Midlands State University

THE EFFECTS OF STOCKING DENSITY ON THE GROWTH PERFOMANCE, SURVIVAL AND FEED CONVERSION RATIO OF NILE TILAPIA (*ORECHROMISE NILOTICUS*) FRY REARED IN CONCCRETE TANKS.

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Dissertation submitted in partial fulfilment of the requirements for the degree of

Bachelor of Science Honours Degree in Applied Biosciences and Biotechnology

Department of Applied Biosciences and Biotechnology

Faculty of Science and Technology

NOVEMBER 2019

Approval Form

This is to certify that the dissertation entitled “The effects of stocking density on the growth performances ,survival and feed conversion ratio of Nile tilapia (*Orechromise niloticus*) fry reared in concrete tanks, submitted in partial fulfilment of the requirements for the Bachelor of Science Honours Degree in Applied Biological Sciences and Biotechnology at Midlands State University, is a record of the original research carried out by STANLEY PANASHE ALIFA R163552G under my supervision and no part of the dissertation has been submitted for any other degree or diploma.

The assistance and the help received during the course of this research have been duly acknowledged. I, therefore, recommend that it be accepted as fulfilling the dissertation requirements.

Name of supervisor ………………………………………

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ABSTRACT

The study was conducted to evaluate the effect of different stocking densities on growth performances, survival rate and feed conversion ratio on the production potential of Nile tilapia fry (*Oreochromis niloticus*) reared in concrete tanks for 30 days from 10 November to 8 December 2018 at Lake Harvest Aquaculture, Kariba. A total of 120 000 fry (0.02 ± 0.002g) were collected, weighed and stocked in 16 tanks (each of 3.2 m² size) at four stocking densities of 3000 fry/ tank (T_1), 6000 fry/ tank (T_2) and 9000 fry/tank (T_3) and 12000 fry/tank (T_4). Each stocking density was replicated four times using a completely randomized design. Fry were fed with 17α- methyl testosterone hormone mixed with formulated feed 6 times a day at an initial rate of 15% of their body weight and adjusted to 10% of their body weight towards the end of experiment. Water quality parameters were monitored and found to be within suitable range for freshwater aquaculture. At the end of trial period, One -Way (ANOVA) using SPSS was used to test for significant variations ($P<0.05$).There were significant differences for growth parameter across all stocking densities. All growth measures were inversely proportional to stocking density. Weight gains were 1.03 ± 0.22g, 0.92 ± 0.08g, 0.65 ± 0.36g and 0.48 ± 0.46g for T_1 to T_4 respectively. Daily weight gains were 0.34 ± 0.0007g, 0.30 ±0.0002g, 0.22 ±0.0012 g and 0.16 ±0.0015g from T_1 to T_4 respectively. Specific growth rates per day were 0.13 ± 0.0007%, 0.13 ± 0.000, 0.12 ± 0.0018% and 0.11 ± 0.0029% from T_1 to T_4 respectively. Survival was indirectly proportional to stocking density. The highest survival rate was 81.55% ± 0.36 in T_1 and the lowest survival was 55.17% ± 1.98 in T_4. Increase in FCR was directly proportional to increase in stocking density .FCR was best in T_1 with mean of 1.08 ±0.22.The worst FCR was found in T_4 with an average of 2.26 ± 0.19. Cost based analysis showed highest feed loss directly proportional to stocking density. The lowest feed loss was 0.82 grams in T_1. Feed loss increased across all treatments to 10.23 in T_4. Net profit was highest in T_2 followed by T_1, T_3 and lowest in T_4.The study concluded that stocking 6000 fry per tank is beneficial for optimum growth, survival and good feed conversion ratio and farmers can stock 6000 fry in 3.2 m² concrete tanks for beneficial and optimum production of fry.

ACKNOWLEDGEMENTS

I would like to thank the Lord God Almighty for life. Special thanks goes to my academic supervisor, Mr. C .Makaka for all the assistance and encouragement rendered during this study. Many thanks to Lake Harvest Aquaculture (Pvt) Limited for funding this study. I am grateful to my friends and family for being a strong support system throughout my studies

DEDICATION

This work is dedicated to my parents for the effort they have put in educating me.

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CHAPTER 1: INTRODUCTION

1.1 Background

Fisheries play an important role in the agro-based economy of Zimbabwe, by providing food and nutrition, alleviating poverty, creating employment opportunities (Shava and Gunhidzirai, 2017) and earning foreign exchange (Mhlanga and Mhlanga, 2013). Fish farming is fast gaining momentum because of its untapped potential to generate employment and improve food security as it provides highly nutritious animal protein and important micronutrients among vulnerable households (Cowx, and Ogutu-Owhayo, 2019).

Aquaculture in Zimbabwe has enormous prospects and scope of development. In 2014, the total production was estimated at 10 600 tonnes and much of the production was Nile tilapia raised in floating cages in Lake Kariba (FAO , 2014). There is a need to further explore the potential in aquaculture, especially small-scale pond and tank fish farming of tilapias and African catfish (Shava and Gunhidzirai, 2017). A lot of technological advancements has not been utilized in Zimbabwe such as recirculating aquaculture system, advanced aeration, and water quality management systems and aquaponics due to their high costs. (Amoussou *et al.*, 2019).

Zimbabwe has an estimated 10,700 large-medium sized dams covering 3 910 km² (Mhlanga and Mhlanga, 2013).This shows the possibilities of small-scale pond fish farming of tilapias. Aquaculture can mitigate the protein deficiency state of the nation (Shava and Gunhidzirai, 2017). Fish farming as an economically viable sector for employment generation is often affected by trends in the international, national and local environment (Nyikahadzoi and Songore, 2016). This can include inflation, economic downturn which discourages markets, and policies (Ncube, 2014). In Zimbabwe, the limited success of fish farming is often attributed to limited funding, technology and poor implementation of fish farming practices (Mhlanga and Mhlanga, 2013).

Nile tilapia is the most farmed fish species in Zimbabwe (*FAO* , 2019). Farming of freshwater fish is important because of its size and taste. Fish farming can provide a cheap source for a country facing austerity measures such as Zimbabwe (Shava and Gunhidzirai, 2017). Tilapia has good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, the ability to convert efficiently the organic and domestic waste into high-quality proteins and rapid growth rate (José et'al, 2016). Fish assure the continued survival of the species in nature by providing greater parental care or by producing more offspring (Gonçalves-de-freitas *et al.*, 2016). Female tilapias, produce only a few hundred offspring per spawn (Popma and Lovshin, 2011). Under appropriate environmental conditions, they spawn frequently every four to six weeks (Abdulkarim and Yusuf, 2015).

1.2 Problem Statement

The reproductive habits evolved by tilapia were sufficient to assure survival in the wild (Gonçalves-de-freitas *et al.*, 2016). Only a few hundred offspring per spawn was needed in the wild because female Oreochromis persistently protect their offspring for several days after incubation (Abdulkarim and Yusuf, 2015). Low fecundity, however, is not a desirable trait because a greater number of female brood fish are required to sustain a commercial aquaculture operation. Commercial feeds have been developed to induce high fecundity in fish (Lutterodt,

2018). This gives farmers the ability to produce high amounts of fish as required by consumers. However, the negative effects of rearing fish under high stocking density on growth can be directly attributed to the induction of a stress response (Melaku *et al.*, 2018).

Stocking density is an important parameter in fish culture as the health, growth and survival of fish depend upon this factor (Fisheries, 2017). Higher stocking density reduces the growth and survival rates during fish culture (Ferdous, 2018). Sometimes excellent fish fry do not perform satisfactory growth unless correct stocking practices are maintained (Moniruzzaman, 2015). Many small scale farmers have failed to culture fish because of insufficient knowledge such as stocking fry at too small size and at high density (Shava and Gunhidzirai, 2017).

1.3 Justification

Fry stage is the most sensitive phase in the life cycle of most of the species because mortality rate high in this stage (Aktar, et'al 2014). Knowing the best densities for a species is a critical f3actor for good husbandry practices and creating efficient culture system. Hence, to gain a better growth and survival of fish fry suitable stocking density is highly essential. The study brings out optimum stocking density required for fry production in tanks. This will erase costs that are lost due to the overstocking of fry. It will also lead to maximizing production and profitability by farmers who rear fry in concrete tanks as a nursery. Data from this research can be used by seed producing companies to maximizing fry seed production.

1.4 Main Objective

To establish the most appropriate stocking density for *O.niloticus* fry in concrete tanks.

1.4.1 Specific objectives

To determine the effects of stocking density on the growth performance of Nile tilapia

To determine the effects of stocking density on the survival rate of Nile tilapia To

determine the effects of stocking density on feed conversion rate of Nile tilapia

To determine the economic benefits of each stocking density.

CHAPTER 2: LITERATURE REVIEW

2.1 Fish Farming In Zimbabwe

Fish farming in Zimbabwe dates back to 1997 when the first fish company Lake Harvest Aquaculture (Pvt) Ltd was granted a license by the ZPWMA to produce Tilapia in cages in the eastern basin of Lake Kariba (Harvest and Expansion, 2013). Since then a few fish farms have been established in Lake Kariba, Lake Chivero and other small dams (Nyikahadzoi and Songore, 2016). Nile tilapia is the most farmed fish species in Zimbabwe followed by trout which is reared in the eastern highlands (Amoussou *et al.*, 2019). However, the potential of fish farming in Zimbabwe is still largely untapped.

The recent development in specialized fish feeds has seen tilapia growth rates rising for indigenous fish suited to high stocking in dams and ponds (Shava and Gunhidzirai, 2017) . The establishment of Aquaculture Quality Control Laboratory in Harare enables fish farmers to receive training in aquaculture value chain, marketing, trade and business development. Although fish farming is still growing at a slow pace in Zimbabwe, networking with other African countries (Kenya, Tanzania, Ghana, Namibia and South Africa) that are flourishing in fish farming is key to regenerating employment and boosting food security (Nyikahadzoi and Songore, 2016).

2.2 Technological advancement in aquaculture

Aquaculture is the fastest-growing food production sector in the world (*FAO*, 2019). It has wide range of approaches that can improve subsistence and commercial aquaculture production and management. Some of the new development in aquaculture systems for enhancing the aquaculture productions are integrated farming, aquaponics, recirculatory aquaculture system (RAS), neo-female technology, biofloc technology (BFT) and compensatory growth technology (Subasinghe *et al.*, 2015).

2.2.1 Biofloc technology (BFT)

BFT is a technique of enhancing water quality in aquaculture through balancing carbon and nitrogen in the system (Azim and Little, 2008). It is the retention of waste and its conversion to biofloc as a natural food within the culture system (Luo *et al.*, 2014). Bioflocs are the aggregates (flocs) of algae, bacteria, protozoans, and other kinds of particulate organic matter such as faeces and uneaten feed (Emerenciano *et al.,* 2013). Each floc is held together in a loose matrix of mucus that is secreted by bacteria. This system promotes nitrogen uptake or Immobilization of ammonium by heterotrophic bacterial growth decreases the ammonium concentration more rapidly than nitrification (Emerenciano *et al.*, 2012). BFT provides a new farming approach to increase the food production in a sustainable way (Ekasari *et al.*, 2015).

2.2.2 Recirculatory aquaculture system (RAS)

RAS technology is the land-based closed systems in which aquatic organisms are cultured through the minimal use of water which is serially reconditioned (Ebeling and Timmons, 2012). This land-based closed containment system improves food security and reduces environmental impacts (Badiola *et al.,* 2012). RAS consists of a series of treatment processes removes organic and other oxygen demanding materials such as suspended solids, nutrients, fats, oil and pathogens from the waste water so that the water can be safely reused (Luo *et al.*, 2014).

2.2.3 Mono sex culture or Neo-female Technology

Mono sex culture or Neo-female Technology Mono-sex culture is a farming practice based on the culture of fish by producing all males or all females' population depending upon the sex which have better food conversion ratio and growth rate (Adamneh, 2013). Generally monosex culture of all female population of Carp, Salmon and all male population of Giant freshwater prawn and Tilapia is carried out that maximize the production level (Hafeez-Ur-Rehman *et al.*, 2008). Neo female technology involves obtaining females through the sex reversal of males and that yield all male progeny (Nahar *et al.*, 2017). In this techniques the sex of the juvenile males are changed through microsurgical removal of the androgenic gland (AG) or through androgenic gene silencing (RNA interference method) to female (termed "neo-females"-phenotypic females with male genotype) and when it mate with a normal male gives all male progenies (Mehrim, 2014). In India, this neo-female technology project for the production of male scampi seeds has been undertaken by RGCA, Tamil Nadu and supplies all-male scampi seeds to farmers of the country (Nahar *et al.*, 2017).

2.2.4 Aquaponics systems Aquaponics

Aquaponics systems Aquaponics is a modern food production system that combines aquaculture and hydroponics (Raising of plants without soil beds) together symbiotically in a balanced recirculatory environment (Haque *et al.*, 2015). Nutrient-rich water from fish tanks is used as liquid fertilizer to fertilize hydroponic production beds (Ali *et al.*, 2016). These nutrients in the water produced from fish manure, algae, and decomposing fish feed which otherwise increases the toxic levels in the fish tanks affecting the fish growth (Abdulkarim and Yusuf, 2015).

2.2.5 Integrated fish farming (IFF)

IFF is the sequential linkages between two or more agri-related farming activities with one of farming as major components (Abdulkarim and Yusuf, 2015). When fish becomes the major commodity in the system, it is termed as integrated farming (Abdulkarim and Yusuf, 2015). The linkage of fish farming with agriculture and animal husbandry is considered as sustainable farming system, which offers greater efficiency in resources utilization, reduces the risk by diversifying crops, and provides income and increased food fish production for small scale farming (Wang and Zhao, 2010).

2.2.6 Development in disease treatment and diagnosis

In fish disease diagnosis rapid detection of pathogens have been developed to prevent economic losses for farmers (Noga, 2010). Techniques of particular mention are immunodiagnostics, molecular diagnostics and multiplex technologies, and also agglutination, fluorescent antibody methods, immunohistochemistry, enzyme linked immunosorbent assay and blot (Magnadottir, 2010). Vaccines have also been developed to control fish diseases and to limit antibiotic use in fish farming (MacConnell, 2012).

2.2 Fry production in tanks

Tank cultivation of tilapia fry and fingerlings is practiced where space for ponds is restrained or costly to obtain (Abdulkarim and Yusuf, 2015). Other materials, such as fiberglass or plastic lined pools, may be used (José L *et al.,* 2016). The tanks may be rectangular, square or circular made of wood, concrete, bricks, fiberglass, or plastic with individual water inlets and drains (Nahar *et al.*, 2017). Tanks may be located in enclosed buildings, outside or under partial cover. Temperature is an important factor influencing tank location (MacConnell, 2012). A minimum water depth of fifty cm to 75 cm should be insisted to inhibit drastic water temperature variations in outdoor tanks (Abdulkarim and Yusuf, 2015). Greater control over water management, easy disease control, easy observation of fish and regular conservation is likely than with alternate methods (Popma and Lovshin, 2011). Fish may be simply harvested with dip-nets or a small seine, and well-built tanks can take a lifetime (Amoussou *et al.*, 2019).

2.3 Fry rearing, growth and sex reversal

Fry rearing is done in two-stage process; rearing after harvesting (hormonal sex reversal) from brooder tanks and advanced fry rearing to attain larger fingerlings over a time period (Aktar et'al., 2014). The Nile tilapia matures early and therefore has the capability to spawn monthly (Little *et al.,* 2003). These qualities result in the over-population of stocked tilapia ponds, slow growth due to overcrowding of the fish resulting in unequal market size fish (Adamneh, 2013). Due to these constraints, the male culture of tilapia is desired because they have the capability to grow faster than the females and therefore it is more profitable than the mixed-sex production (Popma and Lovshin, 2011).

The cultivation of all male tilapia can be achieved by techniques such as separating the males and females manually, Hybridization, Chromosomal manipulation and hormonal sex reversal (Subasinghe *et al.*, 2015). Among these three (3) methods, chromosomal manipulation and sex reversal (Methyl testosterone treatment) of the Nile tilapia fry is the most easy and consistent technique to produce all male tilapia stocks, which reliably grow to a big or unvarying size than mixed sex Nile tilapia (Cowx *et al*.,2019). The Nile tilapia, sex reversal implies the treatment administration of male steroid to newly hatched fry so that the undifferentiated gonadal tissue of generic female develops testicular tissue, which makes them function reproductively as males (Subasinghe *et al.*, 2015). Hormone treatment is administered between 2- 4 weeks by which time there is differentiation in the gonadal tissues (Amoussou *et al.*, 2019).

2.4 Stocking density

Is the concentration at which fish are initially stocked into a system. The stocking density is directly linked to welfare as it affects food competition and consumption, growth, stress, health, and mortality (Gonçalves-de-freitas *et al.*, 2016). For social species, the number of individuals in a group is associated to the probability of encounters (Fisheries, 2017). There are several studies regarding the effects of stocking density on the social behavior (Ferdous, 2018). In high stocking density there is an increased expression of genes related to stress which is likely due to increased aggressive interactions; moreover, they are more susceptible to the consequences of infection by *Saprolegnia parasitica* (Melaku *et al.*, 2018) and have higher mortality rates. Low stocking density is highly associated with high growth rate and food conversion in Nile tilapia (Daudpota, 2014).

CHAPTER 3: MATERIALS AND METHODS

3.1 Study site

The research was carried out at Lake Harvest Aquaculture (Pvt) in Kariba, Zimbabwe from November to December 2018 for 30 days.

3.2 Experimental Design

Sixteen tanks were dried for two weeks before scrubbing with water only. Day-old fry from Lake Harvest Aquaculture hatchery were graded using the Saran hapa. Fry that were < 14 mm were selected using a 3 mm mesh material and were collected for stocking using a standard strainer that holds 3000 fry. Stocked fry had an average body weight of 0.02 grams across all treatments. The study used a completely randomized design with four replications for each treatment (different stocking densities). The four treatments were 3000, 6000, 9000 and 12 000 fry in 3m*1.2m tanks (Figure 1).one hundred grams of salt was poured in each tank to relieve the fish from transportation stress.

12 000 fry 4 strainers	9000 fry 3 strainers	6000 fry 2 strainers	3000 fry 1 strainer	12 000 fry 4 strainers	9000 fry 3 strainers	6000 fry 2 strainers	3000 fry 1 Strainer
			Pathway				
3000 fry 1 strainer	6000 fry 2 strainers	9000 fry 3 strainers	12 000 fry 4 strainers	3000 fry 1 strainer	6000 fry 2 strainers	9000 fry 3 strainers	12 000 fry 4 strainers

Figure 1: Experimental design of the study

3.3 Feeding

Fry were fed commercial fry meal six times a day. Feeding was started at 15% of the average fry body weight and it gradually decreased to 12%, 10% and 8% according to the Raanan growth chat (Appendix 1). The following formula was used to calculate the amount of feed: Feeding amount = Average body weight * feeding ratio * Number of fish in the tank

Fry were fed fry meal mixed with Methyl testosterone (MT) hormone, to induce sex reversal for the first 21 days of the experiment.

3.4 Preparation of hormone impregnated feed

15 ml of 10% MT hormone and alcohol solution were mixed with 75kg fry meal feed, 350ml absolute alcohol. The feed was spread down on a polythene sheet in a closed room.

3.5 Sampling`

Fish samples were taken after every seven days from the day of stocking. Two samples were taken for each tank. The number of samples taken was determined by the Standard operating procedures of Lake Harvest Aquaculture (Appendix 2). Fish in each sample were weighed and counted using volumetric displacement method. The average body weight (ABW) was determined as follows:

ABW = (Final volume – Initial volume) / Number of Fish

Data from the samples was used to estimate the growth performance of fish, deducing feeding rates from growth charts and monitoring feed conversion ratio (FCR).

3.6 Water quality management

Temperature and dissolved oxygen levels were recorded six times a day at 2 am, 6 am, 10 am, 2 pm, 6 pm, and 10 pm. Ammonia, ammonium, pH and alkalinity levels were recorded after every seven days from the day of stocking. Ammonia, ammonium, pH and alkalinity levels were measured using a Spectrophotometer. Temperature and dissolved oxygen were measured using a Deometer. Deviations in water quality were promptly corrected since water quality was not an experimental variable during the period of study.

3.7 Determination of Growth measures

Average body weight recordings from weekly samples were used to calculate growth rate. The following formulae were used to calculate growth parameters.

Weight gain (g) = Final weight (g) – Initial weight (g)

Average daily weight gain (ADG) = (Final weight (kg) –Initial weight (kg)) / Number of days

Specific growth rate (SGR) = ln (Final biomass of the fish) – ln (Initial biomass of the fish) / Number of days the fish has been in the tank

3.8 Determination of survivals

Mortalities (dead fish) were picked and recorded as soon as they would resurface on top of the water. Daily mortality records were used to estimate survival rates across all treatments. The determination of survival was done at the end of the project. Fish could not be weighed for total biomass at every weekly sample because it involved handling of fish which can induce stress. The total biomass of the fish from stocking and harvesting was used to determine survival. The following formula was used to calculate survival rate.

Survival rate (%) = (Number of fish that survived / Number of fish leased)* 100

3.9 Determination Feed Conversion Ratio (FCR)

Weekly samples were used to estimate the FCR of the fish. This was done to explain anomalies during the course of the project. The final FCR was rather used for data analysis. The following formula was used to calculate FCR.

FCR = Total feed consumed (in kg) / Total Biomass in the tank (in kg)

3.10 Data presentation and analysis

Growth variables, survival rate, and FCR were analyzed using a one-way analysis of variance (ANOVA) to compare the treatment means. The main effect test was followed by Tukey's Test and Dunnet-T3 test for multiple comparisons (to test for significant differences between treatment groups) where there was equality of data variances and where there was no equality of data variances respectively. A paired samples T-test was done to test for significant differences between the mean mortalities picked and the mean mortalities calculated using the total biomass on harvesting. All analysis of variances were tested at 5% level of significance using SPSS (Statistical Package for Social Science) version 21.

3.11 Economic Benefits of stocking density

Economic analysis of the different treatments was calculated using purchasing prices of tilapia fry, feed, and the predicted revenue from the sale of tilapia fry after 30 days of study. The prices used in the study were based on Zimbabwean prices for the period October 2019. Data from this research was used to calculate the number of fish, total feed cost, and feed loss per tank, total sales and net profit according to the following formulae:

Number of fish per tank = Total Biomass (g) / ABW (g)

Total feed cost = Total feed (kg) * Price feed per kg (Feed was costing US$4.1 per kg at the time this report was done)

Feed loss per tank = Total feed (kg) –Survival Biomass (kg)

Cost of feed loss = Feed loss (kg) * Price of Feed per kg

Total sales = (Number of fish per tank * price of 1000grams of fish)/1000

Net profit = Sales value – Total feed cost

CHAPTER 4: RESULTS

Table 1 summarizes growth measures and number of mortalities as measured during the study over a period of 30 days.

Table 1. Mean (± sd) of growth measures and number of mortalities of tilapia O. *niloticus* in four different treatments during the study period

	Treatments			
Parameter	T_1 (3000)	T_2 (6000)	T_3 (9000)	T_4 (12 000)
Weight gain (g)	1.03 ± 0.22^a	0.92 ± 0.08^b	0.65 ± 0.36^c	0.48 ± 0.46^d
Daily weight gain (g)	0.34 ± 0.0007^a	0.30 ± 0.0002^b	0.22 ± 0.0012^c	0.16 ± 0.0015^d
SGR (%/day)	0.13 ± 0.0007^a	0.13 ± 0.0003^b	0.12 ± 0.0018^c	0.11 ± 0.0029^d
Mortality rate%	11.23^a	11.37^a	8.27^a	11.18^a

*Values in the same raw with same superscript letter were not significantly different $p < 0.05$

Weight gain was highest in T_1 with (1.03g ± 0.22) and lowest in T_4 with (0.48g ± 0.46) (Table1) .The highest SGR was (0.13 ± 0.0007) and the lowest (0.11 ± 0.0029). Daily weight gain was significantly high in T_1 and T_2 ($P<0.05$) with (0.34g ± 0.0007) and (0.30g ± 0.0002). Analysis of variance (one way) by SPSS version 21 showed significant differences in performances across all treatments for both weight gain, SGR and daily weight gain ($P=0.00$) $F=256.486$ (Appendix 4). Multiple comparisons for post hoc analysis confirmed significant mean differences of all growth measures between all treatments (appendix 5). All growth measures were inversely proportional to stocking density. Mean final body weight decreased with increase in stocking density. The highest average final body weight was (1.05g ± 0.02) in T_1 and the lowest was (0.50g ± 0.46) in T_4 (Figure 2).

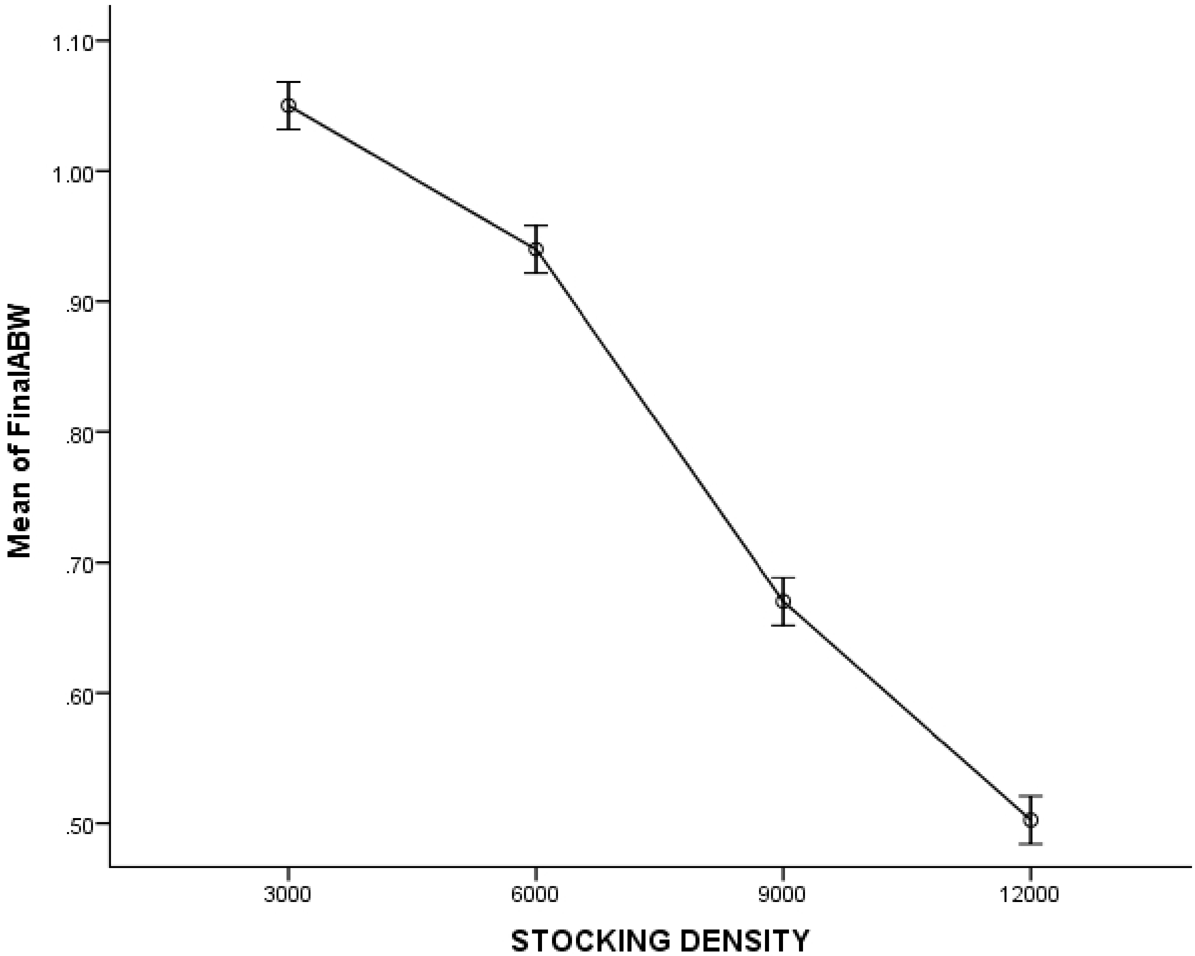

Figure 2: Plot of average body weight against stocking density**.**

Mortality rate was directly proportional to stocking density. Mortality rate averaged around 11% in T_1, T_2 and T_4.T_3 was the only different group, with a mortality rate of 8.27. The highest average number of mortalities per tank 1342 ± 102.21 was found in T_4 and the lowest 337 ± 33.88 was found in T_1. Number of mortalities in a tank per day increased with time from day 7 to day 29 (Figure 3). Survival was inversely proportional to stocking density .The highest survival 81.55% ± 0.36 was found in T_1 .The lowest survival 55.17% ± 1.98 was found in T_4 (figure 4). The paired t test showed significant difference between the mean of mortalities picked and total survival; ($t(15) = -6.967$, $p < 0.05$) (Appendix 5).

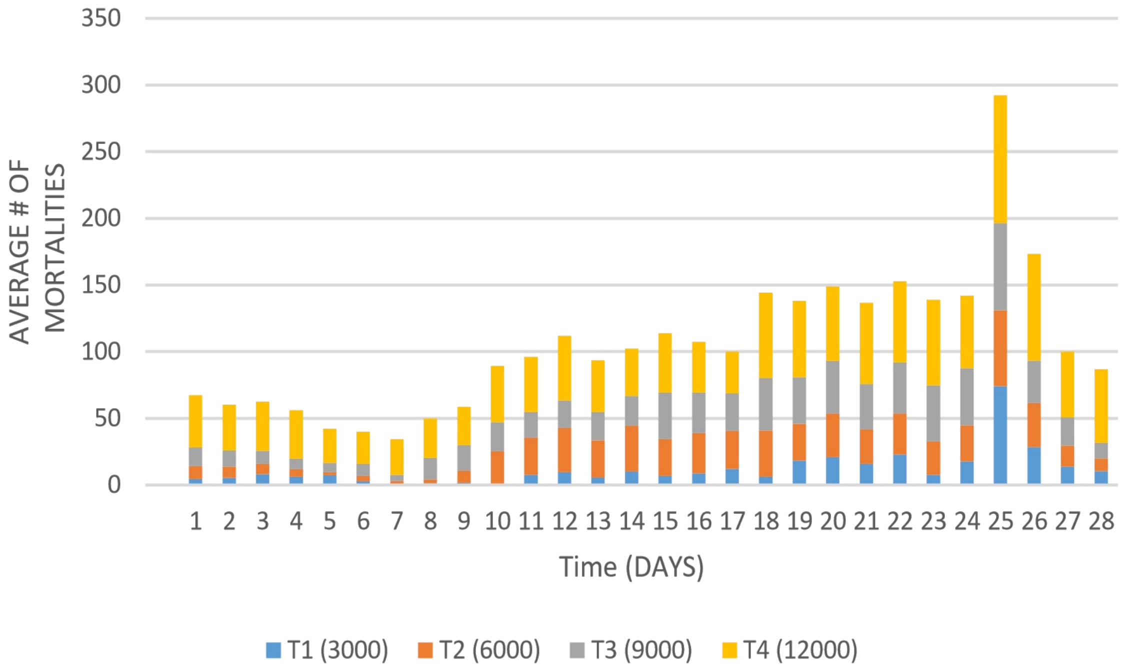

Figure: 3 Plot of Average number of mortalities in a tank per day picked against time in days

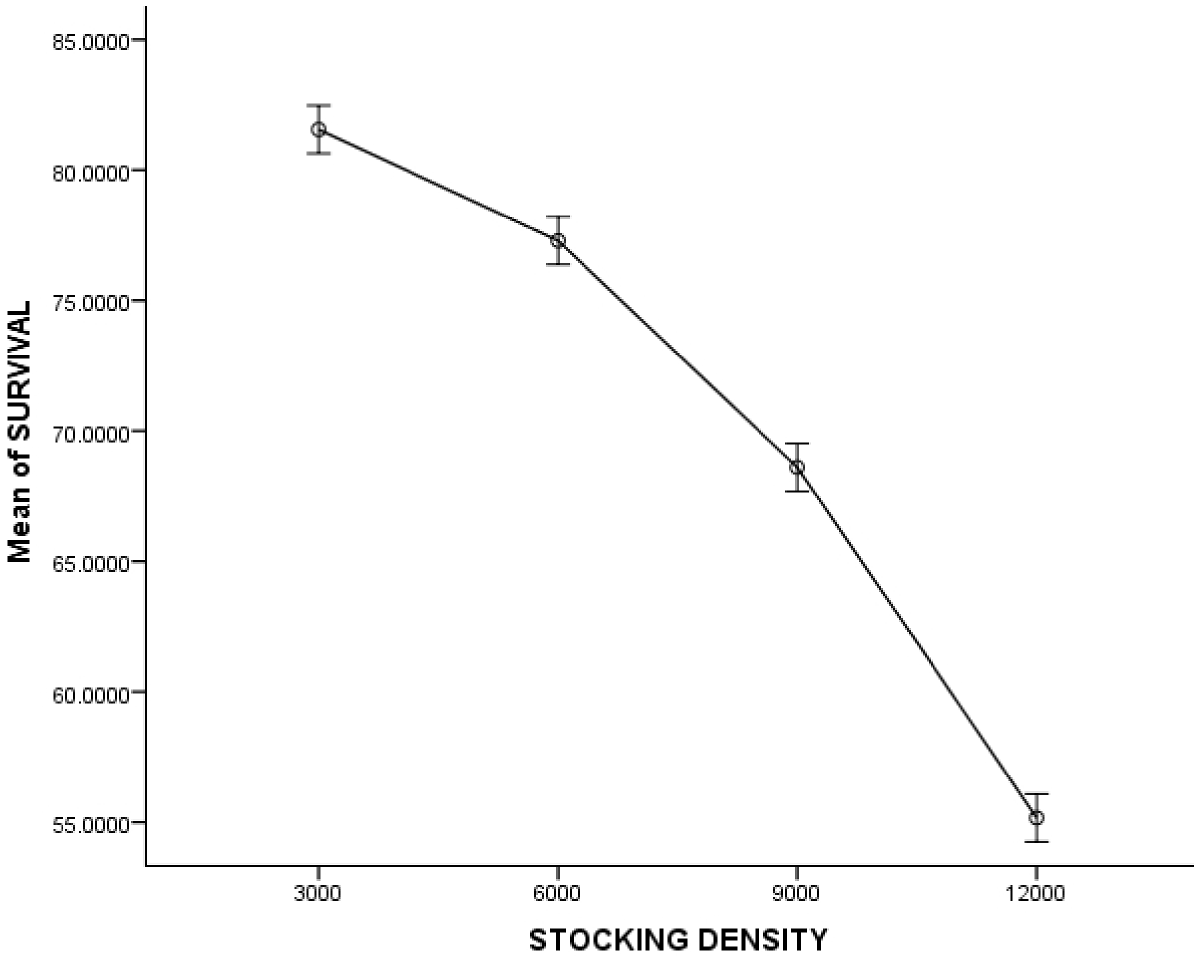

Figure 4: Plot of mean survival against stocking density

Increase in FCR was proportional to increase in stocking density. FCR was best in T_1 with mean of 1.08 ±0.22. The worst FCR was found in T_4 with an average of 2.26 ± 0.19 (figure5). One-way analysis of variance showed significant difference in FCR across all treatments p=0.01(Appendix 4).Tukey test for multiple comparison showed significant difference between the mean FCR of T_1 and T_2 p=0.378 (Appendix 5).

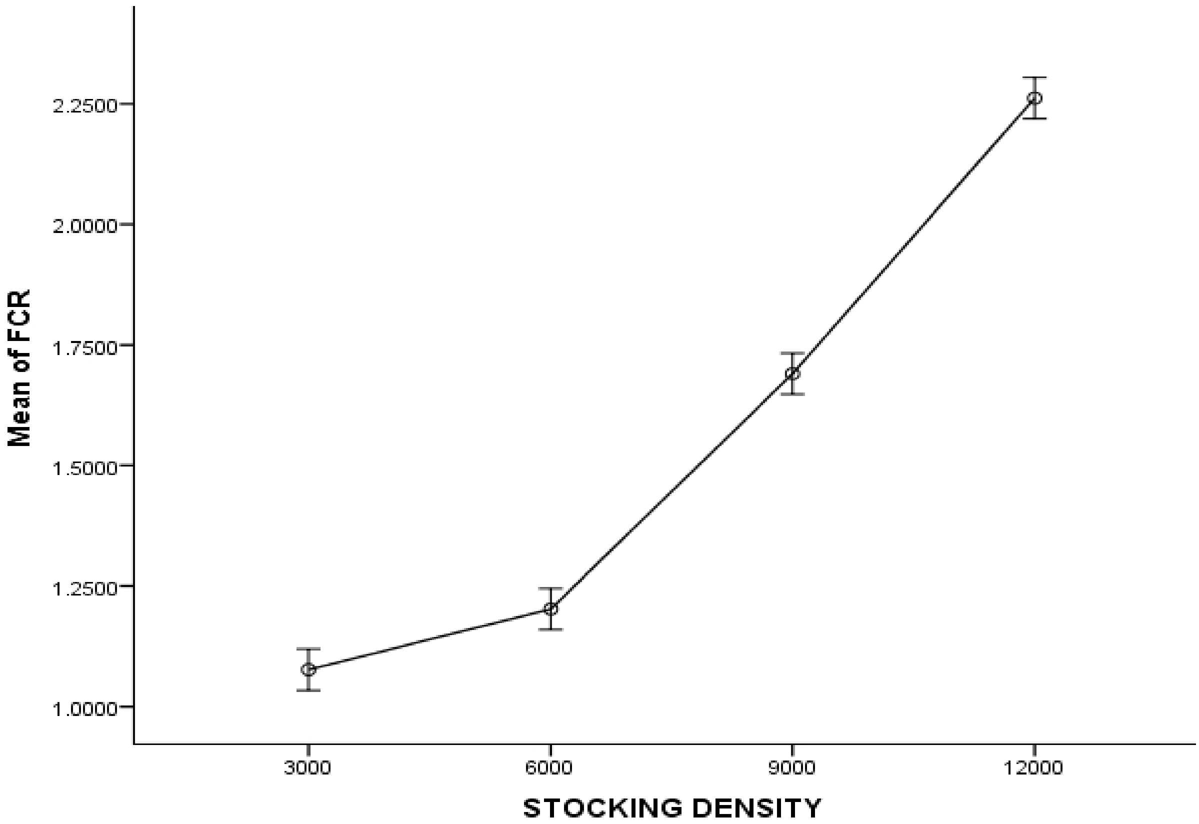

Figure 5: Plot of Feed conversion ratio (FCR) against stocking density of *0.niloticus* against stocking density**.**

4.2 Water quality

Table 2 summarizes water quality parameters as measured during the period of study. There were no significant differences in all measured water quality parameters (P <0.05). This indicates efficient corrective measures to keep water quality variables constant throughout the study.

Table 2. (mean ± sd) of water quality parameters in the four three treatments during period of study.

	Treatments			
Parameter	T_1 (3000)	T_2 (6000)	T_3 (9000)	T_4 (12000)
Alkalinity(mg/l)	95.5 ±16.34	80 ±21.32	76.5 ±18.91	80.5 ±12.04
Ammonia(mg/l)	0.016 ±0.0052	0.019 ±0.0043	0.018 ±0.0075	0.025

				±0.0020
Ammonium(mg/l)	0.22 ±0.0060	0.22 ±0.1161	0.31 ±0.1687	0.39 ±0.1315
Dissolved Oxygen(mg/l)	6.57 ±1.08	5.99 ±0.91	5.65 ±0.77	5.11 ±1.29
pH	6.48 ±0.25	7.58 ±1.08	7.25 ±0.72	6.68 ±0.17
Temperature(°C)	29.2 ±1.95	29.7 ±1.82	29.2 ±1.81	29.4 ±1.84

Table 3: Cost based analysis based on the 30 days of study

Parameter	Stocking density			
	T_1(3000)	T_2(6000)	T_3(9000)	T_4(12000)
Total Feed Consumed (kg)	3.39	6.78	10.17	13.56
Feed Loss Per Tank (kg)	0.82	2.42	6.08	10.23
Cost of Feed loss (US$)	3.37	9.93	24.92	41.94
Cost of Feed (US$)	13.90	27.80	41.70	55.60
Total Sales (US$)	244.65	435.90	409.40	331.01
Net Profit (US$)	241.28	425.98	384.48	289.07

The highest feed consumed was 13.56 kg in T_4 and lowest 3.39 kg in T1.The lowest feed loss was 0.82 grams in T_1. Feed loss increased across all treatments to 10.23 in T_4. Costs of feed and feed loss cost increased across all treatments from US$13.90 and US$3.37 respectively in T_1 to US$22.65 and US$41.94 in T_4.The highest selling price $435.90 per 1000 fry was recorded in T_2. The lowest selling price US$289.07 was recorded in T_4 .Net profit was highest in T_2 followed by T_1, T_3 and lowest in T_4. The economic stocking density was found to be 6000fry/tank.

CHAPTER 5.1: DISCUSSION

The study aimed to seek an optimum stocking density for *O.niloticus* fry in concrete tanks. The study sought to find the effects of density on growth performance, survival and feed conversion rate. In the present study, there was a significant reduction in growth (P<0.01) with increasing stocking density. This result is in agreement with (Daudpota, 2014) who studied the effect of stocking density (1000, 1500, 2000 fry/hapa) on the growth of Nile tilapia and found growth was high in lower stocking density. It is a known fact that growth rate progressively increases as the stocking density decreases and vice versa (de Oliveira *et al.*, 2012). This is because a relatively less number of fish of similar size in a pond could get more space, food, less competition (Fisheries, 2017) and dissolved oxygen .Lower growth performance of tilapia at higher stocking density could also be caused by voluntary appetite suppression, more expenditure of energy because of antagonistic behavioral interaction, competition for food (Moniruzzaman, 2015) and living space (Chattopadhyay *et al.*, 2013) and increased stress (Rahmatullah, Das and Rahmatullah, 2010).

This study found that FCR increased with increase in stocking density. Increase in FCR with increasing stocking density is in agreement with results obtained by (Rahman *et al.*, 2016) .This is a clear reflection of the good feed utilization as confirmed by high growth rates in stocking densities as well. Two treatments T_1 and T_2 had FCRs below the Standard threshold level of 1.5 in aquaculture. The primary determinants of FCR at the production unit level, mortality (Khattab *et al*.,2013) and individual differences between fish in converting feed to biomass, are strongly influenced by the environment (Growth *et al.*, 2018). In this study, high FCR can be attributed to the late mortalities that are caused by stocking fish in high stocking density since water quality parameters had no significant differences across all treatments. This study found that survival was high in lower stocking density than in high stocking density. This result agrees with the findings of previous researchers such as (Shamsuddin *et al.*, 2012). In this study poor survival in high stocking density can be attributed to stress and limited space for fish. However, the high survival rate of Nile tilapia in treatment 2 indicates its amenability to the intensive culture practice (Melaku *et al.*, 2018). The study determined that stocking 6000 fry in a 3m*1.2m gives more economical benefit than stocking at 3000, 9000 and 12000 fry.

5.2 Conclusion and recommendations

The study supports farmers to stock 6000 fry in 3m*1.2m tanks for beneficial and optimum production of fry. This study noted that estimating survival rate using the number of mortalities picked had a significant bias. This study recommends the development of mathematical models and electronic instruments that can predict survival better. There is no readily available literature of similar experiments in Zimbabwe. The study referred to publications of foreign countries. This can have some bias since different countries face different environmental conditions which can result in a significant difference of data. Similarities of this study and other studies may be caused by other factors which are not stocking density. The company at which the study was carried out has is an international company with very high management skills. This means it can afford to meet the strict requirements of intensive feeding, high aeration and regular checks of water quality. Farmers may fail to rear their fry to the average body weight advertised in this study if they do not exercise similar management skills. Further studies are therefore recommended to seek optimum stocking density for farmers who practice semi-intensive feeding strategies.

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Appendices

Appendix 1: Raanan growth Chart for Tilapia (for 30 days)

		Growth forecast		
Day	ABW	Growth per day	NewABW	feeding rate
1	0.02	0.02	0.04	15%

2	0.04	0.01	0.05	15%
3	0.05	0.01	0.06	15%
4	0.06	0.01	0.07	15%
5	0.07	0.01	0.08	12%
6	0.08	0.01	0.09	12%
7	0.09	0.02	0.11	12%
8	0.11	0.02	0.13	12%
9	0.13	0.02	0.15	12%
10	0.15	0.02	0.17	12%
11	0.17	0.02	0.19	12%
12	0.19	0.02	0.21	12%
13	0.21	0.02	0.23	12%
14	0.23	0.02	0.25	12%
15	0.25	0.02	0.27	12%
16	0.27	0.02	0.29	12%
17	0.29	0.02	0.31	12%
18	0.31	0.02	0.33	12%
19	0.33	0.04	0.37	12%
20	0.37	0.04	0.41	12%
21	0.41	0.08	0.49	12%
22	0.49	0.08	0.57	10%
23	0.57	0.08	0.65	10%
24	0.65	0.08	0.73	10%
25	0.73	0.08	0.81	10%
26	0.81	0.08	0.89	8%
27	0.89	0.12	1.01	8%
28	1.01	0.12	1.13	8%

29	1.13	0.12	1.25	8%
30	1.25	0.12	1.37	8%

Appendix 2: LHA' Standard operating procedures on sampling

Level 2 Document	Title: Tanks-Farm to lake transfer protocol	Issue No 1/2017	Page 2 of 3
Document type: Procedure	Prepared: Privilage Marava Signature	Reviewed: Signature	Valid From: 01.10.17
Document no. 1.2.1.1	Authorized: Signature	CEO: James de la Fargue Signature	

	Procedure	Responsibility
Farm to lake transfer		
3.8	The fish shall only be crowded when the boxes are ready.	Nursery crew
3.9	The fish condition shall be assessed before loading. If fish show signs of stress and/or if more than 25% of the fish have visible wounds, transfer shall be halted.	Transfer supervisor/ nursery supervisor
3.10	Small perforated buckets shall be used to deliver fish from the hapas to the boxes.	Nursery crew
3.11	At least 2 random samples shall be done on every tank of fish being transferred and the number calculated per box, not total number. This will reduce overstocking and under stocking in boxes, and give an indication of variation.	Nursery crew
3.12	Immediately after adding fish to the boxes, the oxygen system shall be turned on and regular DO and temperature checks done by the water quality attendant. Once the desired biomass has been added the box is closed.	Farm technical attendant

Level 2 Document	Title: Tanks Water Quality Monitoring protocol	Issue No 2/2017	Page 2 of 3
Document type: Procedure	Prepared: Privilage Marava Signature	Reviewed: Signature	Valid From: 01.10.17
Document no. 1.2.4.1	Authorized: Signature	CEO: James de la Fargue Signature	

APPENDIX 1: OPTIMUM RANGES FOR WATER QUALITY PARAMETERS AND CORRECTIVE ACTIONS

Parameter	Optimum (mg/L)	Corrective action	Notes
Ammonia – NH_3	<0.02	Suspend feeding Fit/ fix / clean biofilter Water exchange with regular pH checks. Do not lime ponds.	Toxic to fish. Excreted as faecal waste and a by-product of organic decomposition. Levels increase with an increase in temperature and pH
Ammonium-NH_4^+		If pH is too low, lime ponds	Non-toxic form of ammonia. Levels increase with a drop in pH and temperature
Nitrite	<1.0		Less toxic than unionized ammonia Intermediate compound in the conversion of ammonia to nitrate
Nitrate	<50	Water exchange	Nitrate is relatively non-toxic to fish (rare toxicity at >300mg/L). It may safely accumulate in the tank until it is flushed out by refreshment water or converted to gaseous nitrogen (N_2) by anaerobic heterotrophs and lost to the atmosphere in a process known as denitrification.
Alkalinity	50-100	Liming ponds	Measures the pH buffering capacity of water. Water with low alkalinity is poor for fish culture. Supports plankton growth due to a scarcity of CO_2. Rarely fluctuates daily so only occasional checks done, unless a need arises
Hardness	80-300	Addition of CaCl	Dissolved calcium in the water aids in osmoregulation and relieves stress in fish. It is usually added as calcium chloride ($CaCl_2$) which dissolves readily and also increases chloride (Cl^-)
Temperature	25 - 31°C	Refresh water or add ice	Plays an important role in the level of dissolved oxygen. The cooler the temperature the higher the DO and vice versa.
DO	5.0-9.0	Improve aeration by switching on aeration or net changing	Major limiting parameter. Low DOs as a result of algal decomposition. Causes stress, slow growth or increase mortalities. Low DO levels increase toxicity of ammonia.

Appendix 3: LHA' Standard operating procedures on water quality

APPENDIX 4: ANOVA output

		Sum of Squares	df	Mean Square	F	Sig.
FinalABW	Between Groups	.749	3	.250	256.486	.000
	Within Groups	.012	12	.001		
	Total	.760	15			
WEIGHTGAIN	Between Groups	.749	3	.250	256.486	.000
	Within Groups	.012	12	.001		
	Total	.760	15			
WEIGHTGAINPERCENT	Between Groups	18715468.750	3	6238489.583	256.486	.000
	Within Groups	291875.000	12	24322.917		
	Total	19007343.750	15			
ADWG	Between Groups	.001	3	.000	256.486	.000
	Within Groups	.000	12	.000		
	Total	.001	15			
SGR	Between Groups	.002	3	.001	163.973	.000
	Within Groups	.000	12	.000		
	Total	.002	15			
FCR	Between Groups	3.485	3	1.162	103.081	.000
	Within Groups	.135	12	.011		
	Total	3.620	15			
SURVIVAL	Between Groups	1626.815	3	542.272	194.065	.000
	Within Groups	33.531	12	2.794		
	Total	1660.347	15			

Appendix 5: Post Hoc (Multiple comparisons)

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
FinalABW	3.402	3	12	.053
WEIGHTGAIN	3.402	3	12	.053
ADWG	3.402	3	12	.053
SGR	4.801	3	12	.020
FCR	5.537	3	12	.013
SURVIVAL	3.043	3	12	.070
Mortality_rate	.734	3	12	.552

Multiple Comparisons

Dependent Variable				Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
FinalABW	Tukey HSD	3000	6000	.11000*	.02206	.002	.0445	.1755
			9000	.38000*	.02206	.000	.3145	.4455
			12000	.54750*	.02206	.000	.4820	.6130
		6000	3000	-.11000*	.02206	.002	-.1755	-.0445
			9000	.27000*	.02206	.000	.2045	.3355

			12000	.43750*	.02206	.000	.3720	.5030
		9000	3000	-.38000*	.02206	.000	-.4455	-.3145
			6000	-.27000*	.02206	.000	-.3355	-.2045
			12000	.16750*	.02206	.000	.1020	.2330

		12000	3000	-.54750*	.02206	.000	-.6130	-.4820
			6000	-.43750*	.02206	.000	-.5030	-.3720
			9000	-.16750*	.02206	.000	-.2330	-.1020
	Dunnett T3	3000	6000	.11000*	.01155	.004	.0584	.1616
			9000	.38000*	.02082	.000	.2979	.4621
			12000	.54750*	.02529	.000	.4408	.6542
		6000	3000	-.11000*	.01155	.004	-.1616	-.0584
			9000	.27000*	.01826	.002	.1809	.3591
			12000	.43750*	.02323	.001	.3212	.5538
		9000	3000	-.38000*	.02082	.000	-.4621	-.2979
			6000	-.27000*	.01826	.002	-.3591	-.1809

			12000	.16750*	.02898	.007	.0591	.2759
		12000	3000	-.54750*	.02529	.000	-.6542	-.4408
			6000	-.43750*	.02323	.001	-.5538	-.3212
			9000	-.16750*	.02898	.007	-.2759	-.0591

WEIGHTGAIN	**Tukey HSD**	**3000**	**6000**	**.11000***	**.02206**	**.002**	**.0445**	**.1755**
			9000	**.38000***	**.02206**	**.000**	**.3145**	**.4455**
			12000	**.54750***	**.02206**	**.000**	**.4820**	**.6130**
		6000	**3000**	**-.11000***	**.02206**	**.002**	**-.1755**	**-.0445**
			9000	**.27000***	**.02206**	**.000**	**.2045**	**.3355**
			12000	**.43750***	**.02206**	**.000**	**.3720**	**.5030**
		9000	**3000**	**-.38000***	**.02206**	**.000**	**-.4455**	**-.3145**
			6000	**-.27000***	**.02206**	**.000**	**-.3355**	**-.2045**
			12000	**.16750***	**.02206**	**.000**	**.1020**	**.2330**
		12000	**3000**	**-.54750***	**.02206**	**.000**	**-.6130**	**-.4820**
			6000	**-.43750***	**.02206**	**.000**	**-.5030**	**-.3720**

			9000	-.16750*	.02206	.000	-.2330	-.1020
	Dunnett T3	3000	6000	.11000*	.01155	.004	.0584	.1616
			9000	.38000*	.02082	.000	.2979	.4621
			12000	.54750*	.02529	.000	.4408	.6542

		6000	3000	-.11000*	.01155	.004	-.1616	-.0584
			9000	.27000*	.01826	.002	.1809	.3591
			12000	.43750*	.02323	.001	.3212	.5538
		9000	3000	-.38000*	.02082	.000	-.4621	-.2979
			6000	-.27000*	.01826	.002	-.3591	-.1809
			12000	.16750*	.02898	.007	.0591	.2759
		12000	3000	-.54750*	.02529	.000	-.6542	-.4408
			6000	-.43750*	.02323	.001	-.5538	-.3212
			9000	-.16750*	.02898	.007	-.2759	-.0591
ADWG	Tukey HSD	3000	6000	.0036667*	.0007352	.002	.001484	.005849
			9000	.0126667*	.0007352	.000	.010484	.014849

			12000	.0182500*	.0007352	.000	.016067	.020433
		6000	3000	-.0036667*	.0007352	.002	-.005849	-.001484
			9000	.0090000*	.0007352	.000	.006817	.011183
			12000	.0145833*	.0007352	.000	.012401	.016766
		9000	3000	-.0126667*	.0007352	.000	-.014849	-.010484
			6000	-.0090000*	.0007352	.000	-.011183	-.006817
			12000	.0055833*	.0007352	.000	.003401	.007766
		12000	3000	-.0182500*	.0007352	.000	-.020433	-.016067
			6000	-.0145833*	.0007352	.000	-.016766	-.012401
			9000	-.0055833*	.0007352	.000	-.007766	-.003401
	Dunnett T3	3000	6000	.0036667*	.0003849	.004	.001948	.005385
			9000	.0126667*	.0006939	.000	.009929	.015404
			12000	.0182500*	.0008430	.000	.014694	.021806
		6000	3000	-.0036667*	.0003849	.004	-.005385	-.001948
			9000	.0090000*	.0006086	.002	.006029	.011971

			12000	.0145833*	.0007743	.001	.010705	.018461
		9000	3000	-.0126667*	.0006939	.000	-.015404	-.009929
			6000	-.0090000*	.0006086	.002	-.011971	-.006029
			12000	.0055833*	.0009659	.007	.001970	.009197
		12000	3000	-.0182500*	.0008430	.000	-.021806	-.014694
			6000	-.0145833*	.0007743	.001	-.018461	-.010705
			9000	-.0055833*	.0009659	.007	-.009197	-.001970
SGR	Tukey HSD	3000	6000	.003684*	.001238	.049	.00001	.00736
			9000	.015006*	.001238	.000	.01133	.01868
			12000	.024658*	.001238	.000	.02098	.02833
		6000	3000	-.003684*	.001238	.049	-.00736	-.00001
			9000	.011321*	.001238	.000	.00765	.01500
			12000	.020974*	.001238	.000	.01730	.02465
		9000	3000	-.015006*	.001238	.000	-.01868	-.01133
			6000	-.011321*	.001238	.000	-.01500	-.00765

			12000	.009652*	.001238	.000	.00598	.01333
		12000	3000	-.024658*	.001238	.000	-.02833	-.02098
			6000	-.020974*	.001238	.000	-.02465	-.01730
			9000	-.009652*	.001238	.000	-.01333	-.00598

	Dunnett T3	3000	6000	.003684*	.000374	.003	.00206	.00531
			9000	.015006*	.000954	.001	.01077	.01924
			12000	.024658*	.001501	.001	.01736	.03196
		6000	3000	-.003684*	.000374	.003	-.00531	-.00206
			9000	.011321*	.000901	.003	.00678	.01587
			12000	.020974*	.001468	.003	.01340	.02855
		9000	3000	-.015006*	.000954	.001	-.01924	-.01077
			6000	-.011321*	.000901	.003	-.01587	-.00678
			12000	.009652*	.001710	.012	.00291	.01640
		12000	3000	-.024658*	.001501	.001	-.03196	-.01736
			6000	-.020974*	.001468	.003	-.02855	-.01340

			9000	-.009652*	.001710	.012	-.01640	-.00291
FCR	Tukey HSD	3000	6000	-.12566	.07506	.378	-.3485	.0972
			9000	-.61363*	.07506	.000	-.8365	-.3908
			12000	-1.18521*	.07506	.000	-1.4081	-.9624

		6000	3000	.12566	.07506	.378	-.0972	.3485
			9000	-.48798*	.07506	.000	-.7108	-.2651
			12000	-1.05955*	.07506	.000	-1.2824	-.8367
		9000	3000	.61363*	.07506	.000	.3908	.8365
			6000	.48798*	.07506	.000	.2651	.7108
			12000	-.57158*	.07506	.000	-.7944	-.3487
		12000	3000	1.18521*	.07506	.000	.9624	1.4081
			6000	1.05955*	.07506	.000	.8367	1.2824
			9000	.57158*	.07506	.000	.3487	.7944
	Dunnett T3	3000	6000	-.12566*	.01237	.002	-.1780	-.0733
			9000	-.61363*	.04661	.002	-.8388	-.3884

			12000	-1.18521*	.09589	.004	-1.6772	-.6933
		6000	3000	.12566*	.01237	.002	.0733	.1780
			9000	-.48798*	.04554	.006	-.7218	-.2542
			12000	-1.05955*	.09537	.006	-1.5565	-.5626

		9000	3000	.61363*	.04661	.002	.3884	.8388
			6000	.48798*	.04554	.006	.2542	.7218
			12000	-.57158*	.10543	.020	-1.0157	-.1275
		12000	3000	1.18521*	.09589	.004	.6933	1.6772
			6000	1.05955*	.09537	.006	.5626	1.5565
			9000	.57158*	.10543	.020	.1275	1.0157
SURVIVAL	**Tukey HSD**	3000	6000	4.2625*	1.1820	.016	.753	7.772
			9000	12.9417*	1.1820	.000	9.432	16.451
			12000	26.3813*	1.1820	.000	22.872	29.891
		6000	3000	-4.2625*	1.1820	.016	-7.772	-.753
			9000	8.6792*	1.1820	.000	5.170	12.188
			12000	22.1187*	1.1820	.000	18.609	25.628

		9000	3000	-12.9417*	1.1820	.000	-16.451	-9.432
			6000	-8.6792*	1.1820	.000	-12.188	-5.170
			12000	13.4396*	1.1820	.000	9.930	16.949
		12000	3000	-26.3813*	1.1820	.000	-29.891	-22.872
			6000	-22.1187*	1.1820	.000	-25.628	-18.609
			9000	-13.4396*	1.1820	.000	-16.949	-9.930
	Dunnett T3	3000	6000	4.2625	1.0616	.092	-1.067	9.592
			9000	12.9417*	.8464	.001	8.787	17.096
			12000	26.3813*	1.0082	.000	21.341	31.421
		6000	3000	-4.2625	1.0616	.092	-9.592	1.067
			9000	8.6792*	1.3333	.004	3.703	13.656
			12000	22.1187*	1.4415	.000	16.831	27.406
		9000	3000	-12.9417*	.8464	.001	-17.096	-8.787
			6000	-8.6792*	1.3333	.004	-13.656	-3.703
			12000	13.4396*	1.2912	.000	8.655	18.224

		12000	3000	-26.3813*	1.0082	.000	-31.421	-21.341
			6000	-22.1187*	1.4415	.000	-27.406	-16.831
			9000	-13.4396*	1.2912	.000	-18.224	-8.655
Mortality_rate	**Tukey HSD**	**3000**	**6000**	**-.12083**	**.66847**	**.998**	**-2.1055**	**1.8638**
			9000	**2.97778***	**.66847**	**.004**	**.9931**	**4.9624**
			12000	**.05625**	**.66847**	**1.000**	**-1.9284**	**2.0409**
		6000	**3000**	**.12083**	**.66847**	**.998**	**-1.8638**	**2.1055**
			9000	**3.09861***	**.66847**	**.003**	**1.1140**	**5.0832**
			12000	**.17708**	**.66847**	**.993**	**-1.8076**	**2.1617**
		9000	**3000**	**-2.97778***	**.66847**	**.004**	**-4.9624**	**-.9931**
			6000	**-3.09861***	**.66847**	**.003**	**-5.0832**	**-1.1140**
			12000	**-2.92153***	**.66847**	**.004**	**-4.9062**	**-.9369**
		12000	**3000**	**-.05625**	**.66847**	**1.000**	**-2.0409**	**1.9284**
			6000	**-.17708**	**.66847**	**.993**	**-2.1617**	**1.8076**
			9000	**2.92153***	**.66847**	**.004**	**.9369**	**4.9062**
	Dunnett T3	**3000**	**6000**	**-.12083**	**.72335**	**1.000**	**-3.1594**	**2.9177**
			9000	**2.97778**	**.74426**	**.052**	**-.0354**	**5.9910**

			12000	.05625	.81674	1.000	-3.0158	3.1283
		6000	3000	.12083	.72335	1.000	-2.9177	3.1594
			9000	3.09861*	.47608	.003	1.3430	4.8542
			12000	.17708	.58292	1.000	-2.0958	2.4499
		9000	3000	-2.97778	.74426	.052	-5.9910	.0354
			6000	-3.09861*	.47608	.003	-4.8542	-1.3430
			12000	-2.92153*	.60867	.018	-5.2250	-.6181
		12000	3000	-.05625	.81674	1.000	-3.1283	3.0158
			6000	-.17708	.58292	1.000	-2.4499	2.0958
			9000	2.92153*	.60867	.018	.6181	5.2250

*. The mean difference is significant at the 0.05 level.

Appendix 6: Paired T test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	BIOMASSSURVIVAL	.7065	16	.10521	.02630
	MORTALITYSURVIVAL	.8949	16	.01587	.00397

Paired Samples Test

		Paired Differences Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2tailed)
Pair 1	BIOMASSSURVIVAL - MORTALITYSURVIVAL	-.18833	.10813	.02703	-.24595	-.13071	-6.967	15	.000