18±0.2 ^a	2.42±0.3 ^b	4.47±0.2 ^c	0.044
Increase in weight (%)	230.9	244.93	160.87	
Survival rate (%)	92.3 ^a	97.0 ^a	98.5 ^a	0.63

Figures with different superscripts within a row are significantly different ($p < 0.05$)

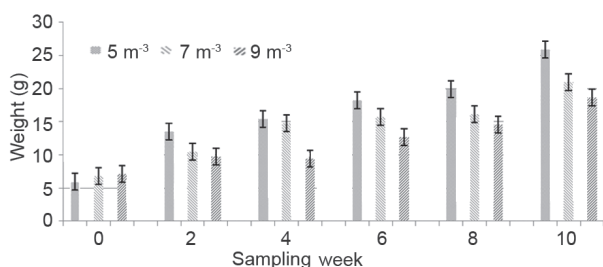


Fig. 1. Mean growth in terms of weight of F5 strain at three different stocking densities

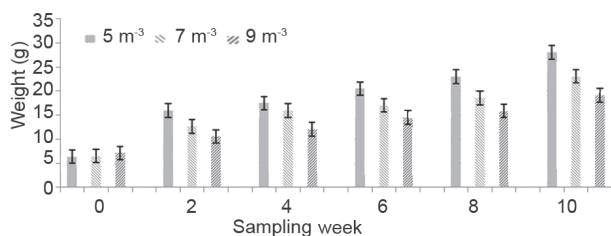


Fig. 2. Mean growth in terms of weight of F6 strain at three different stocking densities

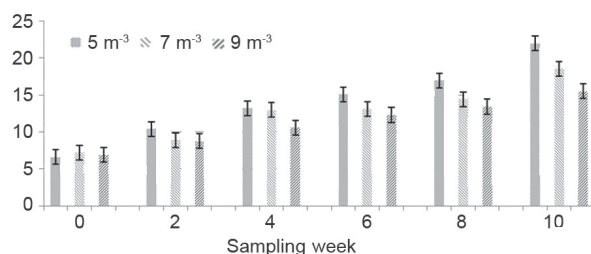


Fig. 3. Mean growth in terms of weight of unimproved strain at three different stocking densities

selection was calculated and it was found that there was 16.8% gain between the unimproved strain and the F₅ while 25.2% between the unimproved strain and the F₆.

Despite the difference in the average body length with F₆ being the longest (92.8 mm) followed by F₅ (90.5 mm) and then unimproved (88.9 mm), there was no significant difference ($p = 0.572$, Table 1) in the average total body length among the three strains. AFCR differed significantly ($p = 0.044$, Table 1) among the strains, with F₆ recording the lowest, and unimproved strain with the highest value.

Water quality parameters during the experiment were within the required range for the growth of *O. shiranus* in ponds. Mean temperature ranged from 24.54 ± 1.5 to 29.66 ± 1.6 °C, while pH ranged from 6.76 ± 0.5 to 8.01 ± 0.3 and ammonia ranged from 0.163 ± 0.02 to 0.204 ± 0.01 mg l⁻¹ (Table 2). Temperature did not differ significantly ($p = 0.998$) across the different stocking densities and fish treatments. pH levels were also not significantly different ($p = 0.072$) in all the hapas. Ammonia levels were not significantly different ($p = 0.057$) and hence their fluctuations did not affect the growth and survival.

The higher growth rate recorded during the present study in F₆ can be attributed to the genetic superiority of the strain. The growth of an organism is said to be contributed by the genetic makeup of the organism and the environment. Since the environment as well as other experimental conditions were constant for all stocking densities and strains, any growth difference can be attributed to the genetic makeup. The difference in the final mean weight between F₅ and F₆ though not significant indicates that the selection of broodstock for F₅ and for F₆ was the best. It also means that the selection of the broodstock was accurate and that there is still substantial genetic variance in the F₅ population to enable genetic selection (A. Maluwa, personal communication). During the experiment it was observed that a certain fish belonging to the unimproved strain at stocking density of 7 fish m⁻³ had incubating eggs in mouth at a body weight of 6.3 g which is lower than the 8 g that Maluwa (1990) reported during his experiment. It was also observed that during the last two sampling exercises of the experiment almost all the three strains

Table 2. Water quality parameters (mean±SE) measured during the experimental period

Parameter	Time	1 st sampling (prior to start of experiment)	2 nd sampling	3 rd sampling	4 th sampling	5 th sampling	6 th sampling
Temperature (°C)	09 00 h	25.04±1.4	24.74±2.1	25.10±1.4	24.66±2.2	24.54±1.5	25.47±1.1
	16 00 h	29.06±1.2	28.94±2.3	29.41±1.4	28.60±1.6	28.30±2.4	29.66±1.6
pH		7.04±0.11	6.96±0.22	7.98±0.31	8.01±0.3	7.12±0.12	6.76±0.
Ammonia (mg l ⁻¹)		0.163±0.02	0.185±0.04	0.200±0.01	0.171±0.02	0.204±0.01	0.196±0.04

started breeding since fry were present in all hapas. This implies that even the improved strain is prone to early breeding and may eventually can lead to stunting growth as well, which is detrimental to the selective breeding program.

Stocking density is one of the most important parameters affecting fish growth and health. According to Stickney (1996), the effect of stocking density on production showed that some species can tolerate extreme crowding but competition for food can limit their growth. Charles (2001) observed poor weight gain in *O. shiranus* stocked at 8 fish m⁻² because of crowding which becomes a source of stress and the fish needs to use energy stored in the body tissue as protein, much of which is mobilised from muscle tissue. Such reports are in agreement with the findings of the present study that fish stocked at higher stocking densities (9 fish m⁻³) recorded poor growth.

The results of our study showed no significant difference in the survival of the fish regardless of its strain and stocking density. This was the case because tilapias are hardy fishes and are able to survive poor conditions even under high stocking densities (ICLARM, 1991). High stocking density even does not affect the breeding behaviour of *O. shiranus* as many fry were found in many experimental hapas regardless of the stocking densities. This is in line with the findings of Delince (1992) that even at very high densities, this fish continues to reproduce.

Having said all the above, perhaps a question worthy reflecting on is; are we closer to any of well-known selective breeding programs in aquaculture? For instance, through the GIFT (Genetically Improved Farmed tilapia) program, a realised response to selection for harvest body weight relative to the base population of 101% had been achieved within five generations of selection (Bentsen *et al.*, 2003). However as indicated above, apparent realised response to selection in *O. shiranus* is 25.2% at 6th generation, which is comparably very low. Much as the unimproved strain used here cannot be equated to base population in *O. niloticus* GIFT program, but it is the better realistic control which fish farmers would like to base their comparison on when making decision on whether to adopt the improved strains or not.

The water quality parameters play a significant role in the biology and physiology of fish (Boyd and Tucker, 1998). These parameters are considered critical because they affect the health and productivity of the culture system, (Landau, 1992). Throughout the experiment, the water quality in all the treatments remained within the favourable range required for tilapias (Boyd, 1990; Pillay 1993). Therefore, the variation in the growth of the fish cannot be attributed to variations in water quality parameters.

In conclusion, the results indicate that F₆ strain grows faster than F₅ and unimproved strain with better growth at lower stocking density of 5 fish m⁻³. Improved strains had low FCR indicating efficient utilisation of feed.

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