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Full Length Research Paper

Evaluation of varying stock densities on development and productivity of Nile tilapia *Oreochromis niloticus*

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A one month trial of sex reversal treatment of *O. niloticus* fry of varying stocking densities was performed in hapas-in-pond to determine the growth performance characteristics and profitability. Larvae were selected, collected, weighed and stocked inside a 10.0 m^2 hapas in a 0.2 ha pond with stocking densities of 10000 (A), 15000 (B) and 20000 (C). Each stocking were made in triplicate. Fry were fed with a 36% crude protein plus hormone incorporated feed five times a day. Weekly samplings of fry were done including water quality parameters. Final average body weights of treated fry were 0.226 ± 0.02, 0.125 ± 0.02 and 0.080 ± 0.01 g for treatments 'A', 'B', and 'C' stocks respectively. The fry growth in treatment 'A' was significant (at $p < 0.05$) among all other stocks. It also exhibited high specific growth rate and a lower feed conversion rate than others; however, high survival was achieved with fry in treatment 'B'. High value of fry crop was achieved in treatment 'C' with a value of GH¢ 638.96. Although profit index did not vary significantly from each other, the treatment 'B' reached the highest value of 23.13 ± 9.01. The increasing fry stocking density of fry significantly affected the growth and feeding conversion rate, however, it did not affect the survival data. Due to the high profit index, relatively high growth rate and high survival, treatment 'B' is recommended for fry rearing in a 10.0 m^2 hapa-in-pond system.

Key words: Nile tilapia, hormonal feed, specific growth rate, profit index, feed conversion rate.

INTRODUCTION

Tilapia is regarded as the second most cultured aquaculture species globally because of its easy to adapt in tropical and sub-tropical areas of the world (Shelton, 2002). Tilapia have numerous advantages as an aquaculture species (Teichert-Coddington et al., 1997) but the ability to reproduce in the production setting has resulted in various techniques being developed to control unwanted reproduction.

Early sexual maturity of this species is a well-recognized problem. Under favorable conditions they will continue to reproduce, the offspring competing with the initial stock for food, resulting in stunted growth and unmarketable fish (Phelps and Popma, 2000). There are a number of ways to control reproduction in mixed sex population. One of these is the culture of all-male tilapia. All male culture of tilapia is preferred because of their faster growth. Several techniques have been adopted for production of monosex (all male) tilapia: Manual sexing

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(Guerrero, 1982); hybridization (Hickling, 1960); genetic manipulation (Pandian and Varadaraj, 1988); and sex reversal through sex hormone administration (Shelton et al., 1978; Guerrero, 1982).

Sex reversal by oral administration of feed incorporated with methyl testosterone is probably the most effective and practical method for the production of all male tilapia, which consistently grow to a larger, more uniform size than mixed sex or all-female tilapias. This is the most common method of sex reversal in most countries (Cagauan et al., 2004).

Hormonal sex reversal has been particularly effective in cichlids because the gonadal differentiation takes place early in the life history. Tilapia species that have been successfully sex reversed are mouth brooding species where hormone treatment begins within a few days after hatching (Phelps and Popma, 2000).

Stocking density and survival are also important indicators that determine the economic viability of a production system (Ako et al., 2005; Aksungur et al., 2007). Fry are most commonly stocked at densities of 3000 to 4000 per m^2 of *hapa*, or flowing water tank. Vera Cruz and Mair (1994) compared stocking densities of 1000, 3000 and 5000 per m^2 of *hapa* using *O. niloticus* and found best sex reversal at 3000 and 5000 m^2 but lower survival at 5000 m^2. High densities help insure an active feeding response needed so all fish are consuming feed. Pandian and Vardaraj (1987) observed that fry can establish a hierarchy in feeding order resulting in small fish not consuming adequate quantities of hormone treated feed for successful sex reversal. Knowing the best densities for a species is a critical factor for good husbandry practices and creating efficient culture systems.

The aim of this study therefore is to: (i) study the effect of growth and survival of *O. niloticus* fry treatment by varying the stocking densities; (ii) establish the profitability in the treatment of *O. niloticus* fry under varying stocking densities; (iii) assess suitable water quality parameters for the reversal process.

MATERIALS AND METHODS

Study site

The trial was conducted at the Aquaculture Research and Development Centre (ARDEC), of the Water Research Institute, Akosombo, Ghana in May, 2012.

Broodstock management

An improved *Akosombo strain* of 'generation 7' *Oreochromis niloticus* broodstock were netted from earthen ponds, manually selected, sexed and transferred into a 10 m^2 hapas in a 0.2 ha pond. A total number of 30 females and 10 males were selected, weighed and stocked in each spawning at a rate of 40 broodfish per spawning hapa (4 fish/ m^2). Broodstock were fed experimental diet containing 36% crude protein at a feeding rate of 1.5% of biomass in each hapa. Broodstock were fed two times a day at 8.30 am and 3.0 pm.

Fry harvest preparation and stocking

Nine hapas of size 10 m^2 were sewn using mosquito netting and fixed in a freshly prepared 0.2 hectare pond. Fry of *O. niloticus* in hapas were harvested using scoop nets, sieved after ten days in the mornings (6.30 am). Separation of eggs, yolk-sacs and fry were done in shade using specialized sieves. Treatment replicates (varying stocking densities of fry: 20,000, 15,000 and 10,000) were randomly distributed to the prepared hapas and stocked with fry of *O. niloticus* harvested. Each treatment stocked was made in triplicate.

The initial weight and number of fry were taken prior to the stocking. Stocked fry were acclimatized for a day before the beginning of the hormonal treatment.

Hormonal feed preparation

A hormone treated feed was prepared as described by Killian and Kohler (1991). The 17α-methyltestosterone (MT) was the hormone used in the present study. A stock solution was made by dissolving 0.06 g of hormone in 750 cm^3 of 95% ethanol. Treatments were made by taking the accurate amount of the hormone from stock solution and brought up to 100 ml by addition 95% ethanol. This solution was evenly sprayed over 1 kg of 36% crude protein diet and mixed. The mixture was mixed again and this was repeated to ensure an equal distribution of the MT throughout the feed. Treated diets were fan dried in shade at 25°C for 24 h then kept in air- tight containers.

Feeding and sampling

Hapas containing fry's at various stocking densities were labeled accordingly. Feeding was done five times a day at every two hour interval starting from 8.00 am to 4.00 pm. Fry's were fed at an initial biomass of 20% for the first two weeks, then 15% from week 3 to 4.

Five hundred (500) frys each were counted in each hapa every week for four weeks and returned to the hapas. Their weights were determined using a weight balance and measured to the nearest ± 0.1 g.

Water quality parameters were measured biweekly. Ammonia was measured using the direct nesslerization method, Nitrite using the diazotization method and Hydrazine reduction method for Nitrate. Turbidity was measured using an ELE Paqualab® turbidity metre, pH was measured using Suntex® model SP-701 pH meter, dissolved oxygen and temperature using WTM Inolab Oxi Level® 2 Oxygen metre.

The cost of hormonal feed and the economic revenue of the treated fry were determined at the end of experimentation.

Growth parameters determination

Some growth and economic parameters estimated include the following:

Specific growth rate, SGR

The specific growth rate for each treatment group was calculated as:

$$SGR = (\ln W_f - \ln W_i \times 100) / t,$$

where, $\ln W_f$ = the natural logarithm of the mean final weight (g),

Table 1. Some growth performance characteristics of sampled fry from the studied three treatments.

Treatment	Initial Av wt. (g)	Final Av. wt (g)	Specific growth rate (g)	Survival rate (%)	Feed conversion rate (FCR)
A	0.01	*0.226± 0.020^{bc}	11.126 ± 0.308^{b}	62.29 ± 28.284^{a}	2.34 ± 0.312^{bc}
B	0.01	0.125± 0.023^{ab}	8.970 ± 0.659^{b}	67.92 ± 26.762^{a}	2.90 ± 0.087^{ab}
C	0.01	0.080± 0.007^{ac}	7.404 ± 0.294^{b}	53.25 ± 26.402^{a}	3.13 ± 0.147^{ac}

*Mean ± standard deviation, a = not significant difference; b, c = significant difference.

$\ln W_i$ = the natural logarithm of the mean initial weight (g), t = time (days) between $\ln W_f$ and $\ln W_i$ (Ricker, 1975).

Food conversion ratio, FCR

The food conversion ratio was then calculated as: FCR = dry weight of feed consumed (g) / wet weight gain (g), by Castell and Tiews (1980).

Biomass

The biomass was calculated as the product of the average final weight and the total number of survivors (Mohammed et al., 2006). A simple economic analysis was used to estimate the profitability in each treatment. The cost of feed, fingerlings and total revenue generated from harvest were estimated:

Profit index = value of fish crop / total cost of feed (Ita and Okeoye, 1988).

Data analyses

Statistical analyses were carried out to determine whether significant difference existed between the different treatments and the parameters tested. All results were analyzed using a one-way variance analysis and Tukey's multiple comparisons of means using GraphPad Instat Software® (1993). Graphical presentations were done using Microsoft excel® programme.

RESULTS

Table 1 shows the growth performance in terms of initial and average weight, specific growth rate, survival and feed conversion ratio of sampled fry for the various stocking densities as denoted as A = 10,000; B = 15,000; and C = 20,000. The average fry in all treatment groups increased from the initial value of 0.01 g.

Treatment 'A' attained the highest average final weight of 0.226 ± 0.02 g with the least being recorded by Treatment 'C' with an average value of 0.08 ± 0.007 g during in the fifth week. There were significant differences (P < 0.05) among the final average weights in all treatment groups except for treatments 'B' and 'C' (Table 1).

The specific growth rate (SGR) was significant (P < 0.05) among the treatment groups. However, by observation, fry stocked at 1000 per m^2, treatment 'A' recorded the highest (11.126 ± 0.308) SGR and fry stocked 2000 per m^2 recorded the lowest (7.404 ±0.294) SGR. Feed conversion ratio (FCR) were significantly (P < 0.05) different for fry stocked in all treatments except for treatments 'B' and 'C' (P > 0.05). The highest of 3.14 ± 0.15 was recorded in treatment 'C' fry and the least 2.34 ± 0.31 recorded by treatment 'A'.

From the experiment, although there were no observed significant (P > 0.05) differences among the treatments in terms of survival, the highest survival rate (SR) of 67.92 ± 26.76% was recorded in treatment 'B' followed by treatment 'A' with 62.29 ± 28.28% and treatment 'C' with 53.25 ± 26.40% was lowest.

Growth curves of fry in response to the different stocking densities over the five (5) week experimental period are shown in Figure 1. Growth of fry in treatment groups was gradual form the initial stages through to the 4th (fourth) week and rose sharply till the end of the 5th (fifth) week. The feed applied to treatment groups were calculated based on their stocking densities and their mortalities rates could not be determined until the end of experimentation.

As shown in Table 2, feed applied and cost of feed was high in Treatment 'C', with a value of 3.13 kg and GH¢ 28.39 respectively. The lower index was recorded for fry in treatment 'A' with a value of 2.34 kg and GH¢ 21.22 respectively. High value of fry crop was found in treatment 'C', although it recorded the least biomass of 848.40 g, with treatment 'A' attaining the lowest value of fry but a high biomass of 1407.75 g. The profit index calculated showed no significant difference (P > 0.05) among treatment groups, however, by observation, treatment 'B' attained the highest with a value of 23.18 ± 9.01.

Table 3 shows a summary about the average values of water quality parameters monitored throughout the trial. The water quality parameters reflected the environmental conditions under which the fish were cultured during the study. All parameters measured were all within the optimal range for tilapia growth.

DISCUSSION

Methyl testosterone treatment of tilapia fry has become the most simple and reliable way to produce all male tilapia stocks, which consistently grow to a larger and more uniform size than mixed sex or all female tilapias. It is highly effective on the Nile tilapia, *Oreochromis niloticus*, the main species farmed commerciall worldwide

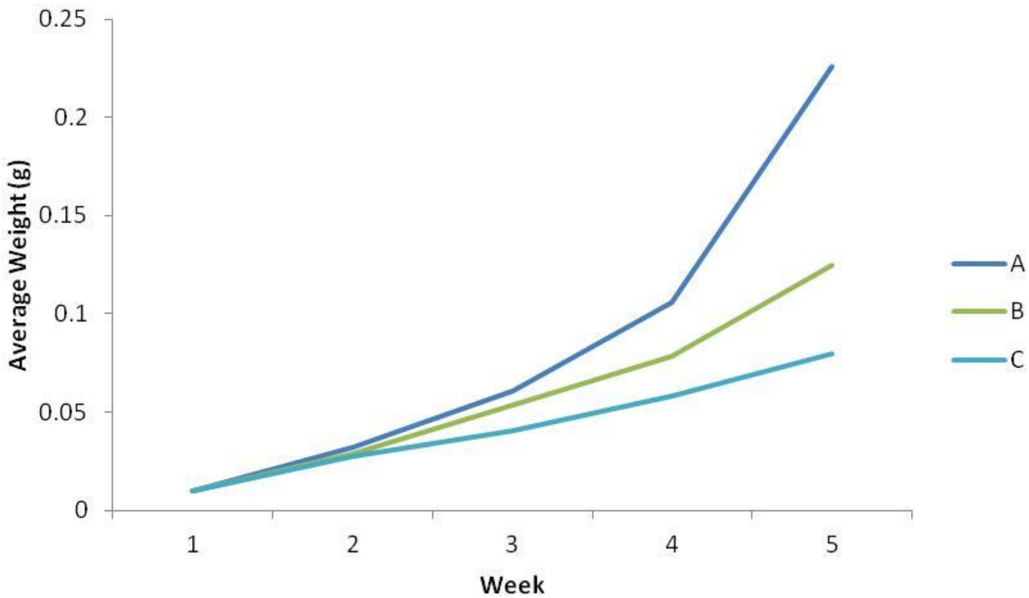

Figure 1. Growth of *O. niloticus* fry culture for 5 weeks under 3 different stocking densities.

Table 2. Some economic variables among the treatment groups.

Treatment	Feed applied (kg)	Cost of hormone feed (GH¢)	Biomass (g)	Value of fry (GH¢)	Profit index
A	2.34	21.22	1407.75	373.74	*18.06 ± 9.541[a]
B	2.90	26.30	1270.15	611.30	23.18 ± 9.008[a]
C	3.13	28.39	848.40	638.96	22.52 ± 11.316[a]

*Mean ± standard deviation, a = not significant difference.

Table 3. Mean values of physicochemical parameters of the treatment pond water.

Parameter	Treatment pond
Temperature (°C)	29.62 ± 0.47*
Dissolved Oxygen (mg/L)	5.02 ± 0.37
Ph	7.24 ± 0.13
Turbidity (NTU)	20.88 ± 3.80
Ammonia (NH_3-N) (mg/L)	0.50 ± 0.06
Nitrite (NO_2-N) (mg/L)	0.013 ± 0.003
Nitrate (NO_3-N) (mg/L)	0.08 ± 0.03

*Mean ± standard error.

In the study, fry in treatment groups grew differently without any adverse effect on growth. Growth curves showed a gradual growth of fry from the initial stages towards the end of experimentation. The final average weight of fry in treatment groups except 'B' and 'C' were significant and this could be attributed to the varying stocking densities. Yousif (2002) reported that it is a generally accepted principle, that increasing the number of fish (density) will adversely affect fish growth. The observation, decrease growth rates with increasing stocking density in this study corresponds to observation also reported by Breine et al. (1996). Social interactions through competition for food and/or space can negatively affect fish growth, hence higher stocking densities leads to increased stress and that resulting increase in energy requirements causing a reduction in growth rates and food utilization. This explanation is in conformity with the study done by Aksungur et al. (2007).

The FCR recorded ranged from 2.34 to 3.13. Treatment 'A' recorded the least, which could be attributed to effective feed utilization which reflected in the growth of fish. In general, high FCR were recorded and this may be due to the quality of feed ingredients used in the feed preparation, inefficiency of fry to convert feed into flesh (nutrient digestibility and absorption), environmental factors etc (Siddiqui et al., 1991; Liti et al., 2006). This explanation is in agreement with Guimaraes et al. (2008) that efficient utilization of diets may vary even within a single species because of the particular strain of fish used and the environmental factors.

Specific growth rate of fry in the treatment groups ranged from 7.4 to 11.13 g. All treatment groups were significant. This shows that growth of the fry was affected by the stocking densities. In a report by Osofero et al. (2009) in a study on the effects of stocking density on growth and survival of *O. niloticus*, they found out an inverse relationship between survival rate and stocking density.

From the study, although, survival rate were not significant among treatments, it was generally high in treatment 'B'. Treatment 'C', which recorded the least survival, could be attributed to overcrowding which led to competition for space and food, hence weaker ones eliminated from the population. This is in conformity with Vera Cruz and Mair (1994) who compared stocking densities of 1000, 3000, and 5000/m^2 of *hapa* using *O. niloticus* and found best sex reversal at 3000 and 5000/m^2 but lower survival at 5000/m^2.

The total feed applied in all treatments had a direct relationship with the cost of hormonal feed. Feed applied in treatment 'C' was high which also reflected in the cost of feed. A high biomass was recorded in treatment 'A' which suggests a relatively high survival. The value of post-treated fry estimated at the end of the study revealed a high amount (GH¢ 638.96) for treatment 'C'. Treatment 'B' attained a value of GH¢ 611.30 with an estimated profit index of 23.18 although among all treatment were statistically insignificant. The high profit index attained in treatment 'B' is as a result of the high survival rate.

All the water quality parameters were within the acceptable ranges as recommended for tropical aquaculture (Boyd, 1982; Beveridge, 1996).

Conclusion

In the study, androgen treatments had no apparent visible effects on the growth and survival of *O. niloticus* fry during the sex reversal treatment. It was revealed thatincreasing the stocking density of fry being treated significantly affects growth, feed conversion and yield, however does not significantly affect survival. Although profit index was not significant among the treatment groups, the cost-effective treatment with high survival and good growth in the trial was achieved in treatment 'B'.

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