بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Effect of Stocking Density on Growth, survival and water parameters of Nile Tilapia (*Oreochromis niloticus)* in concrete tanks.

أثر الكثافة التخزينية على نمو، حياتية وخواص المياه لأصبعيات أسماك البلطي النيلي المستزرعة في أحواض أسمنتية.

Dissertation submitted to the College of Graduate Studies in partial Fulfillment of Requirements for Degree of Master in Fisheries Science and Technology

By:

Ahmed Bashir Dawoud Yousif

College of Animal Production Science and Technology, Sudan University of Science and Technology

Supervisor:

Dr: Ahmed Elaabid Hamad

Mar. 2018

DEDICATION

I like to dedicate this research with love and respect to:

The soul of my late father.

My mother for her loves and supports me for education and life.

My teacher who gave me support, encouragement and believed in the importance of education.

To my Parent,

Teacher Dr. Ahmed E. Hamad

My greatest teacher Dr. Ramzy A. Yousif

My family,

My friends,

And all who gave help to me,

I dedicate this work.

Acknowledgements

With due respect, I would like to thanks God from the beginning. I consider myself the most privilege student for being supervised by Dr. Ahmed E. Hamad for his keen generous help, competent and continuous care he rendered to his student and me is greatly of high value.

My great appreciation goes to all staffs of college of animal production science and technology especially Department of fisheries and wild life , library workers and management for their cooperation, honest and good attitude I have seen in them.

Also, Aim hereby extending grateful thanks to my teacher/ Fawzi Ali Mohammed who was cooperative and helpful during all two years of my study. Thanks also go to my best friend Ayman Elamin Mohammed who added flavor and happiness to all my colleague study.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

Abstract:

The present study was conducted over a 40 days by using three rearing densities (Density (1) =50, Density (2) = 75, and Density (3) = 100fish/m^3) with same leve of feeding rates (10% of body weight) and using Formulated feed 35% crude protein (CP) to show the effect of stocking density on the growth and survival of fingerlings *Oreochromes niloticus* L. cultured in concrete tanks.

Fish initial weight 2 ± 0.03g was stocked at three different densities and same concrete tank (1^3). Fish of each density were fed on the above experimental diet twice daily, 6days a week, for 6 weeks.

The growth parameters were inversely affected by stocking density. The average final weight varied significantly ($p<0.05$) and varied at Density (1) from 2 to 3.2 g, Density (2) from 2.3 to 2.8 g and Density (3) from 2.35 to 2.50g). Fish stocked at 50fish/m exhibited the highest average weight gain (1.2± 0.03 g) whiles; fish stocked at 100fish/m recorded the lowest average weight gain (0.15 ± 0.03 g). The survival rate at each group effected by densities and the overall results recorded here reveal that the best growth performance of *Oreochromis niloticus* at 50 fish /m.

الخلاصة:

أجريت هذه الدراسة لمدة 40يوما باستخدام ثلاث كثافات تخزينية)الكثافة 50 =(1)، الكثافة75 =(2)، الكثافة100=(3)سمكه/م (3مع معدل تغذية موحد %10)من وزن السمكه (باستخدام عليقة تحتوي على %35بروتين للتحقق من تاثير مستوى الكثافة التخزينة على النمو والاعاشة لاصبعيات البلطي النيلي المستزرعة في أحواض أسمنتية .

أدخلت الاسماك بالوزن الابتدائي 0.03± 2جرام في ثلاث كثافات مختلفة، أعطيت أسماك التجربة عليقه مرتين في اليوم ولمدة 6ايام في الاسبوع لفترة 6أسابيع.

أوضحت نتائج التجربة على وجود فرق معنوي p<0.05عند رعاية أصبعيات البلطي النيلي في كثافات تخزينية مختلفة ، حيث تتاثر عكسيا مع الكثافة التخزينية، سجلت الاختلافات الكثافة (1)من 2الى 3.2جرام، الكثافة (2)من 2.3الي2.8جرام ، الكثافة (3)من2.35الى 2.50جرام . (الاسماك المستزرعه في كثافة 50سمكه /م 3سجلت اعلى متوسط في الزيادة الوزنية 1.2±0.03)جرام (بينما سجلت الاسماك المستزرعه في كثافة 100سمكه /م 3اقل متوسط في الزيادة الوزنيه 0.03 ±0.15)جرام .(نجد ان معدل الاعاشة في كل المجموعات تاثرت باختلاف الكثافة بفروق معنويه . (%5)النتائج التي سجلت في هذه الدراسة تشير الي ان أفضل معدل نمو واعاشة حدث عندما تمت رعاية أسماك التجربة في كثافة تخزينية 50 سمكة/م. 3

CHAPTER ONE

Introduction

Fish and fishery products constitute an extremely important source of protein and nutritional security for many people all over the world (FAO, 2012). Fish are low in collagen content, have a nutrient profile superior to all other sources of animal protein and its digestibility is high - as almost every nutrient is absorbed(WHO/FAO,1999).

Modern fish culture means improvement of culture practices through adopting different measures such as proper doses of fertilizer application, regular feeding, optimum stocking density, maintenance of physicochemical factors, disease prevention and various control measures (Balarin and Hailer, 1982). The stocking density is the major concern for mono-culture. Sometimes excellent fish fry do not perform satisfactory growth unless correct stocking practices (Sanches *et al* 1999). Therefore it is important to optimize the stocking density for the target species in aquaculture for desired level of production (FAO, 2012). Tilapia has good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently the organic and domestic waste into high quality protein, rapid growth rate and good flavor (Ballarin and Hallar, 1982). Tilapias are currently having important impacts on poor people in developing countries, both as cultured species in household-management systems and through access to fish produced in informal and formal fisheries (Edwards, 2003). But the culture practice of tilapia varies to a great extent from country to country and even among the different farming systems.

Despite the great potential of tilapia culture, shortage of fry production to meet the increased global demands remains one of the main obstacles limiting the expansion of intensive culture, especially the effect of stocking density on fish, inconsistent and sometimes controversial.

In Sudan, aquaculture has been recognized before long time ago by the government as potential area of interest. However, most of the focus was given to fresh water aquaculture and this is limited to extensive tilapia farms are small and use minimal inputs (Hamad, 2006).

Tilapia is one of the oldest and most rapidly growing cultured finfish species in modern times. Based on species, tilapia represents the third largest group of farmed finfish species after cyprinid and salmonids (FAO, 2007).

The food & Agriculture organization of the united nation (FAO1999) reported that the production of farmed tilapia has risen at an annual rate of 12% since 1984. As a result, this production has jumped from 308 234 metric tons (mt) in 1988 to 1099 268 mt in 1999 with a 35% increase (FAO 2001).

Objectives of the study:

In view of above facts, the experiment was undertaken to achieve the following objectives to:

- Investigate the effect of stocking density on growth, survival and feed conversion ratio (FCR).
- water quality variables (Temperature, Dissolved oxygen, pH, Ammonia and Nitrate).

CHAPTER TWO

Literature Review

2.1 Aquaculture production:

Production from aquaculture in Sudan has been recognized long time ago by the government as potential area of interest. Now a day there are more than 450 fish farms in Khartoum, and about 105 farms in other states for the commercial tilapia production. Globally, aquaculture accounted for 45.7 percent of the world fish production for human consumption in 2008, up from 42.percent in 2006 (Hamad 2006).

2.2 Aquaculture in Sudan:

The Sudan has an area of 1.8 million km², a coastline of 720 km and A huge area of river waters covering million hectares. Besides river water resources, there are ponds, “haffirs”, reservoirs and irrigation canals with individual water capacities ranging from thousands to few million cubic meters and depth of 1 to 20 m. In the Gezira , the canal network consists of 549 km with a depth range of 0.50 to 0.75 m; similarly there are other canal systems in the Managil Extension, Guneid Sugar Estate and kashm EL Girba Project. All these water resources can be good support for fish culture development (Giorge 1975).

Sudan has great potential of tilapia culture but shortage of fry production and Information regarding larval culture is the main problems facing the expansion of tilapia culture in Sudan and all over the world. For example, Dambo&Rana (1992) found that the growth rates of Nile tilapia (*Oreochromis niloticus* L.) fry were negatively correlated with stocking density ranging from 2 to 20 fry /L. They suggested 5 -10 fry /L as optimal stocking density.

2.3 The Importance of Tilapia Culture:

Among the major commercial finfish species, tilapias have become a major source of protein around the world, primarily because of their cut standing adaptability under a wide range of environmental conditions and excellent growth on a variety of natural and prepared diets (Lim and Webster, 2006).

Why have tilapias been successful as a cultured group throughout the tropical countries? Bearing in mind that the bulk of tilapia production is a result of farming, its success can be primarily attributed to the following:

- relative ease of culture under extensive semi- and /or intensive practices, thus relatively less limited by the economic status of the farmer compared to most other finfish species;
- relevant species exhibit many of the desirable traits expected of a species suitable for culture(e.g. relatively high growth rate, wide range of tolerance to physicochemical characteristics, resistance to disease, easiness of propagation, etc);

- moderately high dress –weight ratio;
- long shelf – life, and;
- As a white fish, tilapia is mild and lends itself to industrial preparations better than most other white fish (Picchietti, 1996).

2.4 Food and Feeding behavior of *Oreochromis niloticus:*

One of the key factors to successful fish culture is the understanding of some biological fundamentals especially food and feeding behavior Juvenile and adult Nile tilapias are reported to filter phytoplankton (Norhcott et . 1991).Since Nile tilapia use algal protein raising tilapia for food at lower trophical level can be a cost efficient culture method.

In the estuaries of Sierra Leone reported that the fish of less than 6 cm in length fed on algae, and principally filamentous blue greens which they are able to digest. In brackish water ponds in the Niger Delta receiving only inorganic fertilizers, fish of 1.1 to 5.5 cm standard length are benthic feeders showing a strong preference for rotifers (*Lamina, Pholidina, Branchionus sp.).* They also fed on copepod nauplii, small (2 to 5 micron) benthic diatoms, and detritus (Mahatane, 1986).

Apparently the adult of the species consume and are able to digest variety of natural and artificial feeds. Cisse (1985) consider the fish benthic grazer, and these results are confirmed from stomach analysis in Niger Delta (Mahatane, 1986). However, Fagade (1971) found the fish feeding on algae, detritus, sands, and invertebrates in the Lagos lagoon. Juveniles and adults accept any variety of artificial feeds under a variety of forms and presentations. The fish will readily accept hard or soft pellets, feed in ground and powdered form, as a wet mash, or simply in the unconditioned stats of agriculture by- product. They feed actively on the surface or bottom of ponds and generally accept the feed as soon as they are aware of its presence.

For their sustenance, newly hatched fry depend on their yolk sacs until consumed. They eat the smallest phytoplankton present in the pond. As the fry become bigger, they eat large organisms and supplemental feeds such as rice- bran, fishmeal and others, Tilapia feed on a variety of phytoplankton as their primary food items. They are cannibalistic and will feed on their fry if food is not abundant. The tilapia has a short esophagus leading to small sac- like stomach with and exceptionally long intestine (4x the body long) (Ouattara *et* *al*.,2003). The *O.Niloticus* has firm pharyngeal teeth set on a triangular blade. Its role is to prepare food for digestion, shredding the coarser materials and breaking some of the cell walls before passing it on to the stomach.

2.5 Dietary Requirements:

Tilapia exhibit best growth rates when are feed balanced diet that provides a proper mix of protein, carbohydrate, lipids, vitamins, minerals and fiber. Jauncey and Ross (1982), El-sayed and Teshima(1991) and Stickney (1996) provide excellent reviews that examine the details of tilapia nutrition. The rapid growth of any animal depends on a nutritious diet and adequate Feeds for caged tilapia must be nutritionally complete and balanced. Feeding fish in intensively managed cages can represent 50% or more of the variable costs of production (Gabriel *et al.*, 2007). Nutrients for caged tilapia may come from food sources, such as plankton, bacteria, and insects from within the cage and /or from organic matter and attached organisms.

Although Nile tilapia may obtain a few essential nutrients by filtering these foods from nutrient-rich waters, they still need a complete diet as if they were being cultured in food-free waters to ensure high yield, fast growth and good health (Schmittou, 2006). The feeding frequency for Nile tilapia during optimum growing temperature will vary according to size or stage of the life cycle; from up to 12 times per day for newly hatched fry, 3 to 4 times a day for fingerlings, 2 to 3 times per day for grow-out production fish, and once a day for brood fish (Schmittou, 2006).

2.5.1 Protein requirement:

The protein requirement of tilapia decreases with age and size. Higher dietary crude protein concentrations are required for fry (30–56%) and juvenile (30–40%) tilapia but lower protein levels (28–30%) are given to larger tilapia (Winfree and Stickney, 1981; Jauncey and Ross 1982; Siddiqui *et al*., 1988; Twibell and Brown, 1998).

Tilapia can also effectively utilize carbohydrate levels up to 30 to 40% in the diet, which is considerably more than most cultured fish (Anderson *et al*., 1984). Fiber is usually considered indigestible, as tilapias do not possess the required enzymes for fiber digestion (although some cellulase activity from microbes has been found in the gut of *O. mossambicus*) (Saha *et al.*, 2006). For this reason, and to attain maximum growth, crude fiber levels in tilapia diets should probably not exceed 5% (Anderson *et al*., 1984).

2.5.2 Energy Requirement:

Energy is not nutrient but is a property of nutrient that is released during metabolic oxidation of protein, carbohydrates and lipids. Generally, protein is given the fish priority in formulating fish feeds because it is the most expensive component of the prepared feeds. However, energy should be the first nutritional consideration in feeds formulation since tilapias, like other fish, eat to satisfy their energy needs. If insufficient non-protein energy is available, part of the protein will be broken down into energy. An excess of energy in the diet can limit feed consumption, thus reducing the intake of protein and other nutrients (NRC 1993).

2.5.3 Vitamins Requirement:

Vitamins are organic compounds that are required in small amounts for normal growth, reproduction and health. However, tilapias consume a sufficient quantity of natural food organisms to meet their vitamin needs (Adewolu2008).

In intensive system where limited or no natural foods are available, supplemental vitamins must be added to diets to sustain normal growth and health.

Vitamins and minerals are critical to proper nutrition in tilapia and considerable research has been conducted to determine these requirements (Watanabe *et al*., 1997);EI-Sayed and Teshima 1991;Roem,*et.al*., 1990;Jauncry and Ross 1982). Commercial premixes are available which allow feed makers to purchase a whole group of micronutrients rather than attempting to determine how much is available from the productivity of the system and the other ingredients.

2.5.4 Lipids, Essential Amino and Fatty Acids Requirements:

Dietary lipids are important sources of highly digestible energy and are the only source of essential fatty acids needed by fish for normal growth. Tilapias require the same ten essential amino acids (Methionine, phenylalanine, threonine, tryptophan valine, Alanine, Isolincine, Histidine, Arginine) as other fish and terrestrial animals. The quantity requirements for these essential amino acids have been determined for young Mozambique (Jnancey and ross 1982).

In general, the lipid requirements for fish under two grams represent about 10% of diet. This decreases to 6-8% from two grams to harvest. The lipids should contain both omega-3 and omega-6 fatty acids. Each fatty acid should represent 1% of diet, although some suggest that fish grow better with a higher proportion of omega-6 to omana-3(Boyd, 1990). The fiber component is usually the reciprocal of the lipid content. That is starting at 6-8% in small fish up to 35g and increasing to 10% above 35g.

2.5.5 Carbohydrates Requirement:

Tilapia, like other finfish. Do not have specific requirement for carbohydrates. Several studies have shown that fish grew satisfactorily and without any patliological signs when fed carbohydrate, free diets. However, carbohydrates are always included in fish feeds because they are the most abundant and least expensive source of energy. They function as pellet binder, serve as precursor for the formation of various metabolic intermediates essential for growth, and have a spring effect on the utilization of dietary protein (NRC 1993).

Carbohydrates are often supplied by the least expensive ingredients in the diet. Corn, wheat, rice and a number of agricultural by products are typical carbohydrate sources. The ratio of energy supplied by lipids and carbohydrates to the protein available in the diet is often a critical measure. Shiau (1997) provides a comprehensive review of carbohydrate and fiber utilization in tilapia.

2.5.6 Minerals Requirement:

There is little information on minerals requirement of tilapia. However diaper probably require the same minerals as do other fish for tissue formation and various metabolic functions such as osmoregulation, acids-base balance, and proper functioning of muscles and nerves, like other fish, they probably can absorb several minerals from the surrounding water to meet of their metabolic needs Shiau (1997). Luquet (1992) reported that *O.mossambicus* can absorb calcium efficiently via the gills and phosphorus via gut. Although phosphorus can be absorbed by fish, unlike calcium, phosphorus is usually a limiting mineral in most natural water. Thus, diets must contain sufficient levels of phosphorus to meet the fish needs.

2.6 Importance of Water Quality in Tilapia Culture:

Fish are totally dependent upon water to breathe, feed and grow, excrete wastes, maintain a salt balance, and reproduce. Aquacultural ecosystems, including those involving fish culture, are composed of physical, chemical and biological factors that interact individually and collectively to influence culture performance (Schmittou, 2006). Although all of the impacting variables are important, only those that normally cause fish stress or otherwise limit performance in some way are of concern to the practical aquaculturist. The key water quality variables related to tilapia culture in cages are temperature, dissolved oxygen (DO) and hydrogen-ion concentration (pH). However, other parameters such as ammonia, nitrates, phosphates, alkalinity and hardness also have significant impacts within aquacultural ecosystems (Abolude, 2007).

2.6.1. Temperature

Temperature is among the most important environmental variables and a major metabolic modifier in fishes because fish assume approximately the same temperature as their surroundings. It affects their activity, behavior, feeding, growth, survival, reproduction (Dupree and Hunner, 1994) and efficiency of food conversion (Martinez-Placious *et al*., 1993).

Temperature impacts cage tilapia culture in two major ways: firstly the temperature of the water where the fish are located and secondly, the temperature stratification of the water column in which the cages are located (Schmittou, 2006). Ideally, water temperature surrounding tilapia in production should be about 26°C to 28°C and within optimum range of about 23°C to 30°C. However, *Oreochromis niloticus* shows optimum food consumption and growth at temperatures ranging between 31-36°C (Mires, 1995). Stress-induced disease and mortality are problematic when temperatures exceed 37°C or 38°C. At the other extreme, handling at lower temperatures can also result in stress-induced trauma, and in mortality at temperatures lower than 17°C or 18°C (Schmittou, 2006).

2.6.2. Dissolved oxygen:

Dissolved oxygen is the most important and critical parameter, requiring continuous monitoring in tilapia cage systems. Oxygen naturally enters and dissolves into the water primarily through direct diffusion at the air-water interface and oxygen-releasing photosynthesis. Diffusion is relatively insignificant unless there is considerable wind action (Sverier, and Lied,E (2000) .

Low dissolved oxygen levels are critical to caged tilapia and are responsible for more fish kills, either directly or indirectly, than all other problems combined (Schmittou, 2006). This is because fish aerobic metabolism requires dissolved oxygen.

Fish are not the only consumers of oxygen in cages but bacteria, phytoplankton, and zooplankton in the water also consume large quantities as well.

Low dissolved oxygen is associated with increased ammonia, increase in free carbon dioxide, decreased pH, increased nitrite, increased fish metabolism, increased water temperature, abundant gill parasites and numerous other factors, which when combined can significantly reduce fish production performances (Schmittou, 2006). Tilapia are highly tolerant of low DO concentration, even down to 0.1 mg/l (Magid and Babiker, 1975) depending on the stocking density. Optimum growth for *Oreochromis niloticus* is obtained at dissolved oxygen concentrations greater than 3 mg/l (Ross, 2000).

2.6.3 Hydrogen Ion Concentration (pH)

The effect of pH on the chemical, biological and physical properties of water systems makes its study very crucial to the lives of the organisms in the medium. Therefore, regular monitoring of pH is an essential part of the operation of intensive freshwater-fish culture systems such as concrete. Concrete tilapia seem to grow best in water that is near neutral or slightly alkaline. Lethal limit for high pH is 11 – 12, and *Oreochromis niloticus* can tolerate low pH to approximately 5 however best growth rates are achieved between 7 to 9 (Ross, 2000).

2.6.4 Ammonia:

Ammonia is the principal nitrogenous product of fish metabolism. It originates from the deamination of amino acids and if present at high it will slow and might increase mortality (El-Sherif *et al*., 2008). Ammonia toxicity in caged
tilapia culture is closely correlated with pH and to a lesser extent, water dissolved
temperature and oxygen concentration. Low dissolved oxygen increases ammonia toxicity, however this is largely balanced by decreased toxicity produced by increasing carbon dioxide concentration, which lowers pH (Schmittou, 2006).

Mass mortality of caged *Oreochromis niloticus* occurs with a couple of days of their sudden transfer to water with un-ionized ammonia concentrations greater than 2 mg/l, but optimum concentrations are estimated to be below 0.05 mg/l (El-Sherif *et al*., 2008). The level of nitrite tolerated is approximately 2.1 mg/l however, approximately 50% tilapia acclimated to sublethal levels will survive 3 or 4 days at un-ionized ammonia concentrations as high as 3 mg/l. The first mortalities from prolonged exposure begin at 0.2 mg/l and at concentrations as low as 0.08 mg/l, un-ionized ammonia begins to depress the appetite of tilapia (Schmittou, 2006).

In intensive Mass mortality occurs with a couple of days of their sudden transfer to water with un-ionized ammonia concentrations greater than 2 mg/l, but optimum concentrations are estimated to be below 0.05 mg/l (El-Sherif*et al.*, 2008). The level of nitrite ($NO2$) tolerated is approximately 2.1 mg/l however, approximately 50% tilapia acclimated to sub lethal levels will survive 3 or 4 days at un-ionized ammonia concentrations as high as 3 mg/l. The first mortalities from prolonged exposure begin at 0.2 mg/l and at concentrations as low as 0.08 mg/l; un-ionized ammonia begins to depress the appetite of tilapia (Schmittou, 2006).

2.6.5: Salinity:

Described as total concentration of all ions present in the water, these are most commonly present in the form of chloride, sodium, sulfate, calcium, magnesium, potassium, bicarbonate and Rock salt (sodium chloride) is commonly used in the fresh water aquaculture for the following beneficial reasons:

1. Freshwater fish are always trying to maintain their internal electrolyte (salt) levels up, a little salt in the water helps with the fish's osmoregulatory system, therefore, lessening the amount of stress involved in that process.

2. Salt helps with the fish's slime coat or mucus production, which ultimately aids in the fish's immune system.

3. A certain amount of parasite control can be achieved when constant salinity levels are maintained (Béné *et al.,* 2007).

4. Temporary relief of nitrite toxicity is achieved when salt or sodium chloride (NaCl) is dissolved into water and the chloride ion (Cl) binds to the fish's hemoglobin occupying the same receptors, which the nitrite would otherwise bind, effectively blocking the negative aspects of nitrite poisoning:

a. This is, by no means, an answer to nitrite toxicity but can, and often does, help the aqua culturist avoid a potentially dangerous situation.

2.7. The importance of aquaculture and food value:

Fish and other aquatic products provide at least 20% of protein intake for a third of the world's population, and the dependence is highest in developing countries (Béné *et al.,* 2007).

Small-scale fisheries are by far the most important for food security. They supply more than half of the protein and minerals for over 400 million people in the poorest countries of Africa and South Asia. Furthermore, fisheries and aquaculture directly employ over 36 million people worldwide, 98% of them in developing countries. They also indirectly support nearly half a billion people as dependents or in ancillary occupations (Richardson & Poloczanska (2008).

The importance, therefore, of sustaining wild capture fisheries to secure ongoing supplies of fish to poor consumers cannot be over emphasized. The fact is that the countries that depend most on fish for food rely primarily on catches from the wild. Although aquaculture continues to grow, there is no immediate prospect that it can replace these supplies. As Garcia and Rosenberg (2010) state: “The potential for sustaining catches, food output and value at or near current levels, and supporting the nutrition and livelihoods of many hundreds of millions of dependent people, will rest critically on managing fisheries more responsibly.”

CHAPTER THREE

Materials and method

3.1 Experimental site:

The study was conducted at the Department of Fisheries and WildLife, College of Animal Production Science and Technology, Sudan University of science and technology, Khartoum state, Sudan.

3.2. Materials:

- Balance (Electric Balance – Model: 2003 – max: 200 kg – power: AC220v/50HZ S/N: 119 – Date: 2014-08).
- Finger lings of tilapia (*Oreochromisniloticus).*
- Other instruments like the concrete tanks, nets and plastic tube.

3.3. Culture Procedures:

Three group of mixed-sex Nile tilapia, *Oreochromis niloticus* used in the study were obtained in concrete tanks at Sudan university hatchery, Sudan.

The plastic bags were used to transport fingerling from big to smallest tanks in hatchery where the study done. The fish were let in experiment tanks for 10 days until become more active and stopped mortality due to stress during transportation.

At the end of conditioning period, the initial weight was recorded; fingerlings were reared for 40 days (1 October 2017 to 10 November 2017).

3.4. Experiment Design:

The experiment designed to study the effect of stocking density on fish survival and feed utilization efficiency, (225) fingerlings stocked in (3) concrete tanks (D1=50, D2 =75, D3=100fish /m) each triplicate and fed with locally available ingredients feed having 35% crude protein manually, twice day at (9:00am, and 16:00pm) for 40 days.

3.5. Sampling of fish and measuring of growth parameters:

Fish were randomly sampled every 10 days with scoop net for their body weight by using digital balance (lutron GM-600.0g*0.1g). Mortality of the fish also recorded throughout the experiment.

3.6. Growth Performance, Survival and Feed Utilization:

At the end of experiment, all fish in each tank was netted, weighed. Growth performance was determined and feed utilization was calculated as described by sveier*et al.* (2000) as follows:

(1) AWG= FW – IW.

(2) LWG= AWG/ IW ×100.

(3) SGR (day) =LnFW- LnIW/40 (T) ×100.

(FCR)= Feed Intake/ AWG. (5) PI= Feed Intake × 35÷100.

(6) PER= AWG/ PI.

(7) Feed Intake (g/fish) =Total Day Feed Intake/ Total Number of Fish.

Where: IW and FW are initial and final fish weight, respectively.

SGR: Specific Growth Rate

Relative growth rate (RGR): $RGR (\%) = \frac{Wf - Wi}{Wi} \times 100$

Where:

Wf =final average weight at the end of the experiment and

Wi = initial average weight at the beginning of the experiment.

Feed conversion ratio (FCR) = Feed intake /Weight gain

Protein efficiency ratio (PER) = Weight gain / protein intake

Survival of the fish was monitored to determine the survival rate (SR) of various treatments using the formula (Ogunji et al., 2008):

$$SR\% = \frac{\text{Initial number of fish stocked} - \text{mortality}}{\text{Initial number of fish stocked}} \times 100$$

Condition factor (k) = 100(Wt /L).

Where:

Wt is fish body weight (g), L is total length (cm) according to Hengsawat and Jaruratjamorn (1997).

3.7. Feed and feeding supplements:

The experimental diet was formulated from local materials based on the use of Fish Meal, Peanut meal, Wheat bran and Dura flour (Table 2).

The fish were fed 6days/ week (twice daily) at 9:00 am and 16:00 pm when the daily surface water temperature is warmer. The experimental diets were fed on center of tanks to avoid feeding competition between fish, and the feeding rate is 10% of the body weight of the fish per day throughout the experiment. The amount of Daily Supplementary Feed (DSF) was calculated by using the average body weight (ABW), the total number of the fish (N) and the feeding rate per day (FR/d) using DSF= ABW × N × FR/ d.

Table (2): The ingredients of experiment diet (in percent):

Feed ingredient	**Amount of feed (%)**
Fish meal	34
Peanut meal	33
Wheat bran	15.5
Dura flour	15.5
Starch	2
Total	100

3.8. Water Quality Determination

Physic-chemical parameters of water were monitored bi-weekly thereafter to ensure that they were within the recommended limits for fish growth Temperature was monitored daily around 09:00 am and 16:00 pm.

Dissolved oxygen, total alkalinity, ammonium-nitrogen, nitrate-nitrogen and nitrite-nitrogen of the water were determined bi-weekly. Water samples analysis were collected from the top of the water column at 20 cm below the surface.

Samples of water were collected in 1 liter bottles that were rinsed with portions of the tank water. All water quality measurements and sample collection were made between 08:00 and 09:00 am.

CHAPTER FOUR

Results

4.1. Growth Performance and Survival:

Table (3): Specific Growth Rate (SGR) of *Oreochromis niloticus* affected by stocking density:

Stocking densities)fish/m^3(	**Initial(g)**	**Final (g)**	**WG(g)**	**Final length(cm)**	**SGR (%)**
50	2	3.2	1.2	6.5	1.18
75	2.3	2.8	0.5	5.4	0.49
100	2.35	2.50	0.15	5.3	0.15

Table (4): Survival Rate (SR) of *Oreochromis niloticus* affected by stocking density:

Stocking densities)fish/m^3(	**Initial(g)**	**Final (g)**	**WG(g)**	**Final length(cm)**	**SR (%)**
50	2	3.2	1.2	6.5	0.98
75	2.3	2.8	0.5	5.4	0.96
100	2.35	2.50	0.15	5.3	0.95

Table (5): Condition factor (K) of *Oreochromis niloticus* affected by stocking density:

Stocking densities)fish/m^3(	**Initial(g)**	**Final (g)**	**WG(g)**	**Final length(cm)**	**K**
50	2	3.2	1.2	6.5	49.2
75	2.3	2.8	0.5	5.4	51.8
100	2.35	2.50	0.15	5.3	47.1

4.2 Feed and protein utilization:

Feed utilization of Oriochromis *niloticus affected* by stocking density. That shown in table (6).

	FCR	PER	SGR
Density1	0.66	0.034	60
Density2	0.06	0.014	21.7
Density3	2.66	0.004	6.38

4.3. Water quality parameters:

The quality of the water in the concrete tanks was monitored throughout the period of the study. During the experiment temperature ranged from 20 to29 $^{\circ}$**C**

Dissolved oxygen ranged from 3 to 6 mg/ L,

PH ranged from 7 – 7.8; Ammonia ranged from 0 – 0.25mg/L; and Nitrate ranged from 0 – 0.6.

Figure (4): The effect of stocking on temperature during study period.

Figure (5): The effect of stocking on Oxygen during study period.

Figure (6): The effect of stocking on pH during study period.

Figure (7): The effect of stocking on Ammonia during study period

Figure (8): The effect of stocking on Nitrate during study period.

CHAPTER FIVE

Discussion

5.1 Growth performance and survival:

Average of final body weight were affected by stocking density of Nile tilapia as illustrated in tables (4 and 5) from the data presented it can be seen that increasing stocking density from 100fish/m reduction in growth performance.

The growth performance of *O.niloticus*at this treatment indicates that, the average initial weight of the test fish varied slightly ($p<0.05$) among the treatment. However, at the end of the trail, the average final weight was significantly ($p<0.05$) and varied at D1from 2 to 3.2 g, at D2from 2.3 to 2.8 g and D3from 2.35 to 2.50. Fish stocked at 50/m exhibited the highest average weight gain (1.2 g) whiles, fish stocked at100/m recorded the lowest average weight gain (0.15g).

In many cultivated fish species, growth and feed utilization are inversely related to rearing density, and this is mainly attributed to social interaction such as competition for food and /or space that can negatively affect fish growth (Canario*et al.*1998).

Generally, *Oreochromis niloticus* Fingerlings stocked at 50 fish/m^3 treatment significantly showed higher individual weight gain, and specific growth Rates while those stocked at 75fish/m^3 and 100fish/m^3 were statistically lower (Table 4). The study therefore showed an inverse relationship between stocking density and growth.

The lower growth performance of Nile tilapia stocked at stocking densities of 75 Fish/m3 and 100 fish/m3, relative to the 50 fish/m3 could have been caused by increased Stress (Ouattara*et al.*, 2003), voluntary appetite suppression, more expenditure of energy because of intense antagonistic behavioral interaction and competition for food and living space dependent social interaction in concrete tanks also influenced the growth and general (Diana *et al.* 2004). Possibly, pheromones influences, which are suspected density performance of Fish stocked at 75 fish/m^3 and 100fish/m^3.

5.2 Effect of Stocking Density on Feed Utilization:

Feed utilization (food conversion ratio and protein efficiency ratio) in this study was significantly affected by stocking density as was the case of Gibtan*et al.*, (2008) and Osofero *et al*. (2009) although differences in 50 fish/m3 and 100 fish/m3 treatments were similar. Feed Conversion ratios (FCR) observed in this study ranged between 6.7 to 62.7 and it showed significant increment with higher stocking densities.

The affected of feed utilization in the study is expected; as the number of fish stocked in an aquarium increases, the amount of feed available to each fish decrees (Chang, 1988).

Feed conversion ratios obtained in the 50 fish/m3 is better than values obtained in the 75 and 100 fish/m3. The relatively better FCRs obtained for 50 and 75fish/ m^3 treatments (Table 5) suggests more efficient food utilization through the extraction of nutrients from the feed and converting it into flesh.

On the other hand, poor utilization of feed in the 100 fish/m3 treatment could be attributed to fish expending more energy on aggressive feeding than converting into flesh. Feed Wastage might also be a contributing factor to the poor performance at high densities because as density increases, feed loss potential increases due to increased fish-induced water Turbulence at feeding time (Schmittou, 2006).

The protein efficiency ratio (PER) was decreed with increasing fish density. The maximum PER were obtained when fish at lower density, these result may have obtained because weight gain is between protein anabolism and catabolism, in this study fish density could affect the efficiency of feed utilization.

5.3 Water Quality Parameters:

Average maximum and minimum temperature, Do, pH, ammonia and nitrate during the study (Table 3) remained within the limits for good tilapia culture (Boyd, 1990).

Water temperature ranged from19 to 29, these values are under the preferred range for optimum growth for Nile tilapia,*O.niloticus*, but the growth was not depressed in this study.Tiliapias are best described as thermophlic (philippart and Ruwet,1982) growth occurs between 20 and 35, whilst37, increasing mortalities are likely to occurs.

Tilapias are rather tolerant to low dissolved oxygen, and concentration of 3 to 4mg/L apparently are not extremely harmful to them even with long term exposure. Dissolved oxygen range of 3 to 6mg/l in this study were lower than recommended level of 5 to 8mg/l , there were no observed apparent effects on the growth of fish, trail fish consumed feed aggressively at each time of administration.

Change in pH ranged from 7 to 7.8 as recorded in this study, However, El-sherif and El-feky (2008) recommended pH range of 7 (neutral) to 8 (basic) as optimum for the culture of *O.nilotius*

Ammonia concentration in this study ranged of (0to o.25) mg/l, this concentration was lower and that could not have resulted in growth depression.

Nitrate ranging from 0 to 0.6mg/l in this study were within tolerable level (Stickney, 1996).

CHAPTER SIX

Conclusion and Recommendations

In this study, the effects of stocking density were significant on the growth of Nile tilapia in terms of weight gain, feed conversion ratios, specific growth rates, food utilization. Adopting growth performance, the resultant trend was that as stocking density increased, the indicators- growth rate, specific growth rates and final weight gain decreased significantly. Hence growth performance attributed to the stocking densities showed superiority in the order 50 fish/m3 >75fish/m3 > 100fish/m3.

The following recommendations were distilled based on the major findings from the study:

A. Training on concrete culture practices especially stocking densities, is required to equip small-scale farmers with sufficient scientific knowledge on this subject. Strengthening of technical assistance and extension services to the operators through regular farm visits and consultation could be of major help. Extension workers should also be encouraged to be more active and respond to the needs of the farmers.

B. Farmers could use any of the stocking densities studied but their choice must be guided not only by the cost of production but the awareness that, the most economical that which results in the highest yield per unit area.

C. Research should be problem solving and focused on the needs at the farm level. The farmers should participate in developing research plans and short term studies should provide immediate practical application of results to address significant issues.

References

Abolude, D. S. (2007). Water quality and metal concentration in sediments and fish from.

Adewolu, M.A.(2008) Potentials of sweet potato (*Ipomea batatas)*leaf meal as dietary ingredient for *Tilapia zilli* fingerlings. Pak. J. nutr., 7(3):444449.

AhmaduBello University Reservoir, Zaria. (Doctoral dissertation). Ahmadu Bello University Zaria Nigeria. 264 pp.

Anderson, J., Jackson, A. J., Matty, A. J., & Capper, B. S. (1984). Effects of dietary carbohydrate and fiber on the tilapia *Oreochromis niloticus* (Linn.) *Aquaculture*.

Balarin, J. D. and R. D. Haller. 1982. The intensive culture of Tilapia in tanks,raceways &ages, P. 265-355. In J. F. Muir 8R. J. Roberts (eds.).

Béné C, Macfadyen G, Allison EH. 2007. *Increasing the Contribution of Small-scale Fisheries to Poverty Alleviation and Food Security*. Rome: United Nations Food and Agriculture Organization (FAO).

Boyd, C. (1990). Water quality in ponds for aquaculture. Union Springs, AL: Agriculture Experiment Station, Auburn University.

Canario AVM, Condeca J,Power DM, Ingleton PM(1998) The effect of stocking density on growth in gilthead sea-bream, Sparus aurata (L.).Aquacult Res.29:177-181.

Chang, S.L., Huang , C.M. and I.C. Liaio (1988): Effect of various feeds on seed production by Tiawanese red tilapia; In proceeding of the 2nd International symposium on tilapia in aquaculture. Pullin, RS.V., Rhukaswan, T., Tonguthai, K. and Maclean, J.K., Eds,ICLARM,Bangkok.

Cisse, A. (1985): Result at spreliminaires de I alimentation artificial de Tilapia guineensis (Bleeker) *et sarotherodon melanotheron* (Ruppel) en elevage. Proceeding IFS Aquaculture meeting, Kisumu, Kenya, 1985. (In press).

Dambo W.B. & Rana K.J. (1992):effect of stocking density on growth an survival of Nile tilapia *Oreochromis niloticus (L.)* fry in the hatchery. Aquaculture and Fisheries Management 23,71 -80.

Diana J. S., Yi, Y., & Lin, C. K. (2004). Stocking densities and fertilization regimes for Niletilapia *(Oreochromis niloticus)* production in ponds with supplemental feeding. In R.

Bolivar, G. Mair, & K. Fitzsimmons (Eds.).(2004). *Proceedings of the Sixth InternationalSymposium on Tilapia in Aquaculture* (pp. 487- 499). Manila, Philippines, BFAR, Philippines. 12th -16th September, 2004.

Dupree, K. H., & Hunner, J. V. (1994). The status of warm-water fish farming and Progress in fish farming research U.S. Fish and Wild life service, Washington, D.C., U.S.A.

Edwards, P. (2003). Role of tilapia in rural Aquaculture. Global Aquaculture Advocate, February-2003. 59-61 pp. Hussain, M. G. 1997. Studies on production, growth and survival of Tilapia area in Syrian experimental ponds. UNV multi-sectoral Asst.projectSYR/78/077.Unitednation Developmentprogramme, Damascus, Syria.

El-Sherif, M. S., Feky, E., & Amal, M. (2008). Effect of ammonia on Nile*(O.niloticus*) performance and some hematological and histological measures. *Proceedings of the 8th International Symposium on Tilapia in Aquaculture* (pp. 513-530). Cairo, Egypt. 12th - 14th October, 2008.

Elsayed, A.F.M., and S.I Teshima (1991): Tilapia nutrition in aquaculture: Reviews in aquatic sciences. 5(3-4):247-265.

Fagade, S.O. (1971): The food and Feeding habits of Tilapia speicies in the Lagos Lagoon. J. Fish Biol. 3:152- 156.

Food and Agriculture Organization of the United Nation (FAO) (1999): The state of the World Fisheries and Aquaculture 1998. FAO, Rome.

Food and Agriculture Organization of the United Nation (FAO) (2001): Summary tables of fishery statistics: World aquaculture production by principle species.

Food and Agriculture Organization of the United Nation (FAO) (2007): World review of Fisheries and Aquaculture. In:R. Grainger(ed.), The State of the World Fishery and Aquaculture 2006 Food and Agriuaculture Organization United Nation, Rome, Italy, 3-62pp.

Food and Agriculture Organization of the United Nation (FAO) (2012): The state of the World Fisheries and Aquaculture. Food and Aquaculture Organization, Rome, Italy, 209pp.

Gorge T.T.(1975): The history and status of fish culture in Sudan and the urgency of an experimental project for its development into an industry a review. Supplement I to the report of the symposium on Aquaculture in Africa Accra, Ghana, 30 September – 2 October 1975 Reviews and Experience papers.

Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N., & AnyaP. E (2007). Locally produced fish feed: potentials for aquaculture development in sub- Saharan Africa. *African Journal of Agricultural Research*, 2, 287-295.

Gibtan, A., Getahun, A., & Mengistou, S. (2008). Effect of stocking on the growth performance and yield of Nile tilapia (*Oreochromis niloticus* L., 1758) in a cage culture system in Lake Kuriftu, Ethiopia. *Aquaculture Research*, 39, 1450-1460.

Hamad, A.E. (2006): First commercial shrimp farming trail on the Red sea costal of Sudan: assessment and documentation. PhD dissertation; Faculty of animal production and technology, Sudan University of science and technology.

Hengsawat K.; Ward F.J. and Jaruratijamorn P.(1997):The effect of stocking density on yield, growth and mortaility of African cat fish (*clarias gariepinus* Burchell 1822) cultured in cages Aquaculture 152:67-76.

Jauancy, K. and Ross (1982): A Guide to tilapia feeds and feeding. Institute of Aquaculture, University of Sterling, Scotland. 111pp.

Lim, C.E.; Webster, C.D. (eds), (2006): Tilapia: Biology, Culture, and Nutrition. Complete Book. Haworth press, Binghamton, NY, 703.

Magid, A., & Babiker, M. M. (1975). Oxygen consumption and respiratory behaviour three Nile fishes. *Hydrobiologia*, 46, 359-367.

Martinez- Placious, C. A., Sanchez C. C., & Olvera, M. A. (1993). The potential for Cultur of the American Cichlidae with emphasis on *Cichlasoma urophthalmus.* In J. F. Muir& R. J. Roberts, (Eds.), RecentAdvancesinAquaculture.BlackwellScientificPublications.

Mires, D. (1995). The tilapias. In C. E. Nash & A. J. Novotony (Eds.), *Production of Aquatic Animals: Fishes* (pp133-152). *Elsevier*, New York.

Mahatane, A. (1986): Report of junior scientist Program at the African Regional Aquaculture Centere, Port Harcourt, Nigeria.

NCR (National Research Council) (1993):Nutrition requirement of fish Washington,D.C.

Northcott, M. E., M. C. M.Beveridge and L. G. Ross. (1991): Alaboratory investigation of the filtration and ingestoion rates of the tilapia *oreochromisniloticus*, feedind on two species of blue green algae.Environ.Biol, 31:75 85.

Ogunji J, Toor R,Schulz C, Klos W(2008). Growth performance, nutrient utilization of Nile tilapia *oreochromes niloticus* fed housefly maggot meal (Magmeal) diets. Turkish J.Fish. Aquat.Sci., 8:141-147.

Osofero, S. A., Otubusin, S. O., & Daramola J. A. (2009). Effect of stocking density on tilapia

(*Oreochromis niloticus* Linnaeus 1757) growth and survival in bamboo-net cages trial. *African Journal of Biotechnology,* 8, 1322-1325.

Ouattara, N., Teugels, G., Douba, V., & Philippart, J. (2003). Aquaculture potential of the black-chinned tilapia, *Sarotherodon melanotheron* (Chiclidae): comparative study of the effect of stocking density on growth performance of landlocked and natural populations under cage culture conditions in Lake Ayame (Cote d'Ivoire). *Aquaculture Research*, 32, 1223-1229.

Philippart, J.Cl. and J.CLI.Ruwet(1982):Ecology and distribution of tilapia, In:R.S.V. Pullin and R.H. Lowe Mconnell(eds.) The biology and culture of tilapias. ICLARM Conf.Pro., 7:15-60.

Picchietti, M. (1996): Tilapia marketing maturity. *Aquaculture Magazine*22:19 -26.

Richardson AJ, Poloczanska ES. 2008. Under-resourced, under threat. *Science* 320 (5881): 1294–1295.

Ross, L. G. (2000). Environmental physiology and energetic. In M. C. M. Beveridge & B. J.

Sanches, L.E.F. and C. Hayashi. 1999.Stocking density effect on Nile Tilapia (0. niloticus) fry performance during sex reversal. Acta seientiarum. 21(3): 619-625.

Saha, S., Roy, R. N. Sen, S. K., & Ray, A. K. (2006). Characterization of cellulase-producing bacteria from the digestive tract of tilapia, *Oreochromis mossambica* (Peters) and grass carp, *Ctenopharyngodon idella* (Valenciennes). *Aquaculture Research*, 37, 380-388.

Siddiqui, A. Q., Howlader, M. S., & Adam, A. E. (1991). Effects of water exchange on *Oreochromis niloticus* L. growth and water quality in outer concrete tanks. *Aquaculture*, 95, 67-74.

Schmittou, H. R. (2006). Cage Culture. In C. E. Lim & C. D. Webster (Eds.), *Tilapia Biology, Culture, and Nutrition* (pp. 181-210). Food Products Press, New York. 678 pp.

Stickney, R.R. (1996): Tilapia update, 1995. World Aquaculture 27(1):45-50.

Shiau, S.Y. Utilization of carbohydrates in warmwater fish – with particulaarrefrence to tilapia, *Oreochromisniloticus xO.aureus.* Aquaculture 151:79-96.

Sverier, H.,Raae, A.J. and Lied,E.(2000): Growth and protein turnover inAtlantic salmon *(samosalar* L.) The effect of dietary protein level and protein paractile size. Aquculture, 185: 101-120.

Twibell, R. G., & Brown, P. B. (1998). Optimal dietary protein concentration for hybrid tilapia (*Oreochromis niloticus Oreochromis aureus*) fed all- plant diets. Journal of *World Aquaculture Society*, 29, 9-16.

Watanable, T., Kiron . V. and S. Satoh (1997): Trace mineral in fish nutrition. Aquaculture151:185-207.

Winfree, R. A., & Stickney, R. R. (1981). Effects of dietary protein and energy on growth feed conversion efficiency and body composition of *Tilapia aurea*. *Journal of Nutrition,* 111, 1001-1012.