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Appropriate Stocking and Feeding of Lake Shrimp (*Caridina niloticus*) Diet to Enhance Nile Tilapia Fry's Growth in an Intensive Aquaculture System

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ABSTRACT

Nile tilapia (*Oreochromis niloticus* L.) pond culture in Kenya is currently gaining popularity through the governments' economic stimulus programme intervention. However, lack of sufficient fry seeds to stock the ever increasing dug-out ponds is curtailing its expansion. The study therefore aimed to determine the ideal optimal stocking and feeding regimes that would enhance the growth (in <60 days) of fry's fed a locally prepared Lake Shrimp (*Caridina niloticus*) diet in an intensive aquaculture pond system. Experimental fry's with mean weights 0.06 ± 0.02 g and lengths 13.9 ± 0.7 mm were obtained from the same source and stocked into 1m^2 pond submerged net cages locally known as (hapas) labeled A, B, C and D, respectively. Hapa A with 100 fry's fed five times acted as control whereas Hapa B, with also 100 fry's was only fed twice within the day. Hapas C and D with 50 and 600 fry's, respectively, were both fed five times within the day as used in the farm. All feedings were done at 3% of total mean fry body weights for the entire experimental period. Daily pond water quality parameter values were also recorded and calculated weekly to determine the ideal water culture conditions. Weekly length (mm) and weight sampling values were also used to determine length and weight growths in addition to the fry's Food Conversion Ratios (FCRs). Results indicated that intensively stocked fry's at 100 individuals in 1m^2 pond area and fed twice daily using the locally prepared *Caridina* diet had slight significant growths ($p = 0.04$) with no significant FCRs ($p = 0.06$) in these intensive stagnant aquaculture ponds.

Key words: Fry's, *Caridina niloticus* diet, growth, stocking density, feeding frequency

INTRODUCTION

Tilapia is the common name given to three tilapine (Nile tilapia, Mozambique tilapia and the Blue tilapia) genera fishes of the Cichlidae family (Santiago and Laron, 2002). The genus *Oreochromis* includes Nile tilapia (*Oreochromis niloticus*), Mozambique tilapia (*Oreochromis mossambicus*) and the Blue tilapia (*Oreochromis aureus*). Regionally, it is the most preferred East African cultured fish species and second most worldwide after carps (Dan and Little, 2000; El-Sayed, 2006).

The culture of tilapia started around 2000-2500 BC (Chimits, 1957) and has since increased consistently with more than 22 tilapia species being cultured today in many tropical and sub-tropical regions (Fitzsimmons, 2000; El-Sayed, 2002). This has been made possible as a result of the fish's high resistance to diseases, ability to survive at low oxygen tensions and feeding on a wide range of foods (Nandlal and Pickering, 2004; Gibtan *et al.*, 2008; FAO., 2012). However, to ensure higher yields and faster growths, a well prepared balanced feed is essential (Ogello *et al.*, 2014; El-Sayed, 2013).

Globally, the culture of Nile tilapia also popularly known as 'aquatic chicken' has become the shining star of many aquaculture systems today due to its increasing consumption demands (Fitzsimmons, 2005; Ogello *et al.*, 2014). In Kenya, its intensive culture has currently gained popularity as a viable economic activity with the governments' economic stimulus programme intervention. However, lack of adequate fry seeds to stock the ever increasing dug-out ponds in addition to lack of high quality cheaper feeds has continued to curtail its expansion in most commercial aquaculture productions. Consequently, farmers mostly use non-conventional and locally available ingredients to feed their fish. Such feeds have not however, led to increased pond productivity due to poor processing, higher fiber content and anti-nutritional factors that limit nutrient bio-availability to the pond organisms (Koprucu and Ozdemir, 2005). Thus, diet formulation objectives should utilize the knowledge of fish nutrient requirements, local availability of the feed ingredients and digestive capacity of the cultured fish species. This enables development of a nutritionally balanced mixture of feedstuffs, which will be eaten in sufficient amounts to provide optimum growth productions at acceptable costs. However, sometimes excellent quality feeds have also not performed satisfactorily unless correct pond water quality parameters are maintained and proper feeding practices and rates used.

The main objective of this study was therefore to determine the ideal optimal stocking and feeding regimes that would enhance the growth (in <60 days) of fry's fed a locally prepared Lake Shrimp (*Caridina niloticus*) diet in an intensive aquaculture pond.

MATERIALS AND METHODS

Experimental site and design: The experiment was carried out in a privately owned intensive aquaculture pond system set-up at Dominion Farms Limited, Siaya County, Kenya in their Airstrip Aquaculture fish farm pond. Nile tilapia (*Oreochromis niloticus*) fry's were obtained from the farm and stocked into four 1 m² net cages (locally referred to as Hapas) submerged in an earthen pond of 1.5 m depth. The hapas were assigned labels A, B, C and D. Hapas A and B contained 100 fry's each while C and D had 50 and 600 fry's respectively for the experiment. The initial mean body weights of the experimental fry's were between 0.06±0.02 g while mean lengths were between 13.9±0.7 mm. Weekly measurement sampling was undertaken to monitor growth, feed conversion ratios and weekly adjustment of the feed amount to be offered.

Feed ingredients, diet formulation and feeding frequency: Dry Lake Shrimp by-catch (*Caridina niloticus*) was purchased from Kisumu fish supply stores, while rice bran, 1% vitamin premix and 1% fish oil was provided by the fish farm. The shrimp and rice bran ingredients were ground using a commercial feed mill (Farmers Feed, Lexington, KY, USA) and processed into fine powder form using a kitchen hand sieve of 500 µm (i.e., 0.050 mm) mesh size before being subjected to proximate analysis prior to diet formulation. Thereafter, the diet was formulated containing 68% protein (provided by *Caridina niloticus*), 30% carbohydrate (provided by rice bran) and 1% each in

the case of both the vitamin premix and fish oil. The vitamin premix and fish oil were added to the protein and carbohydrate ingredients and dried under shade at the hatchery to a moisture content of 10% before use. Feed was offered at 3% of mean total fry weights per day for the whole experimental period. Fry's in Hapas A and C were hand fed five times within the day at 08:00, 10:00, 12:00, 14:00 and 16:00 h using their feed ration divided into five portions. Those in hapa B were fed twice at 08:00 and 16:00 h using their feed ration divided into two portions. All feedings were done by scattering of the feed throughout the pond water surface. At the end of each week, all fry's were removed and sampled for growth, feed conversion ratios and adjustment of the feed ration to be offered in the subsequent week.

Evaluation of growth performance: The fry's growth performance evaluations were done using weekly length and weight measurements. Lengths were measured using a fish measuring board (Aquatic Eco-Systems, Inc., USA) whereas weight measurements were done using a top loading balance (OHAUS Cs 2000). The values were then used to determine mean weekly growth (length and weight increases) and FCRs using below formulae's:

- **Mean weekly weight gain per fry in the hapa:**

$$\frac{\text{Final total fry weights in the hapa} - \text{Previous total stocking fry weights in the hapa}}{\text{Initial total stocking fry weights in the hapa}}$$

- **Mean weekly total fry weight gains per hapa:**

$$\text{Mean weight gain per fry in the hapa} \times \text{No. of fry's in the hapa}$$

- **Weekly standing fry crop per hapa:**

$$\text{Mean fry weight in the hapa} \times \text{No. of fry's in the hapa}$$

- **Weekly food conversion ratio per hapa:**

$$\frac{\text{Amount of feed ration per hapa}}{\text{Final fish fry standing crop per hapa} - \text{Previous standing fish fry standing crop per hapa}}$$

Pond and water quality management: The experimental pond water temperature, pH, turbidity and Dissolved Oxygen (DO) were measured in the pond thrice daily at 07:00, 14:00 and 16:00 h and recorded in a labeled pond water quality parameter worksheet. Dissolved Oxygen was measured using an YSI Model 550A oxygen meter (YSI industries, Yellow Springs, OH, USA). Temperature and pH were however, measured using an electronic pH probe (pH Testr 2; Aquatic Eco-Systems, Inc., USA).

Statistical data analyses: Data was sorted and subjected to the non-parametric one-way ANOVA Kruskal-Wallis (Dunn's post hoc test) using Prism 5 package software to identify means that were significantly different from each other. All computations were performed at the significance probability level of $p < 0.05$.

RESULTS

Determination of growth length and weight responses: All initially stocked fry's at the start of the experiment had average length and weight measurements of 13.45 ± 0.45 mm and 0.06 ± 0.02 g respectively. The final mean growth length increases were 13.74 mm in hapa A, 15.48 mm in B, 15.25 mm in C and 8.48 mm in D (Fig. 1). The highest fry length at the end of the experiment was in hapa B with a length of 28.93 mm, followed by 28.70 mm in C, 27.19 mm in A and 21.93 mm in D. Final mean weight increases (Fig. 2) also increased by 0.66 g in hapa C, followed by B (0.54 g),

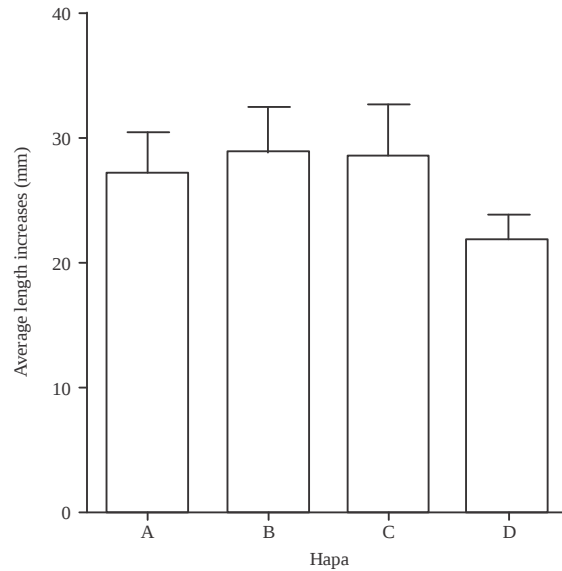


Fig. 1: *Oreochromis niloticus* fry's length (mean length increases in $\text{mm} \pm \text{SEM}$) growth responses during the experimental period. Bars represent positive mean standard error length increases

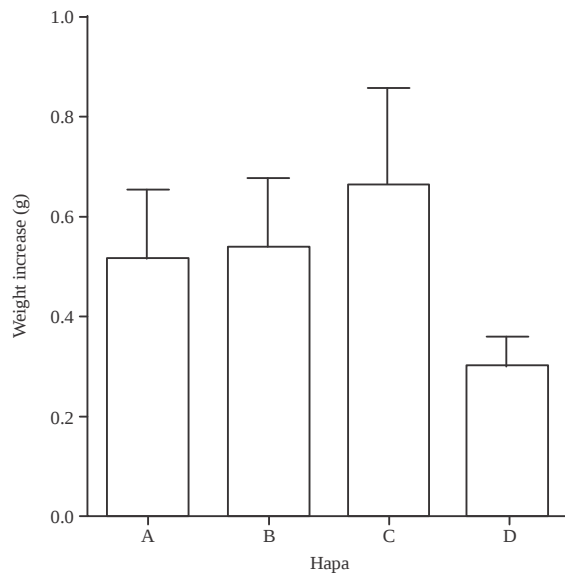


Fig. 2: Mean weight gain (mean weight increases in $\text{grams} \pm \text{SEM}$) growth response for the fry's during the experiment. Bars represent positive mean standard error weight increases

Table 1: Mean pond water quality parameter values during the study period

Parameters	Values
Mean DO (mg L^{-1})	3.7
Mean pH	8.7
Mean turbidity (cm)	13.3
Mean temperature ($^{\circ}\text{C}$)	26.9

DO: Dissolved oxygen

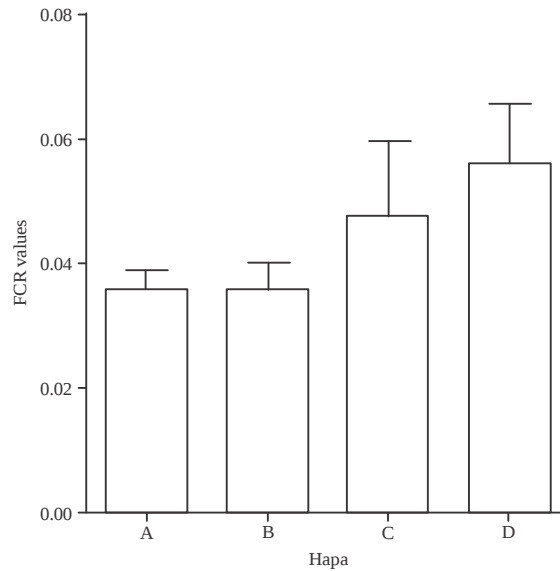


Fig. 3: Food conversion ratio of the Nile tilapia (*Oreochromis niloticus*) fry's reared in the experimental hapas during the study period

A (0.52 g) and D (0.30 g), respectively. This resulted in mean fry weights being 0.72 g in hapa C, 0.60 g in B, 0.58 g in A and 0.36 g in D at the end of the experiment.

Mean food conversion ratio determination: Mean food conversion ratios in the four experimental hapas were 0.038 in hapa A, 0.039 in hapa B, 0.046 in C and 0.055 in D (Fig. 3). The mean active overall food conversion ratio of the diet by the fry's was between 0.04 ± 0.005 .

Mean pond water quality parameters: Mean pond water quality parameters during the entire study period were 3.71 mg L^{-1} for Dissolved Oxygen (DO), 8.7 for pH, 13.3 cm in case of turbidity and 26.9°C in case of temperature (Table 1).

DISCUSSION

Even though slight length and weight growths ($p = 0.04$) were observed during the study (Fig. 1 and 2), it can be explained to have arisen from the applied stocking densities and feeding frequency regimes. This is because stocking density has already been cited as an inhibitory factor playing part in fish growths as a result to food competitions (Irwin *et al.*, 1999; Islam, 2002), space limitation (Ewing *et al.*, 1998) and low dissolved oxygen (Yi *et al.*, 1996). Huang and Chiu (1997), also argued that since tilapia is a territorial and aggressive fish, their density growth effects arises

from their competition for territories, as well as from the permanent stress caused by crowding. This leads to inhibitory fish growth as a result of the fish's physiological alterations elicited by stress responses so that adequate energy is mobilized from the consumed diets (Kebus *et al.*, 1992; Ruane *et al.*, 2002; Ruane and Komen, 2003). Therefore, since slight significant growth responses was observed with higher variances occurring in the hapas with the stocking densities of 50 and 100 fry's, indicated that stocking density had effects on the fry's growth.

Feeding frequency and distribution has also been shown to affect growth (Kestemont and Baras, 2001) through feed consumption inter-individual variation effects (i.e., when feed is unavailable for a certain period of the day, the better competitors that gain early access to food may have digested their previous meal and feed again during subsequent feeding positively enhancing their growth), whereas the individuals having their previous meals later may not regain their appetite before the end of the feeding period. This also leads to the deterioration of water quality as a result of the uneaten food ending up negatively affecting growth (Pankhurst and van der Kraak, 1997). Hence, the lower growth performances obtained in the study hapa D with higher stocking and five feeding frequency regimes could have resulted from the low DO values (Table 1) impacted by the uneaten food. Secondly, the feeding regimes have also been found to positively modify social feeding intake interactions of same species when restricted rations are given than when fed *ad libitum* (McCarthy *et al.*, 1992; Carter *et al.*, 1996).

In the study, Fish Conversion Ratio (FCR) was also found to be density dependent and higher fish density hapa D resulted in higher FCR values (Fig. 3). This is thought to have been probably as a result of the density-induced stressors that reduced the fry's appetite for food with most simply ending up in the sediment. Thus, the lower FCR values obtained in the study indicated better food utilization efficiency at lower stocking densities that were closer to those reported by Yi *et al.* (1996) in Nile tilapia cultured for 90 days in ponds stocked at 2 m^{-3} and containing a 4 m^3 cage stocked at either 60 or 70 fish m^{-3} . It is therefore, important to carefully monitor and plan the development of aquaculture in a model that can simulate fish growth on the basis of available fish species and local conditions like water quality, feeding frequency regime and feed quality. Therefore, based on the growth performance and low-cost investment value of this locally prepared *Caridina niloticus* by-catch diet, the density of 100 fry's m^{-2} with a 2 feeding frequency regime in an intensive aquaculture set-up appears to be the most ideal method for consideration as it resulted in slightly rapid growth and better food utilization.

CONCLUSION

Based on the above results, fry's stocked at 100 individuals with two feeding frequency regimes performs slightly better. Thus, we can conclude that Nile tilapia (*Oreochromis niloticus*) fry's cultured in an intensive aquaculture set-up and fed a locally prepared *Caridina niloticus* by-catch diet needs to be stocked at a density of 100 fry's with 2 feeding frequency regimes in 1 m^2 pond area to have slightly better faster growths and food utilization. This in turn improves yield, production and profitability of the farmers with stagnant aquaculture earthen ponds.

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