UNIVERSITY OF CAPE COAST

ASPECTS OF THE BIOLOGY OF THE NILE TILAPIA

(*OREOCHROMIS NILOTICUS* L.)

IN THE WEIJA RESERVOIR (GHANA)

BY

EBENEZER DELALI KPELLY

THESIS SUBMITTED TO THE DEPARTMENT OF FISHERIES AND AQUATIC SCIENCE, UNIVERSITY OF CAPE COAST IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AQUACULTURE

FEBRUARY 2010

DECLARATION

CANDIDATE'S DECLARATION

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

………………………………….. Date:………………

Ebenezer Delali Kpelly

SUPERVISORS' DECLARATION

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

……………………. Date: ………………

Prof. John Blay Jnr.

Principal Supervisor

……………………. Date: ………………

Prof. Kobina Yankson

Co-Supervisor

ABSTRACT

Studies on aspects of the biology of the Nile tilapia (*Oreochromis niloticus* L.) were undertaken in a man-made lake, the Weija reservoir in Ghana from September 2007 to August 2008. A total of 657 specimens of *O. niloticus* from commercial landings were examined of which 357 were males and 300 were females (sex ratio of 1: 0.84; $P < 0.05$).

GSI was low in December 2007 and August 2008 and highest in March and May 2008. Fluctuations in the GSI, suggested that *O. niloticus* spawned throughout the year but major spawning occurred in March. Length at first sexual maturity (L_{50}) was 13.49 cm for females and 16.33 cm for males. Observations on frequency distribution of ovum size which measured between 1.2 to 3.1 mm, showed two distinct peaks which were not completely separated from each other. This indicates protracted spawning in the population probably shedding eggs in batches.

Fecundity ranged from 563 to 1542 ova for fish of total length 15.6 - 21.5 cm with mean of 851 ± 13.2 eggs. The relationships between fecundity (F) and total length (TL), and fecundity and body weight (BW) were: $F = 12.36\ TL + 628.5$ and $F = 0.519\ BW + 785.4$. The major reproductive activity of *O. niloticus* in the reservoir based on studies on monthly fluctuations in GSI and occurrence of ripe gonad, coincided with months with increasing total alkalinity, dissolved oxygen and reducing water temperature.

The regression co-efficient of 3.1 for the length-weight relationship (for both females and males) was not significantly different from the expected value of 3.0 ($P > 0.05$), indicating isometric growth of the population.

Collection of the species as brood stock or seed for stocking by fish farmers is recommended in March-April. Also appropriate management policies with periodic studies of the fishery and limnology of the reservoir are essential to sustain fishery production.

ACKNOWLEDGEMENTS

I am very grateful to Prof. John Blay Jnr. for taking time to painstakingly read through my scripts, his constructive criticism, suggestions and advice have resulted in the completion of this work. I also thank my co-supervisor, Prof. Kobina Yankson for his advice and invaluable suggestions.

I would like to acknowledge the staff of GWCL/AVRL at Weija for making available data on the hydrographic factors of the reservoir and also the staff of Ghana Survey Department in Accra for producing the map of Weija area for my study.

My sincere thanks go to all in the Fisheries and Aquatic Science (FAS) Department of the University of Cape Coast for their concern and especially my colleagues for their encouragement and support when the going became tough.

DEDICATION

This piece of work is dedicated to my lovely wife Mrs. Vida A. Kpelly, the yet to be born and all loved ones who encouraged, advised, cared and supported me. Your contributions to my life are beyond measure. God richly bless you all.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

Background to the study

Fish is among the first natural resources to be exploited by man and supplies over 50% of the total animal protein consumed in developing countries, and a little below this value in developed countries (FAO, 2000). It is recognized as the most important source of animal protein in Ghana, contributing about 60% of the daily animal protein intake (Frimpong *et al*., 1992). Among various sources of protein, fish stands out as the most important in terms of food security because its low price is very competitive compared to the price of other high quality protein sources such as milk, meat and eggs (FAO, 2000). More so, it is the only source of high quality protein whose shelf life can be readily enhanced through low-cost sustainable technologies such as smoking, drying and salting.

According to FAO (2008), fish provides more than 2.9 billion people with at least 15 % of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9 % in 1992 to a peak of 16.0 % in 1996, declining to about 15.3 % in 2005. Notwithstanding the relatively low fish consumption of 13.8 kg per capita in 2005 in low-income food-deficit countries, the contribution of fish to total animal protein intake was significant at 18.5 %. This is probably higher than indicated by official statistics in view of the under-recorded contribution of small-scale and subsistence fisheries.

Preliminary estimates for 2003, based on reports by some major fishing countries, indicated that total world fishery production decreased slightly by 1% compared with 2002 (FAO, 2004). However, the total amount of fish available for human consumption increased to 103 million tonnes and, on average, the per capita supply was maintained through aquaculture (FAO, 2004). Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants (Bardach *et al*., 1972). Farming here implies some sort of intervention in the rearing process to enhance production, which may include regular stocking, feeding, and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture (FAO 1997). Aquaculture is the fastest growing segment of food production in the world and by 2002, the practice contributed approximately 30% by weight of finfish and shellfish consumed worldwide (FAO, 2004). Fish culture has been identified world-wide as an important option for increasing fish production (Bardach *et al*., 1972). According to the FAO (2004) report, global production from capture fisheries and aquaculture supplied about 101 million tonnes of food fish in 2002, providing an apparent per capita supply of 16.2 kg (live weight equivalent), with aquaculture accounting for the growth in per capita supply since

2000. The contribution of aquaculture to the total amount of fishery production has been steadily increasing. From 1950 to 1969, aquaculture production grew at an annual rate of about 5%. During the 1970s, it increased to 8%, and then to 10% annually during the 1990s (Stickney, 2005).

Tilapias are among the most important warm water fishes used for aquaculture production. The culture of tilapia is practised in over 80 countries in the tropical and subtropical regions of the world with a total production of 478,641 metric tonnes, with an average compound growth rate of about 12% per annum since 1986 (FAO, 1997; Lovshin, 1997). According to Balarin and Hatton (1979), the culture of tilapia can provide a welcome solution to the insufficient protein supply still existing in numerous developing countries. Tilapias are widely recognized as one of the most important groups of finfish for culture purposes in a wide range of freshwater culture systems, from simple waste-fed fish to intensively stocked and managed culture systems (Pullin, 1985; Fitzsimmons, 2000). Attempts have also been made in some developed countries to grow them in full-strength sea water. The researchers however observed extremely poor hatching success in ova spawned in full-strength sea water (32 ppt.) (Watanabe *et al*., 1992).

Tilapias belong to the family Cichlidae of which three genera are well-known, namely *Oreochromis, Tilapia* and *Sarotherodon*. The species are classified mainly according to differences in their mode of reproduction and to some extent their feeding habits, morphology and biogeography (Lowe-McConnel, 1958; Trewavas, 1983). Members of the genus *Tilapia* (for example

Tilapia zillii) are substrate spawners. Both parents guard, protect, aerate the brood, and help move clutch to different nest sites. The fry at first feeding are 4 - 6 mm long (TL) and show feeble swimming ability which results in relatively low fry survival (Lowe-McConnel, 1958; Trewavas, 1983). The genus *Sarotherodon*, shows paternal or biparental care. For example in *S. melanotheron,* both parents stay close to each other, their eggs and fry are brooded in the oral cavity of the male with the females helping sometimes, when the male fails to pick up all the eggs. The Fry are between 7 - 9 mm (TL) at first feeding, with well developed fins for swimming giving them a high fry survival (Lowe-McConnel, 1958; Pauly, 1976; Trewavas, 1983). In the genus *Oreochromis* the female is solely involved in brood care by orally incubating the fry until they reach free swimming stage as such they are regarded as maternal brooders (Lowe-McConnel, 1958; Pauly, 1976; Trewavas, 1983). They also observed that the female leaves the nest to orally brood her clutch in safety among the submerged vegetation and rocks with an extended period of care during which fry seek shelter in the buccal cavity of the female. Members of this genus include *Oreochromis niloticus* (L.) commonly called Nile tilapia.

Oreochromis niloticus and its hybrids are the most important cultured fish species, in particular the subspecies *O. niloticus niloticus* which is becoming an increasingly important food fish in many parts of the world (Pullin *et al*., 1991; Garibaldi, 1996). *O. niloticus* is the major species farmed in Ghana and according to FAO (2005), constitutes over eighty percent of aquaculture production in the country and it occurs in several rivers, and in natural as well as man-made lakes.

Biogeographical distribution of *Oreochromis niloticus*

O. niloticus is widely distributed in areas such as the Nile river from below Albert Nile to its delta. The connection between the Nile and Lake Chad tributaries eventually enabled the westward migration of *O. niloticus* via Lake Chad basin and the rivers Niger, Benue, Volta, Gambia and Senegal into West Africa (Beveridge and McAndrew, 2000). Although *Oreochromis niloticus* is endemic to Africa, it has been introduced with many existing strains into many different areas of the world for aquaculture purposes.

O. niloticus, it is believed was introduced into the Weija reservoir in 1985 as a result of escape of the species from a flooded fish farm at Adoagiyri a suburb of Nsawam (pers. com Dr. Abban, 2011). Presently, it is one of the most dominant and important fish species in the reservoir, from both economical and ecological points of view (FAO, 2004). This can be attributed to several factors including the ability of the species to use a wide range of food material, fast growth rate, extended spawning periods and oral brooding all of which enhance survival and the water quality of the reservoir (FAO, 2004).

Water quality is one of the important parameters relevant to the production and management of fish. This includes the physical, chemical and biological factors of the environment of the fish. It is therefore important to study the major water quality parameters of the fish's environment, their interrelationships, and how they affect the growth and health of the fish to predict or improve their condition (Charkroff, 1976; Hussain, 2004).

Temperature, salinity and dissolved oxygen tolerance

Oreochromis niloticus is eurythermal and can tolerate temperatures between 8.0 and 42.0 °C in captivity depending on acclimatization temperature and environmental conditions. In its natural environment however, it occurs in a temperature range of 13.5 °C – 33.0 °C (Yashouv, 1958; Beamish, 1970; Philippart and Ruwet, 1982). The species is euryhaline and can withstand salinity range of 0 to 29 ‰ but compared to many other introduced tilapias it has a much reduced salinity tolerance (Kirk, 1972; Trewevas, 1983; Suresh and Lin, 1992). *O. niloticus* survived after direct transfer to 50 % seawater (17.5 ‰), but not 75 % seawater (Stickney, 1986). It can tolerate low dissolved oxygen up to 0.1 mg/l under severe low dissolved oxygen conditions (Stickney, 2005). However, when dissolved oxygen levels fall below the optimum, the fish are seen gulping air from the surface film of water in their holding facilities (Beamish, 1970; Magid and Babiker, 1975).

Feeding, growth and reproduction

Oreochromis niloticus is an omnivorous grazer that feeds on phytoplankton, periphyton, aquatic plants, small invertebrates, benthic fauna, detritus and bacterial films associated with detritus. It can filter feed by entrapping suspended particles, including phytoplankton and bacteria, on mucus in the buccal cavity. It does not show seasonal variation in the food items it ingests and diel feeding regime indicates that it is a diurnal feeder (FAO, 2006). Although, principally herbivorous in nature feeding mainly on phytoplankton, it can feed on a wide variety of natural food organisms found in organically fertilized pond as well as on artificial feeds (Moriarty, 1973; Moriarty and Moriarty, 1973). Fish food consumption might be influenced by many environmental factors such as water temperature, food concentration, stocking density, fish size and fish behaviour (Houlihan, *et al.*, 2001).

Male tilapias grow faster than females and they divert less energy in reproduction (Stone, 1980; Tave, 1980; Pagan, 1970). Stone (1980) observed that the expression of disparity in growth in both sexes of *O. niloticus* was so pronounced that even prevention of reproduction still resulted in the males growing faster than the females. This could be attributed to genetic differences between the males and females as suggested by Pagan (1970) and Tave (1980). The largest scientifically measured Nile tilapia was 60 cm (almost 24 inches) in total body length. Maximum fresh weights obtained for some tilapiines are 4324 g for *O. niloticus,* 2200 g for *O. esculentus* and 300 g for *T. zillii* (Froese and Pauly, 2005). Among all the tilapias, the Nile tilapia grows to the largest size. Commercial tilapia productions generally prefer male monosex populations since mixed-sex populations develop a large size disparity among harvested fish, which affects marketability (FAO, 2004).

O. niloticus is a prolific breeder and a single female may have several size classes of ova in the ovaries at any one time, indicating multiple spawns in a single season. Being a maternal mouth brooder, the number of eggs per spawn is small in comparison with most other tilapias (Froese and Pauly, 2005). The number of eggs in the gonads is proportional to the body weight of the female. A

100 g female will produce about 100 eggs per spawn, while a female weighing 600 - 1000 g can produce 1000 to 1500 eggs (FAO, 2006). The eggs are laid in approximately 20 batches over a 45-minute to 2-hour period and the female picks up the eggs as soon as they are laid and fertilized. A female may brood up to 2000 eggs at once (Latif and Rashid, 1972). While the female is brooding, she eats little or nothing. The female incubates the eggs in her mouth and broods the fry after hatching until the yolk sac is absorbed. Incubation and brooding is accomplished in 1 to 2 weeks, depending on the water temperature. After fry are released, they may swim back into her mouth if danger threatens (Lowe-McConnel, 1958; Trewevas, 1983; El-Sayed, 2006). The uncontrolled breeding of tilapia in ponds, which led to excessive recruitment, stunting and a low percentage of marketable-sized fish, dampened the initial enthusiasm for tilapia as a food fish. The development of hormonal sex-reversal techniques in the 1970s represented a major breakthrough that allowed male monosex populations to be raised to uniform, marketable sizes (FAO, 2006).

Fishery and culture potential

In Ghana, the geo-ecological climate is generally favourable for breeding of the fish. The various freshwater bodies, including the Volta River, the Volta Lake and their tributaries, like the Oti, Pra, White Volta, Black Volta and Asukawkaw rivers, drain more than two thirds of the country (Dankwa *et al.,* 1999), with the Nile tilapia constituting an important part of commercial fish stocks (Ofori-Danson, 2000). Other Lake fisheries including Bosomtwi, Weija, Barekese, Tano, and Kpong also support populations of the Nile tilapia (FAO, 2006). In Ghana, *O. niloticus* culture is basically semi-intensive. Whereas commercial tilapia farms report yields of 10,000-15,000 kg/ha/yr, small-scale pond farms have yields of approximately 500kg/ha/yr (Machena and Moehl, 2001).

The species exhibits excellent culture characteristics such as easy reproduction even in captivity, and high tolerance of a wide range of environmental conditions, efficient use of low protein diet and high resistance to stress and infections. *O. niloticus* is a primary consumer which makes it the most preferred aquaculture candidate because it can be easily raised in ponds through less expensive methods of fertilization. The species also has high acceptance for supplementary feed, an excellent texture and taste, and can grow to a large market size of about 11 - 25 cm (Total Length) within six months of culture. The fish has phenotypic plasticity for facing different environmental conditions and is therefore easily domesticated and can be used readily in any aquaculture management system making it the most preferred species for culture (Gwahaba, 1978; Trewevas, 1983; Duponchelle and Panfili, 1998). In Ghana, the species is cultured in earthen ponds, pens and cages with culture in earthen ponds being the most predominant. The fish is capable of breeding very easily and thus most culture systems are characterized with early sexual maturation and unwanted reproduction in mixed sex fish farming. This particular problem in the culture of the species tends to have considerable negative impact on productivity and this has led to the widespread use of monosex fish (especially all males) in the industry since males grow bigger and faster. Late sexual maturation and to a lesser extent, reduced fecundity, are thus considered desirable traits by growers even though these are undesirable traits for hatchery producers (Rana, 1988).

With the ever increasing need for cheap sources of protein worldwide, more and more attention is being focused on fish farming. In the developing countries where the problem is acute, finfish aquaculture is believed to offer one of the solutions, especially in view of the unpredictable nature of the existing capture fisheries.

Many Ghanaian freshwater bodies readily support the culture of *O. niloticus* and yet much work is needed to be done to make available, efficient culture techniques and information in order not to undervalue the aquaculture potential of the fish. One of the key factors to successful fish culture is the understanding of some biological fundamentals of the species selected and how they are affected by the prevailing environmental factors.

Statement of Problem

While the global human population continues to increase rapidly (FAO, 2005), the yields from many capture fisheries are almost fixed at their maximum (FAO, 1997) and to meet the increased demand for food fish, aquaculture production should increase by 50 million metric tonnes by 2050 (Tacon, 2001).

Although fish is the most important source of animal protein in Ghana accounting for about 60% of animal protein consumption (Abban *et al*., 1995; NAFAG, 2007), there is a deficit of about 400,000 metric tonnes of food fish (Frimpong *et al*., 1992; FAO, 2006). Ghana produced only 51.7% of its requirements from its domestic sources and in 2004, achieved 68.1 % of its fish requirement through domestic production and imports (FAO, 2006). The national demand for fish always seems to be greater than the country can supply and the gap is widening year after year. TRADEZONE (2007) reported that even though the national fish demand for 2007 was 913,992 tonnes, the country was able to supply only 511,836. The development of aquaculture has therefore, been adopted as a means of meeting this deficit.

The biology of many tilapias in natural systems is well documented (Fryer and Iles, 1972; Pauly, 1976; Siddiqui, 1977; Trewevas, 1983; Silva, 1985; Blay and Asabere-Ameyaw, 1993; Gomez-Marquez *et al.*, 2003 Njiru *et al*., 2006; Olurin and Aderibigbe, 2006). Despite the predominance of *O. niloticus* in the Weija reservoir in particular, key aspect of the biology of the species in terms of its growth and reproduction has not been fully investigated. This research therefore, seeks to contribute important scientific data by examining aspects of the biology of *O. niloticus* in the Weija reservoir, a man-made lake, that are relevant to its culture.

Objectives

The objectives of the study are to consider aspects of the biology of the fish in terms of:

a. Growth viz
    i. length-frequency distribution
    ii. length-weight relationship
    iii. fluctuations in condition factor
    iv. fluctuations in visceral fat index and
b. Reproduction under
    i. sex ratio
    ii. fecundity
    iii. length at first maturity
    iv. fluctuations in gonado-somatic index (GSI) and
    v. frequency of ovum diameter distribution.

Additionally, the effects of some prevailing hydrographic factors of the Weija reservoir on some aspects of the biology of the fish will be considered.

CHAPTER TWO

MATERIALS AND METHODS

Study Area

Figure 1 shows the Weija reservoir, located about 17 km west of Accra (5° 33′ and 5° 36′ N; 0° 20′ and 0° 23′ W). The reservoir, also known as Lake Naye Densu is part of the 116 km long River Densu which takes its source from the Atewa Atwiredu mountain range in the Eastern Region of Ghana. It was created when the Weija Dam was constructed by Ghana Water Company Limited (GWCL) in 1978 to replace an earlier one which collapsed in 1968 with the aim of providing portable water for domestic consumption, while irrigation and fisheries development serve secondary purposes. The reservoir is 14 km long, 2.2 km wide and has total surface area of 38 km^2 with mean depth of 5 m (Vanden-Bossche and Bernacsek, 1990). It covers a catchment area of 2,460 km^2, and about 220 ha of land are irrigated by the reservoir (Gordon, 2006). The average water temperature is 27 ^oC and rainfall in the area is seasonal, with peaks in June and September and an annual average of 65.5 mm, while the period between December and March is dry (Asante *et al*., 2006). The vegetation around the lake is of the coastal savannah type mainly characterized by shrubs, grasses and some trees dominated by *Cassia sp.* The main economic activities in the catchment are fishing and crop farming. The major crops cultivated include maize, cassava, sugar cane and vegetables.

Fish sampling and data collection

Fish samples were obtained from commercial landings at the New Galilea landing site of the Weija reservoir (see Fig. 1) about the middle of each month from September 2007 to August 2008. The fish were caught with cast nets (20.0 mm) and gill nets (small mesh size 10 – 25 mm; medium mesh size 30 – 40 mm and large mesh size 50 – 70 mm, knot to knot and overall net size about 20 m long). The samples (at least 40 specimens) were kept on ice in a plastic container and transported to the laboratory for routine studies.

In the laboratory, the total length (TL) and standard length (SL), to the nearest 1.0 mm were taken using a fish measuring board. The total length was determined from the tip of the snout to the end of the caudal fin and the standard length from the tip of the snout to the base of the caudal fin. The fish were blotted dry with a towel and the body weight (BW) determined to the nearest 0.01g using an electronic top loading balance. Each fish was dissected to determine the sex. Gonads were removed and weighed to the nearest 0.01g using an electronic top loading balance.

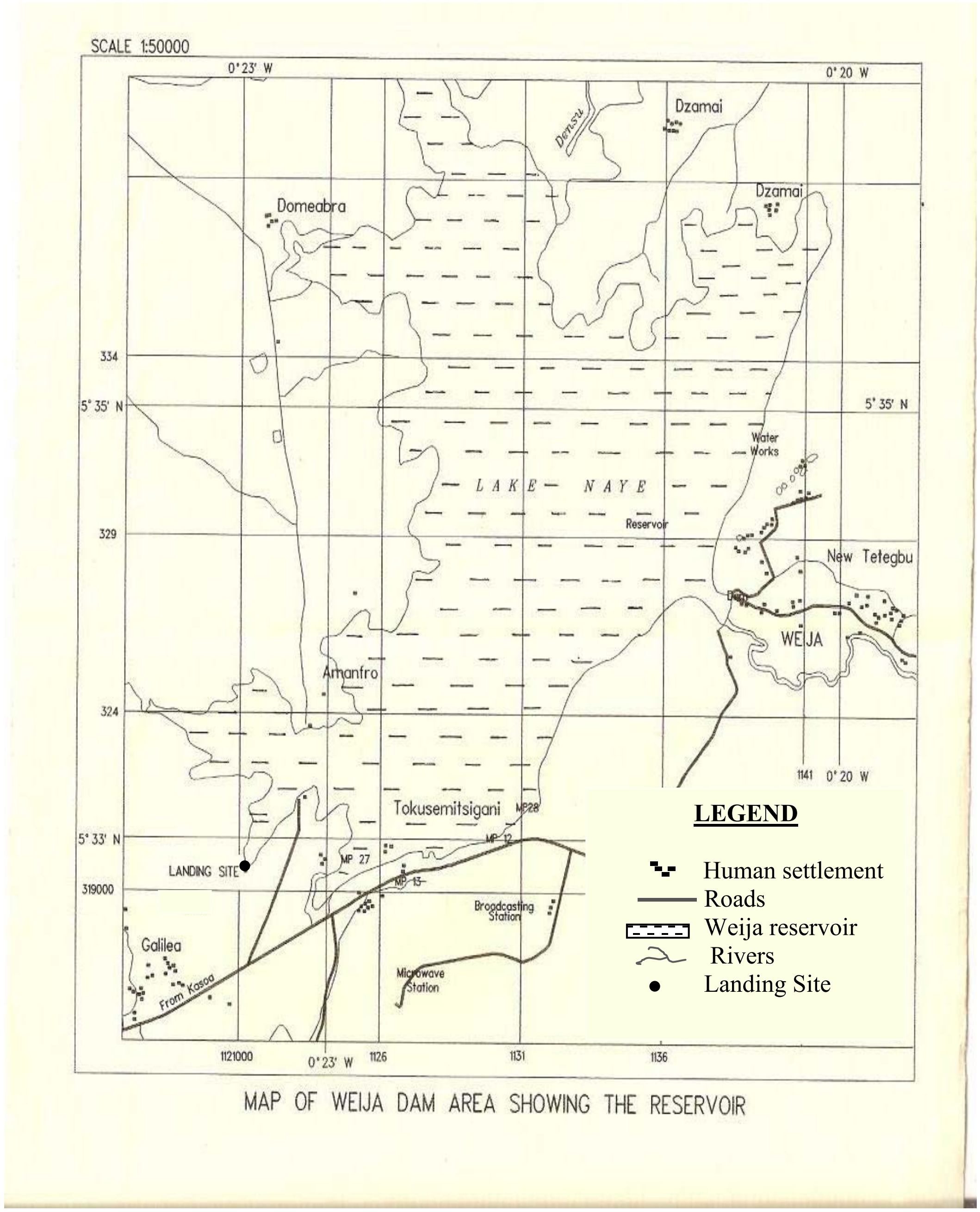

Fig. 1: Map of Weija area showing the reservoir

(Source: Ghana Survey Department, 2008)

Determination of length frequency distribution and length-weight relations

The data obtained on the total length (TL), standard length (SL) and body weight (BW), were analysed to investigate the monthly length-frequency distribution and length-weight relationships to show recruitment of the fish and their growth pattern.

Determination of condition factor (K)

The data obtained from the measurement of body weights (BW) and standard lengths (SL) were used to calculate the condition factor (K) of each fish using the formula:

$$K = \frac{BW}{SL^3} \times 100 \quad \text{(Tesch, 1971)}$$

The mean monthly condition factor of male and female fish was plotted to illustrate the fluctuations in the relative 'well being' or 'fatness' of the fish during the period of study.

Determination of visceral fat index

The amount of visceral fat content of each fish after dissection was observed and estimated using a three point scale, according to Kwei (1970) and recorded as follows:

1: viscera with very low fat volume.

2: viscera with moderate fat volume.

3: viscera with high fat volume.

The data on fat index of the male and female was analyzed using Minitab (version 15) statistical software to obtain the mean monthly fat index of the fish and their standard errors. These were plotted using Microsoft Excel (version Office 2007) to show the fluctuations in 'fatness' of the fish which also gives an indication of their condition.

Determination of sex ratio

Monthly sex ratio of male:female fish was determined using the data obtained after sexing them. A Chi-square goodness of fit test was also performed to test for any difference in the sex ratio of the monthly samples of *O. niloticus* population from the 1:1 ratio.

Gonadal staging

The gonads of the fish were examined and staged according to Witte and Van Densen (1995), based on their appearance. Ovaries were staged using a three-point scale:

Stage 1- Immature: small haline ovaries with very small whitish ova.

Stage 2- Developing: ovaries with few yellowish-white or yellow ova.

Stage 3- Ripe: gravid ovaries with large yolky ova.

Testes were classified as either immature or ripe as it was difficult to describe intermediate developmental stages. Testes of immature fish were very transparent and thin while ripe testes were reddish or creamy in colour and swollen with milt which flows out easily when the testes are cut.

The percentage of ripe males and females in each monthly sample was determined and plotted to show monthly fluctuations of the ripe gonads in the fish.

Determination of gonado-somatic index (GSI)

The gonado-somatic index (GSI) of female and male was calculated as

$$GSI = \frac{GW}{BW-GW} \times 100$$ (Htun-Han, 1978)

where GW is gonad weight (g) and BW is body weight (g).

The data were analyzed using Minitab (version 15) statistical software to obtain the mean monthly GSI of the fish and their standard errors. The mean monthly GSI of both male and female fish were plotted to determine the changes in reproductive activities of the fish.

Determination of fecundity

Fecundity was determined using the whole count method (Bagenal and Braum, 1978). All ripe ovaries were cut into pieces and preserved in sample bottles containing Gilson's fixative for about four weeks. This was done to permit infiltration of the ovarian tissues by the fixative, and ensure hardening of the eggs. Each bottle was vigorously agitated periodically to facilitate separation of the eggs from ovarian tissues (Bagenal and Braum, 1978). The content was poured into a petri dish and eggs separated from the ovarian tissue with the aid of a pair of forceps and a dissecting pin prior to counting. All ripe eggs in an ovary were counted. The relationship between fecundity and standard length (SL) and body weight (BW) were established using analysis of variance.

Determination of length at first maturity (L_{50})

The data on the total length (TL) and gonadal stages of the fish were used to determine the length at first maturity (L_{50}). The percentage of male and female considered mature were used to determine the percentage maturity for the selected class size. These values were used to plot graphs for male and female using the statistical software Origin Professional (version 6.0) to estimate the length at which 50% of the population is considered sexually matured.

Measurement of Ovum Diameter

Ovaries of four ripe females selected at random were used. After determining the fecundity, the ova were measured on their longest axis to the nearest 0.1 mm, using a dissecting microscope with a stage micrometer and recorded. The data obtained for each pair of ovaries selected were sorted, grouped in diameter class at 0.2 mm interval. This was used to plot frequency distribution of ovum diameter using Microsoft Excel (version Office 2007) to help predict the spawning frequency of the fish.

Hydrographic factors

Monthly mean data on some hydrographic factors namely, total alkalinity, temperature and dissolved oxygen of the surface water of the reservoir were obtained for the period of study from the Ghana Water Company Limited (GWCL)/AVRL at Weija (see Appendix 6). The data were plotted to show their range and monthly fluctuations during the period of study using Microsoft Excel (version Office 2007) to show any possible relation between them and growth or reproductive activities of the fish.

CHAPTER THREE

RESULTS

Monthly length-frequency distribution

The monthly length-frequency distributions *O. niloticus* in the Weija reservoir from September, 2007 to August, 2008 are presented in Figure 2. Majority of the fish sampled were in the range of 14 to 20 cm TL. Apart from the month of November 2007 where juveniles were encountered, other monthly samples were skewed towards individuals measuring 12 or 13cm (TL). Males were relatively larger than the female as shown in the modal classes of 16.0 – 16.9 cm and 19.0 – 19.9 cm for female and male fish respectively. The size distribution in July, 2008 was bimodal with the modal groups as 14.0-14.9 and 20.0-20.9 cm TL. The months of September, October, November and December 2007 exhibited unimodal distribution with their modal class within 17.0–17.9, 18.0–18.9, 12.0-12.9 and 13.0-13.9 cm respectively. Similarly, the months of January, February, March, April, May June and August also exhibited unimodal distribution with their modal classes in the 11.0 – 11.9, 15.0- 15.9, 16.0-16.9, 15.0-15.9, 12.0-12.9, 16.0- 16.9 and 19.0- 19.9 cm respectively. A bi-modal size distribution was observed in July with the modal classes in the 14.0-14.9 cm and 20.0- 20.9 cm size groups.

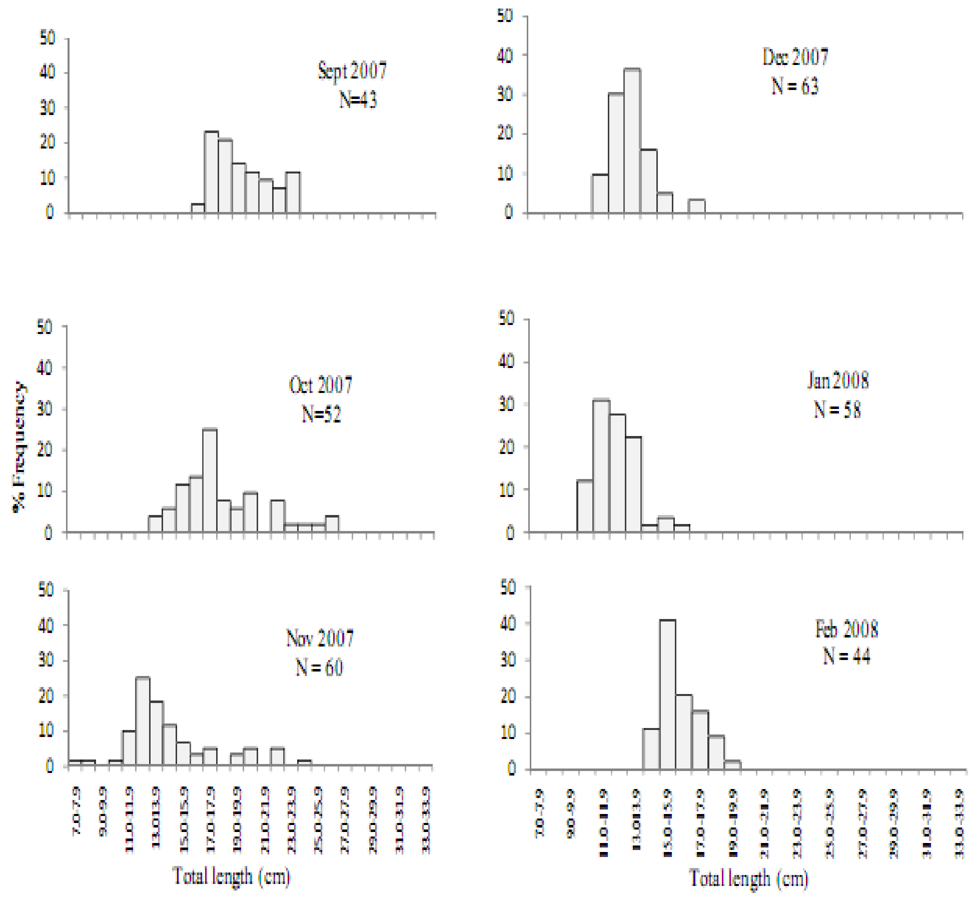

Fig. 2: Monthly length-frequency distribution of *O. niloticus* caught in the Weija reservoir.

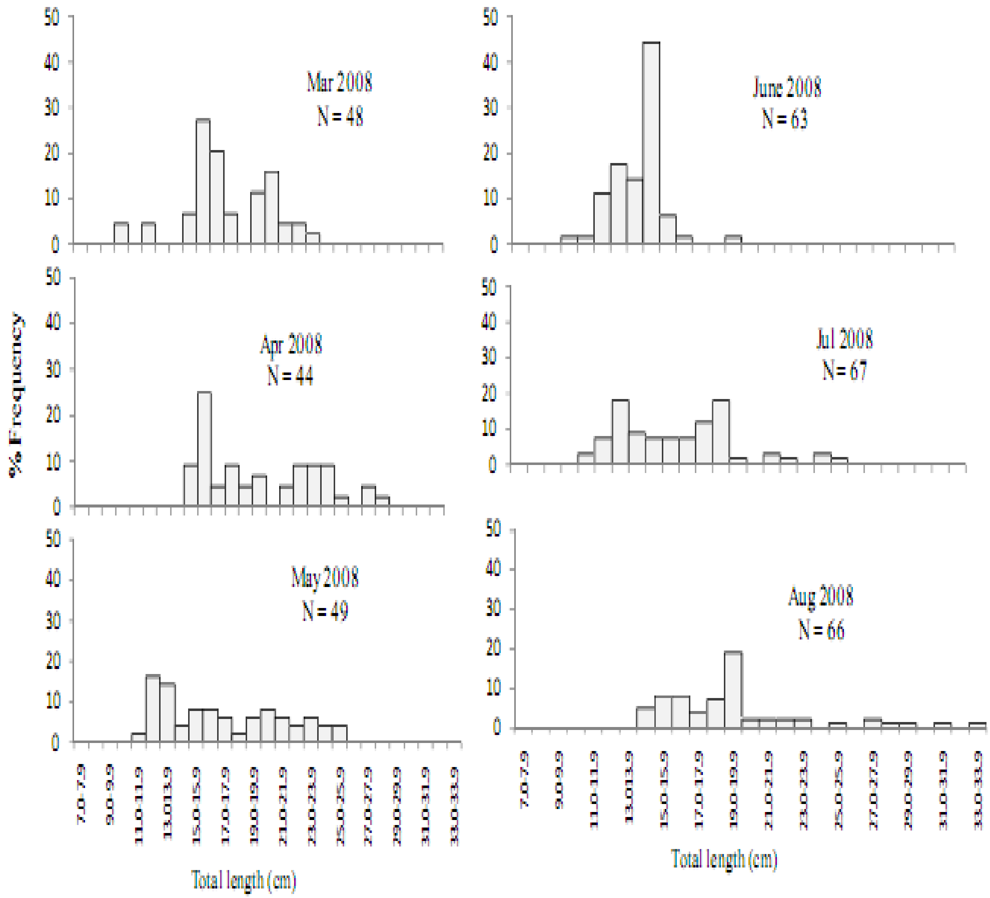

Fig. 2 (cont.): Monthly length-frequency distribution of *O. niloticus* caught in the Weija reservoir.

Length-frequency distribution of female and male

The length-frequency distribution for females and males are shown in Figure 3. The distributions for females and males were unimodal with the modal classes within the 16.0 – 16.9 cm and 19.0 – 19.9 cm groups respectively. Apart from the fact that more males (N= 357) were encountered, the males were also larger than the females. The smallest fish obtained was a female in the 7.0 – 7.9 cm size group, and the largest female obtained belonged to the 30.0 – 30.9 cm group. The smallest male was within the 8.0 – 8.9 cm group with the largest in the 33.0 – 33.9 cm group.

Overall length-frequency distribution

Figure 4 shows the overall size-frequency distribution of *O. niloticus* in the Weija reservoir during the period of study. The distribution is unimodal with the modal size being within 17 cm TL. In all a total of 657 specimens with total length range of 7.0 – 33.3 cm were sampled.

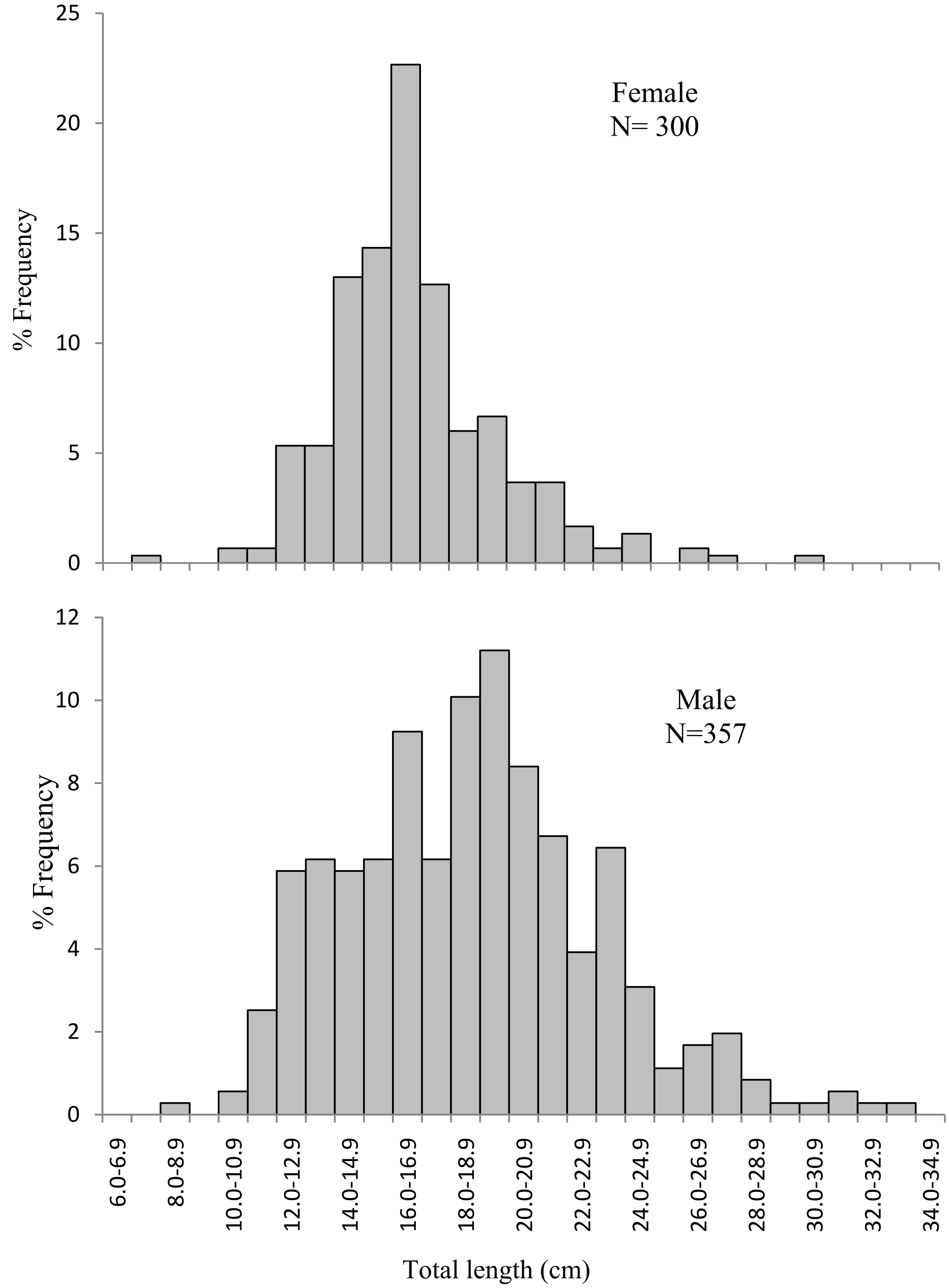

Fig. 3: Length-frequency distribution of female and male *O. niloticus* caught in the Weija reservoir from September, 2007 to August, 2008 (N=total number of fish).

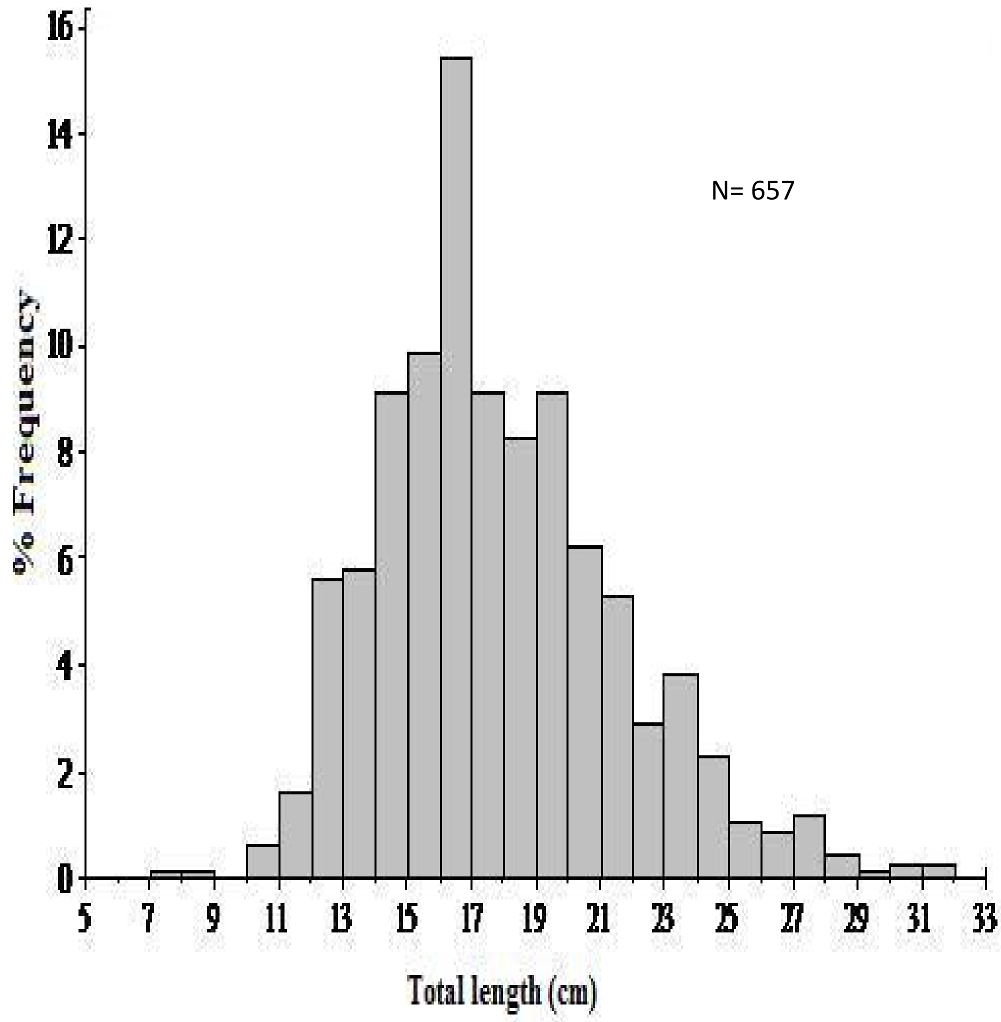

Fig. 4: Overall length-frequency distribution of *O. niloticus* caught in the Weija reservoir from September, 2007 to August, 2008 (N= number of fish).

Length-weight relationship

The scatter plots of length-weight relation of the population of *O. niloticus* in the Weija reservoir during the period of study and the curve of this relationship are presented in Figure 5. The total length (TL) of all the 657 specimens sampled, ranged between 7.0 and 33.3 cm and weighed between 17.85 g and 700.00 g. An exponential relationship is revealed between the standard length (SL) and body weight (BW). The equation describing this relationship is $BW = 0.0317\ SL^{3.0932}$ (Fig. 5). A student t-test generated from Microsoft Excel (version Office 2007) revealed that $b = 3.0932$ was not significantly higher ($P > 0.05$) than the expected 3.0 (see Appendix 2).

Condition factor

The fluctuations in the condition factor (K) of female and male of *O. niloticus* are presented in Figure 6. The mean monthly condition factor ranged from 3.56 ± 0.191 to 4.31 ± 0.131 for the females and 3.76 ± 0.06 to 4.96 ± 0.125 for the males. Except for May 2008, the condition factor for both sexes during the period of study seemed to follow a similar trend with that of the males being relatively higher. The fish were in their best condition in October 2007, declining in November that year and not varying significantly for the rest of the study period except in May 2008.

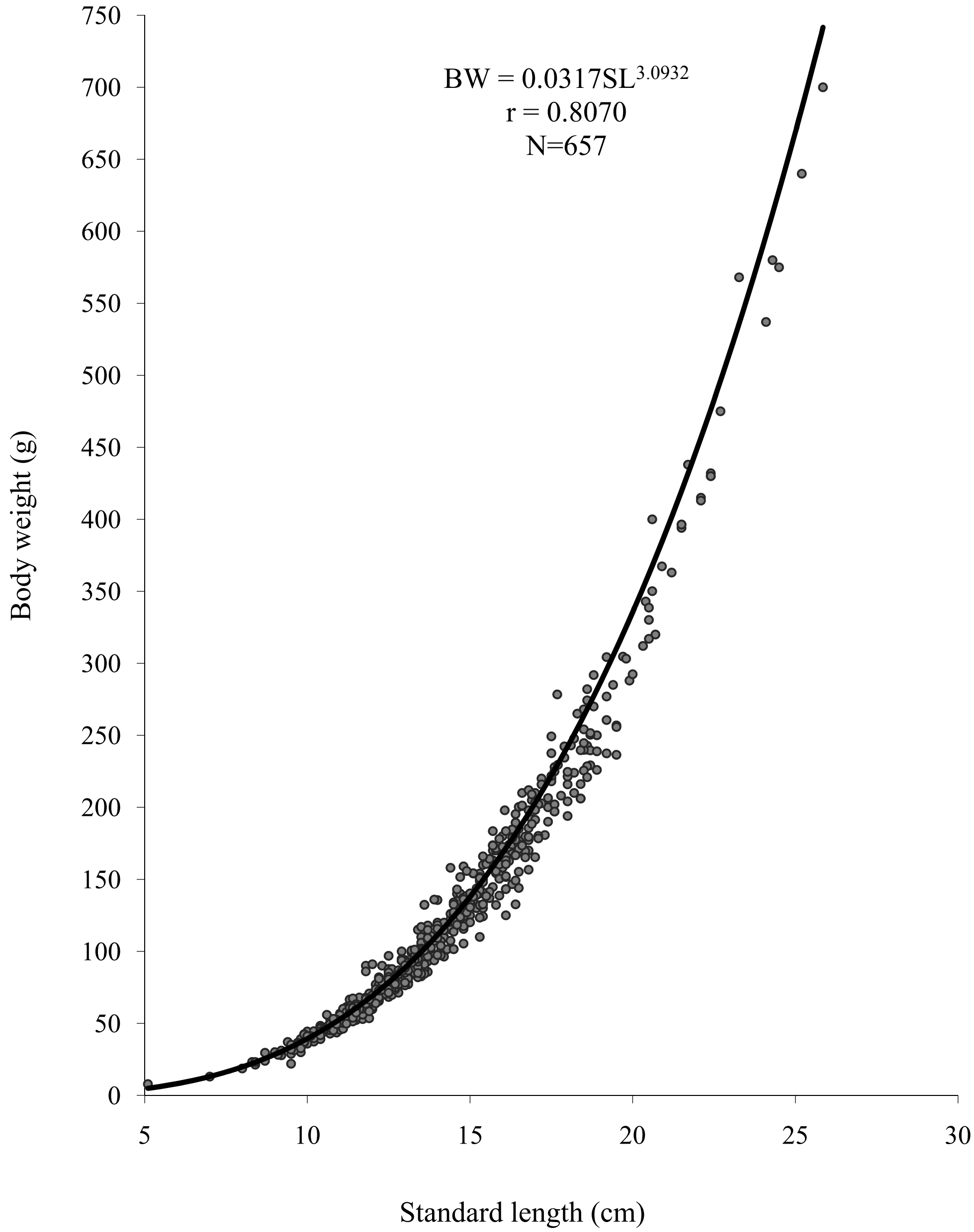

Fig. 5: Length-weight regression of *O. niloticus* population in the Weija reservoir from September, 2007 to August, 2008.

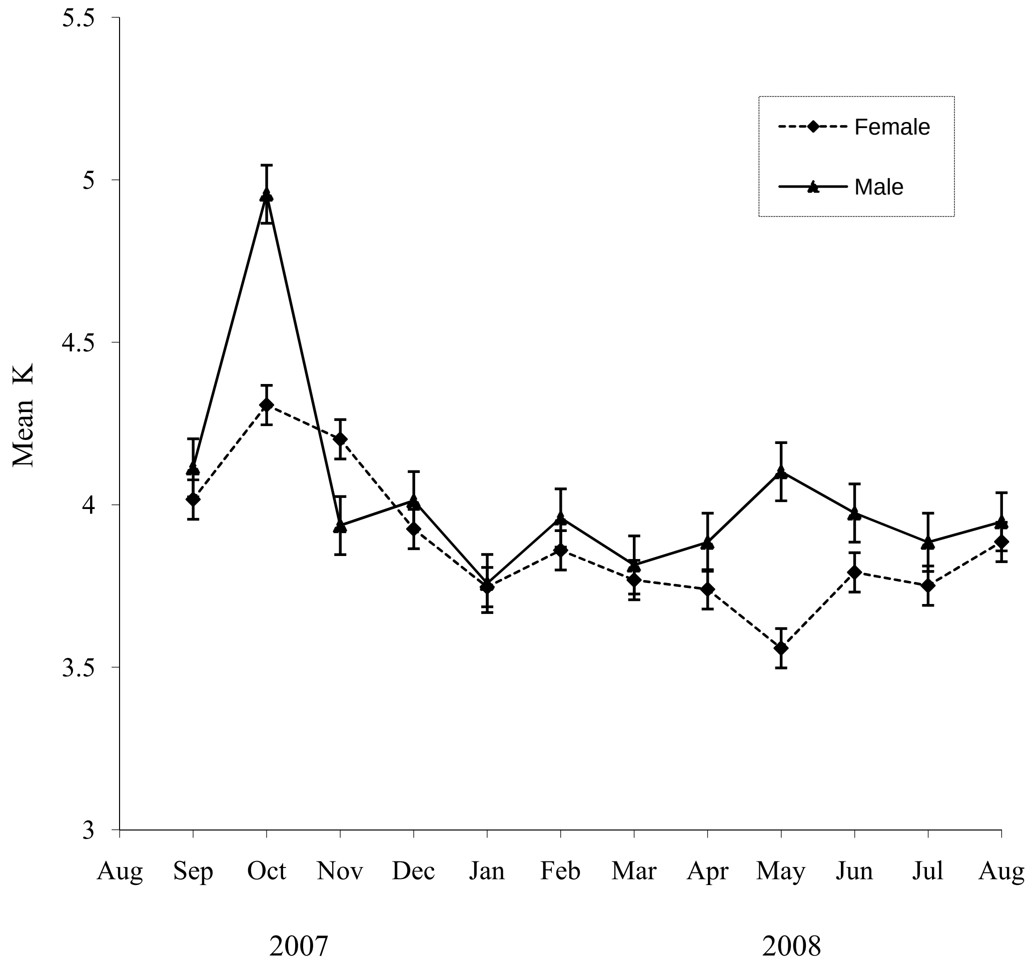

Fig. 6: Fluctuations of Condition Factor (K) of *O. niloticus* in the Weija reservoir (vertical bars = standard error).

Analysis of visceral fat index

Figure 7 shows the monthly fluctuations in the visceral fat index for female and male *O. niloticus* in the Weija reservoir. The female visceral index ranged between 1.17 ± 0.09 and 1.87 ± 0.15 during the study period. It increased from 1.57 ± 0.16 in September 2007, attaining a peak of 1.87 ± 0.15 in November. Generally, the fluctuations in the visceral fat index of females were irregular. The lowest value of 1.17 ± 0.10 was observed in April 2008. The visceral fat of males decreased from 1.65 ± 0.11 in September 2007, to 1.42 ± 0.10 in December. It then increased to a peak of 2.69 ± 0.15 in March 2008 and dropped sharply till May 2008, where the lowest value of 1.23 ± was observed. It then increased steadily from June reaching 1.82 ± in August 2008. Two major peaks were observed for males in March and August 2008. The monthly visceral fat index of males was generally higher than that of the females except for the months of November 2007 and June 2008.

Sex ratio

The monthly sex ratio of *O. niloticus* is shown in Table 1. Out of 657 Nile tilapia examined, 357 were males and 300 were females giving an overall sex ratio of 1:0.84. Except for the months of January, March and June 2008 where the females outnumbered the males, the males generally were more in all the monthly samples. The sex ratios for the monthly samples of April, July and

August 2008 were significantly different from the expected 1:1, in favour of the males.

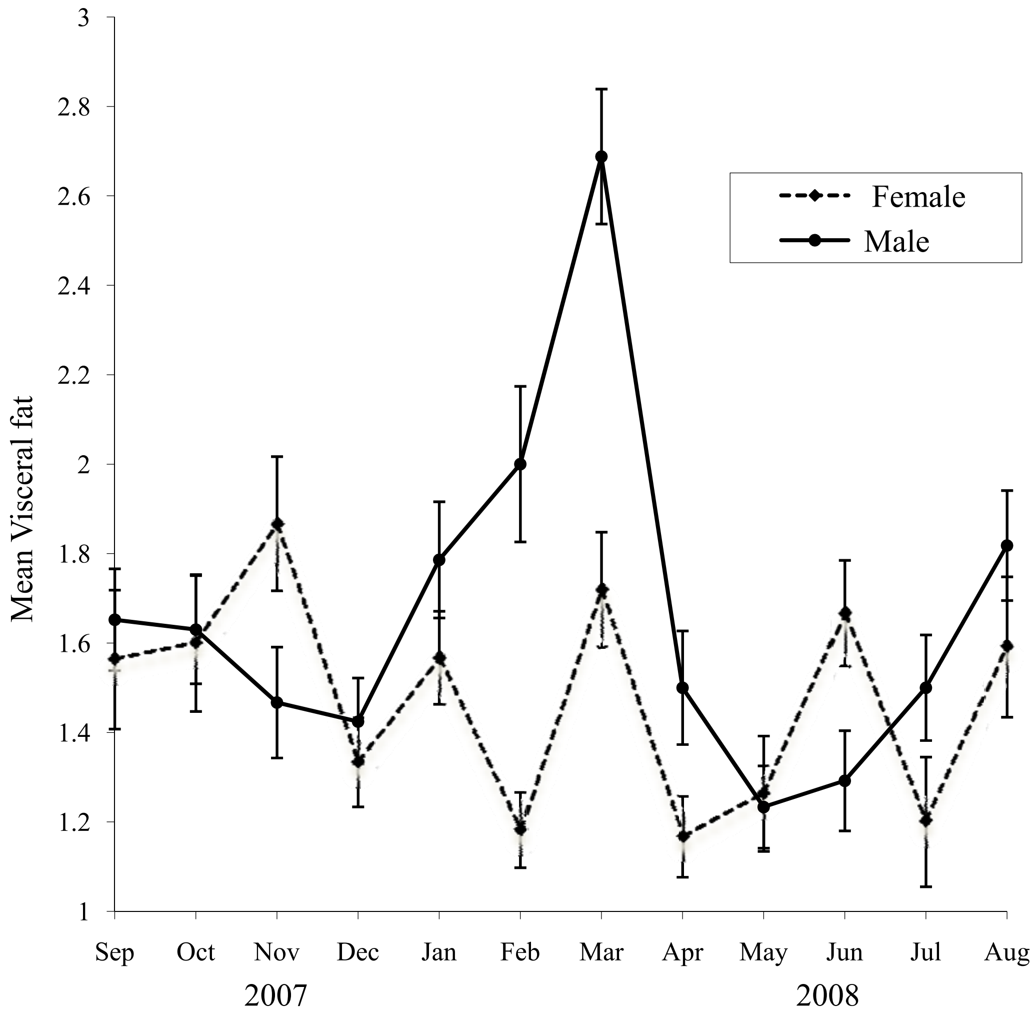

Fig. 7: Fluctuations in the visceral fat index of *O. niloticus* in the Weija reservoir (vertical bars = standard error).

Table 1: Sex ratio of *Oreochromis niloticus* in the Weija reservoir.

Year	Month	Males	Females	Sex Ratio ♂:♀	χ^2	p (0.05)
2007	Sep	25	18	1:0.7	1.14	NS
2007	Oct	27	25	1:0.9	0.077	NS
2007	Nov	30	30	1:1	0.0	NS
2007	Dec	33	30	1:0.9	0.78	NS
2008	Jan	28	30	1:1.07	0.31	NS
2008	Feb	22	22	1:1	0.0	NS
2008	Mar	16	32	1:2	5.33	S
2008	Apr	26	18	1:0.7	1.45	NS
2008	May	30	19	1:0.6	2.47	NS
2008	Jun	24	39	1:1.6	3.57	NS
2008	Jul	52	15	1:0.3	20.43	S
2008	Aug	44	22	1:0.05	7.33	S
	Total	**357**	**300**	**1:0.84**	**4.95**	**S**

S = Significant

NS = Not significant

A Chi-square test conducted indicated that the overall difference from the 1:1 ratio was significant ($P < 0.05$) and in favour of the males ($\chi^2 = 4.95$).

Fecundity

The absolute fecundity of 94 individuals of *O. niloticus* from the Weija reservoir was determined. The fecundity ranged from 563 ova for fish measuring 15.6 cm TL and weighing 108 g to 1542 ova for fish measuring 21.5 cm TL and weighing of 200 g. The mean fecundity of the fish examined was 850.8 ± 13.2. Figure 8 shows the relationship between fecundity (F) and total length (TL), and Figure 9 shows the relationship between fecundity and body weight (BW).

The relationships are described by the equations:

$$F= 12.36TL + 628.5 \quad (r = 0.40)$$

$$F= 0.519BW + 785.4 \quad (r = 0.37)$$

There was a weak correlation between fecundity and total length ($r = 0.4$), and fecundity and body weight ($r = 0.38$).

Length at first maturity (L_{50})

The fitted logistic curves for length at first maturity of both male and female *O. niloticus* in the Weija reservoir are shown in Figure 10. Majority of the fish obtained were sexually mature. The fish attain maturity beyond 10.00 cm

TL. Females larger than 13.49 cm TL have 50% and more chance of being sexually matured. Males with size greater than 16.33 cm TL also have more than 50% chance of being sexually matured.

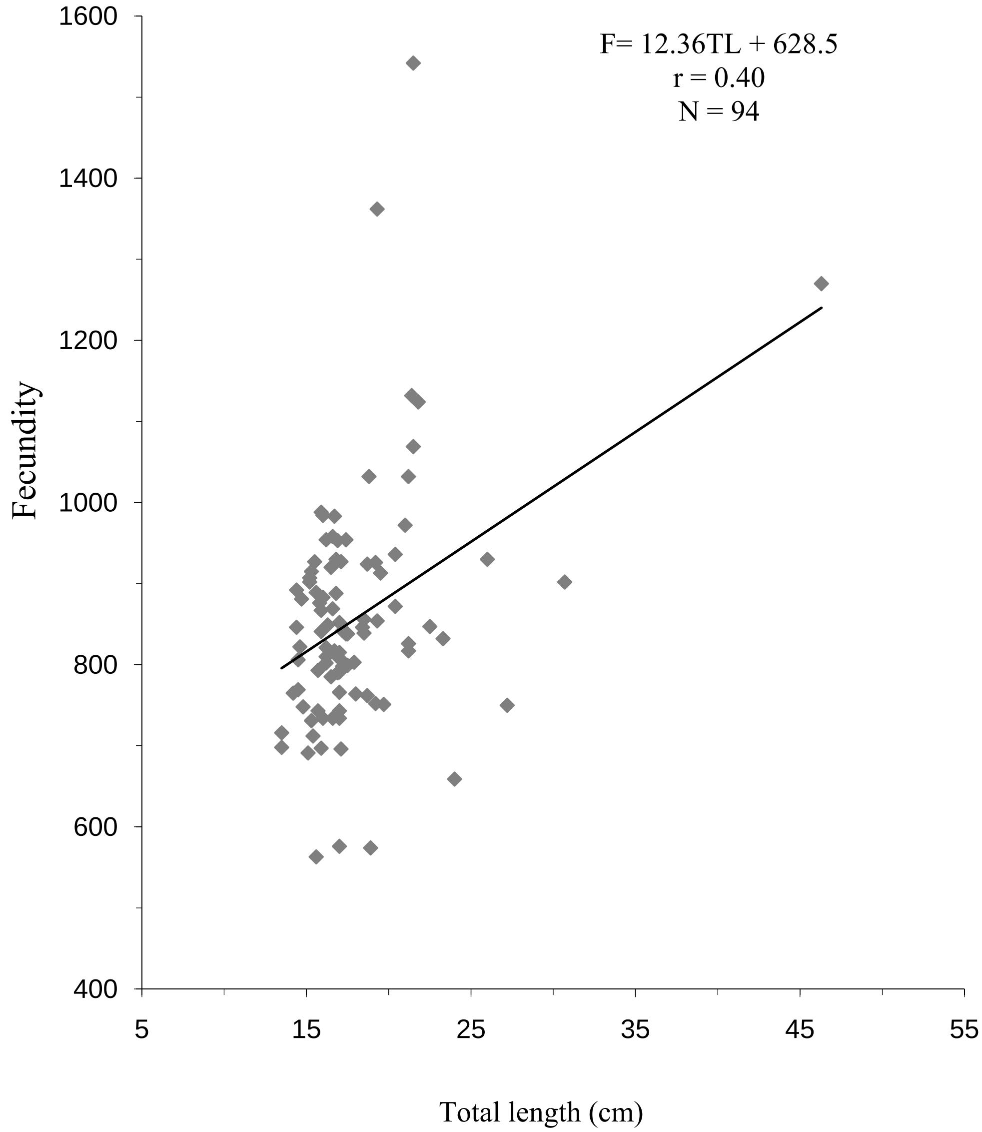

Fig. 8. Relationship between fecundity and total length of *O. noliticus* in the Weija reservoir.

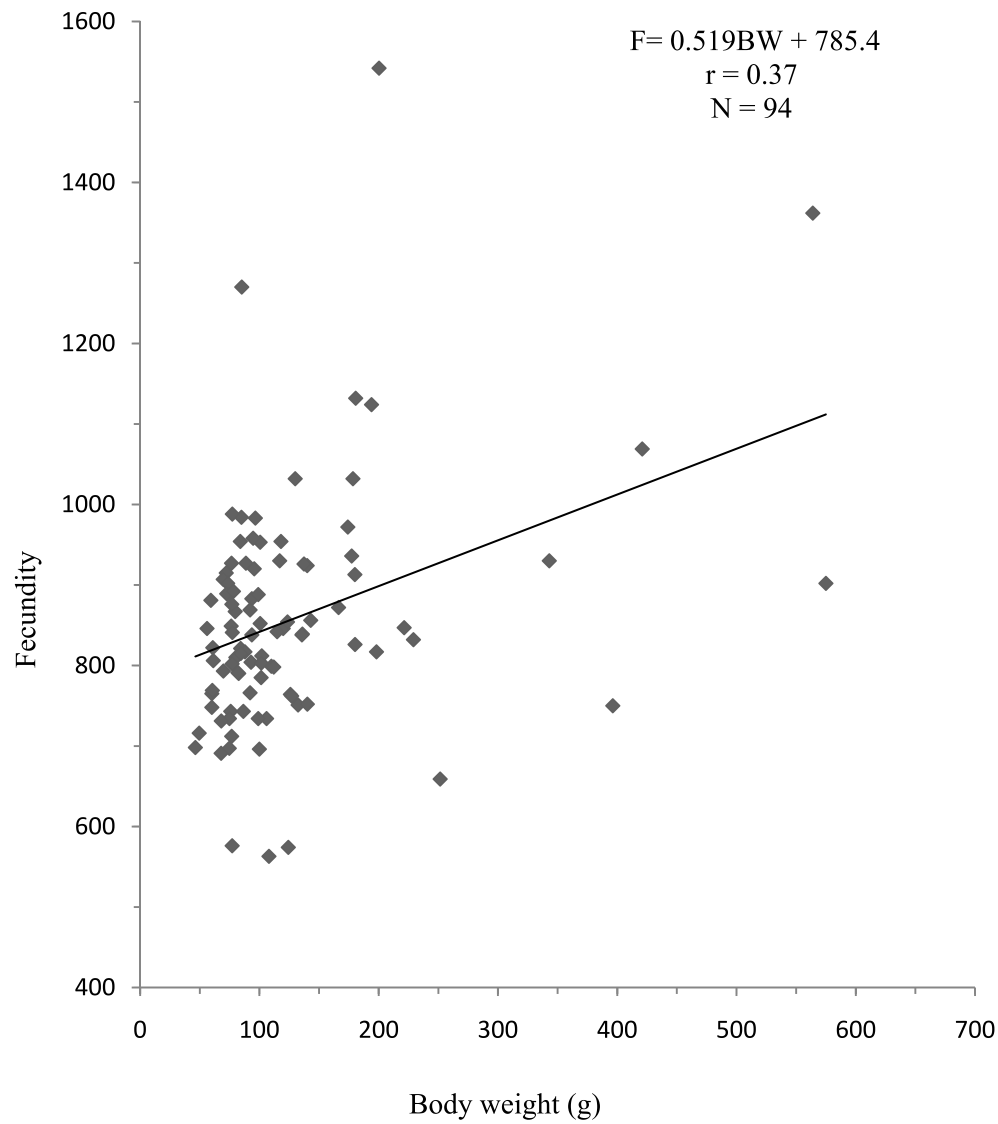

Fig. 9: Relationship between fecundity and body weight of *O. niloticus* in the Weija reservoir.

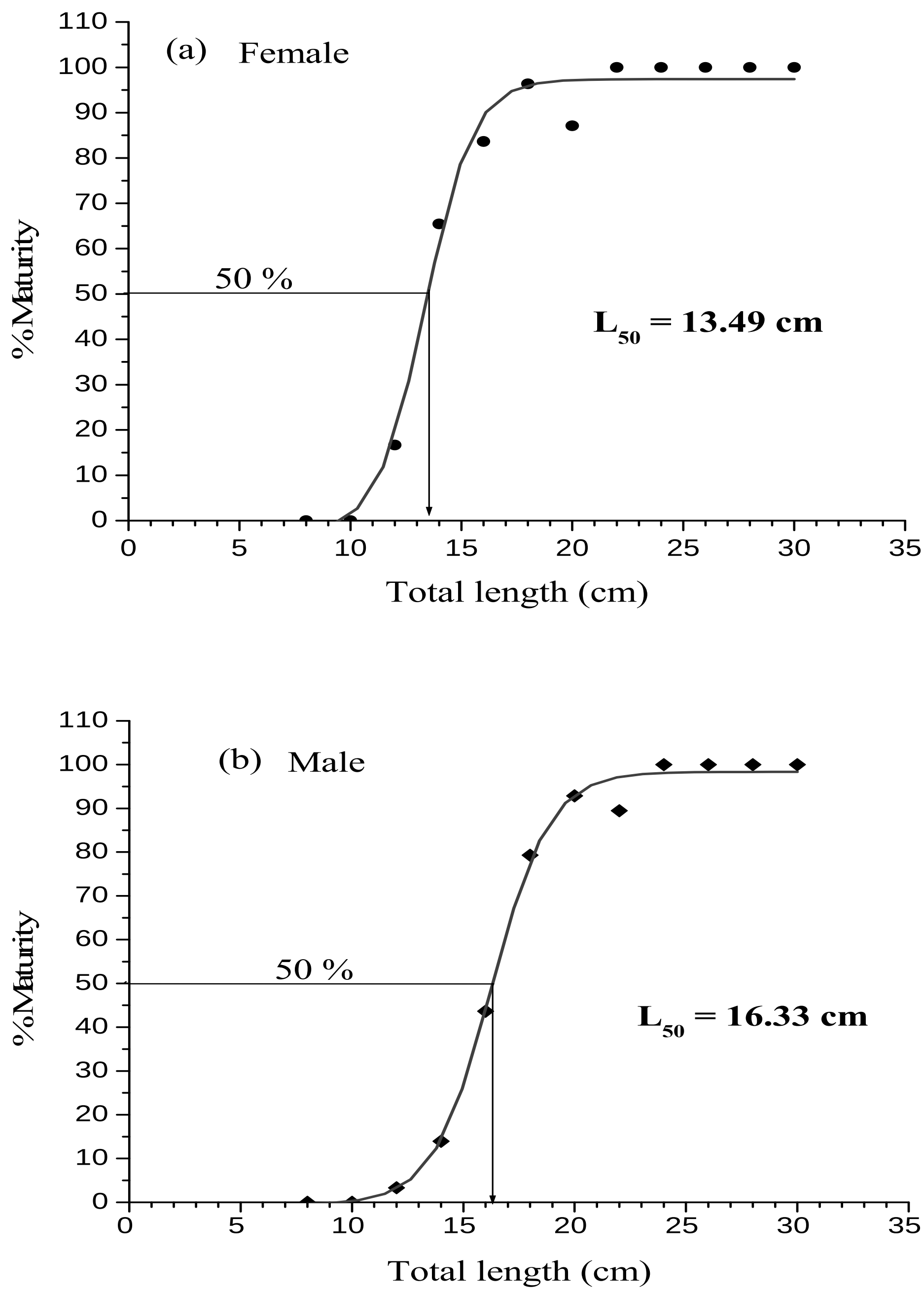

Fig. 10: Length at first maturity (L_{50}) of (a) female and (b) male *O. niloticus* in the Weija reservoir. (L_{50} = 13.49 cm and 16.33 cm for females and males respectively).

Fish of total length greater than 18.00 cm is expected to be fully matured. Males mature at a larger size (L_{50} = 16.33 cm) than the females (L_{50} = 13.49 cm).

Fluctuations in ripe gonad representation

The monthly occurrence of ripe gonads in the samples is shown in Figure 11. Percentage ripe testes ranged between 7 % and 100 % and that of the ovaries between 15 and 53 %. Peaks of percentage ripe testes occurred in September 2007, February and July 2008 while those of ovaries occurred in September 2007 and March. The lowest value for percentage ripe testes was recorded in November 2007 and that of the ovaries occurred in June, 2008.

Figure 12 shows the relationship between monthly variation in ripe gonads representation and some hydrographic factors (total alkalinity, temperature and dissolved oxygen) of the Weija reservoir. The minimal total alkalinity value of 98 mg/l recorded in October 2007 increased through November, December 2007 and then January 2008 reaching a maximum of 128 mg/l in February. There was a slight drop in the total alkalinity of the water in March and April 2008 followed by a sharp drop to a value of 100 mg/l in May. The value increased sharply through June, July till a value of 115 mg/l was reached in August. From September to October 2007 the temperature of the water remained at 27.5 ºC and then increased to 29.0 ºC in November and later dropped to 26.7 ºC in January 2008. A sharp increase in the water temperature was observed in February, reaching the highest value of 30.5 ºC. This value dropped sharply to a minimum value of 23 ºC the following month. The temperature of the water again increased steadily to 27.8 ºC in June and then declined slighly to 26.8 ºC in August. The dissolved oxygen concentration of the water decreased from 11.2 mg/l in September, 2007 to 7.8 mg/l in January 2008, then increased to 9.7 mg/l in March and decreased to 6.6mg/l in June. The oxygen content thereafter increased steadily to 7.6 mg/l in August. The periods of marked changes in the hydrographic factors (total alkalinity, temperature and dissolved oxygen) appeared to coincide with the month with the highest ripe ovaries for *O. niloticus* in the reservoir (Fig. 12). The highest percentage ripe testes recorded in February 2008, however, seemed to be a phase ahead of the months with the marked changes in hydrographic factors.

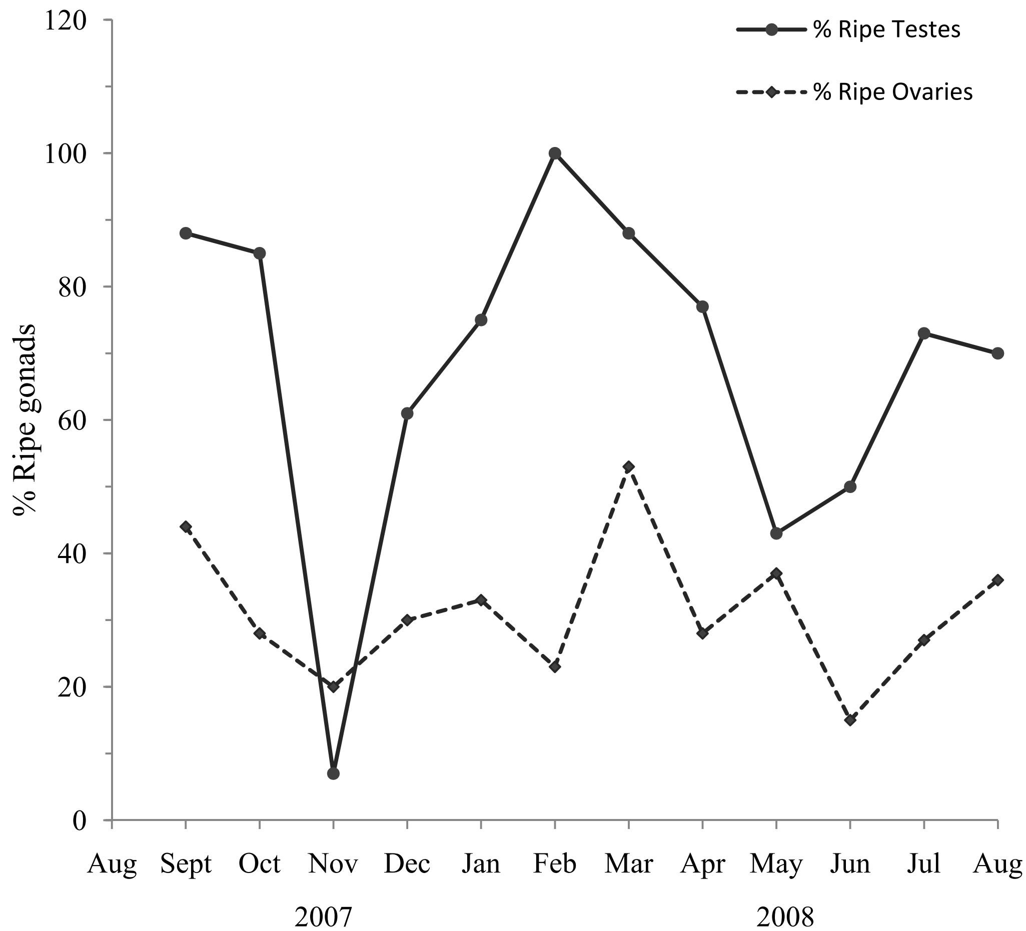

Fig. 11: Monthly fluctuations in ripe gonads of *O. niloticus* in the Weija reservoir.

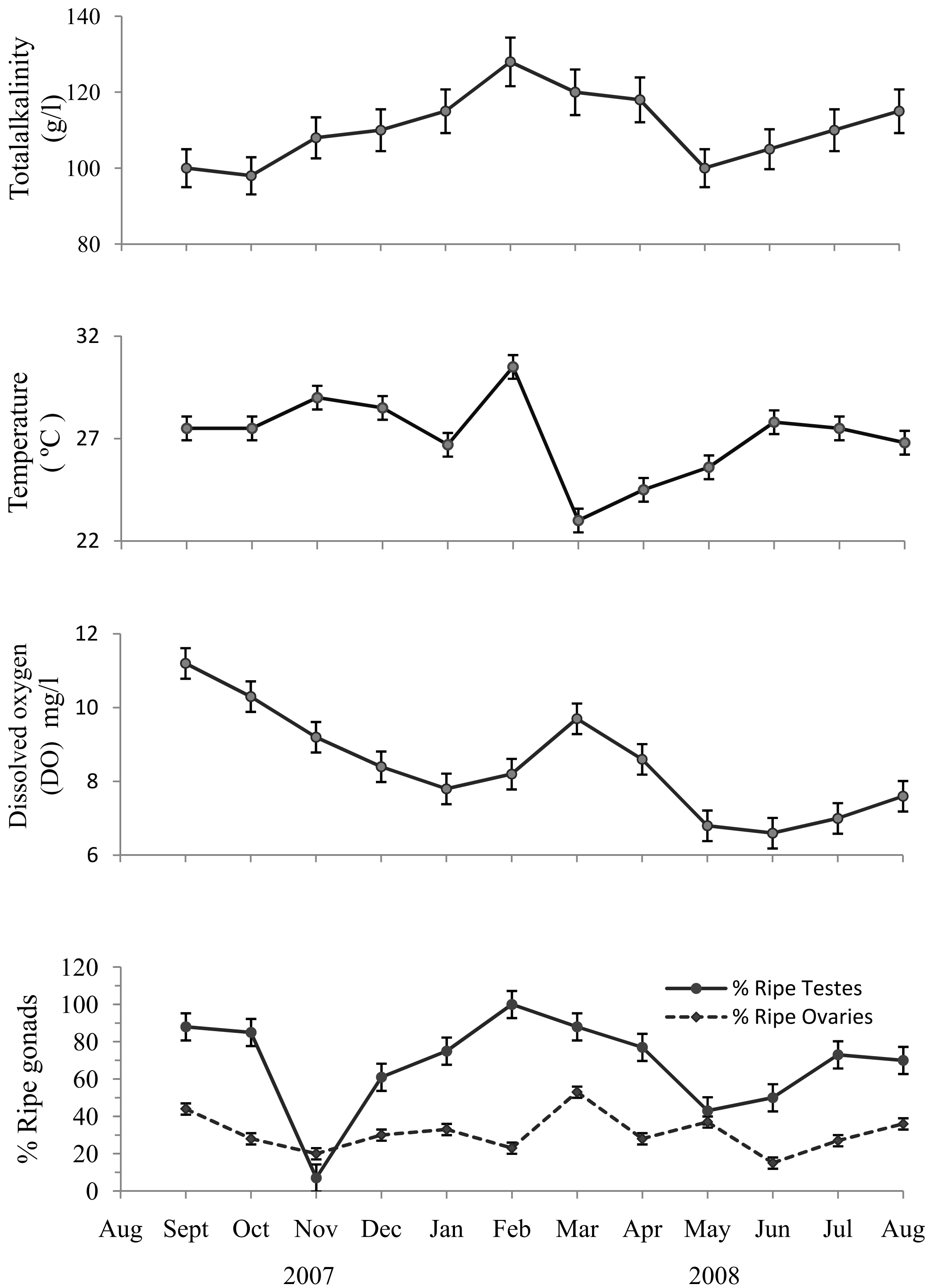

Fig. 12: Relation between fluctuations in the ripe gonads of *O. niloticus* and some hydrographic factors (From: GWCL/AVRL-Weija, 2008) of the Weija reservoir (vertical bars = standard error).

Fluctuations in gonado-somatic index (GSI)

Figure 13 shows the monthly variations of the GSI of male and female *O. niloticus* in the Weija reservoir. Generally, the GSI for females was higher than that of males because the ovaries were heavier than the testes. In the females, GSI values dropped from 2.60 in September 2007, to 1.73 in December, after which it increased marginally in January to February with a sharp increase in GSI to a peak of 3.63 in March 2008. This was followed by a sharp decrease in April (2.07) and remaining generally low for the rest of the study period. The GSI values for males increased from 0.29 in September, to 0.39 in November 2007. This was followed by a drop to 0.25 in December. There was a general increase in GSI from January reaching a peak of 0.69 in March 2008. This was followed by another drop to 0.43 in April.

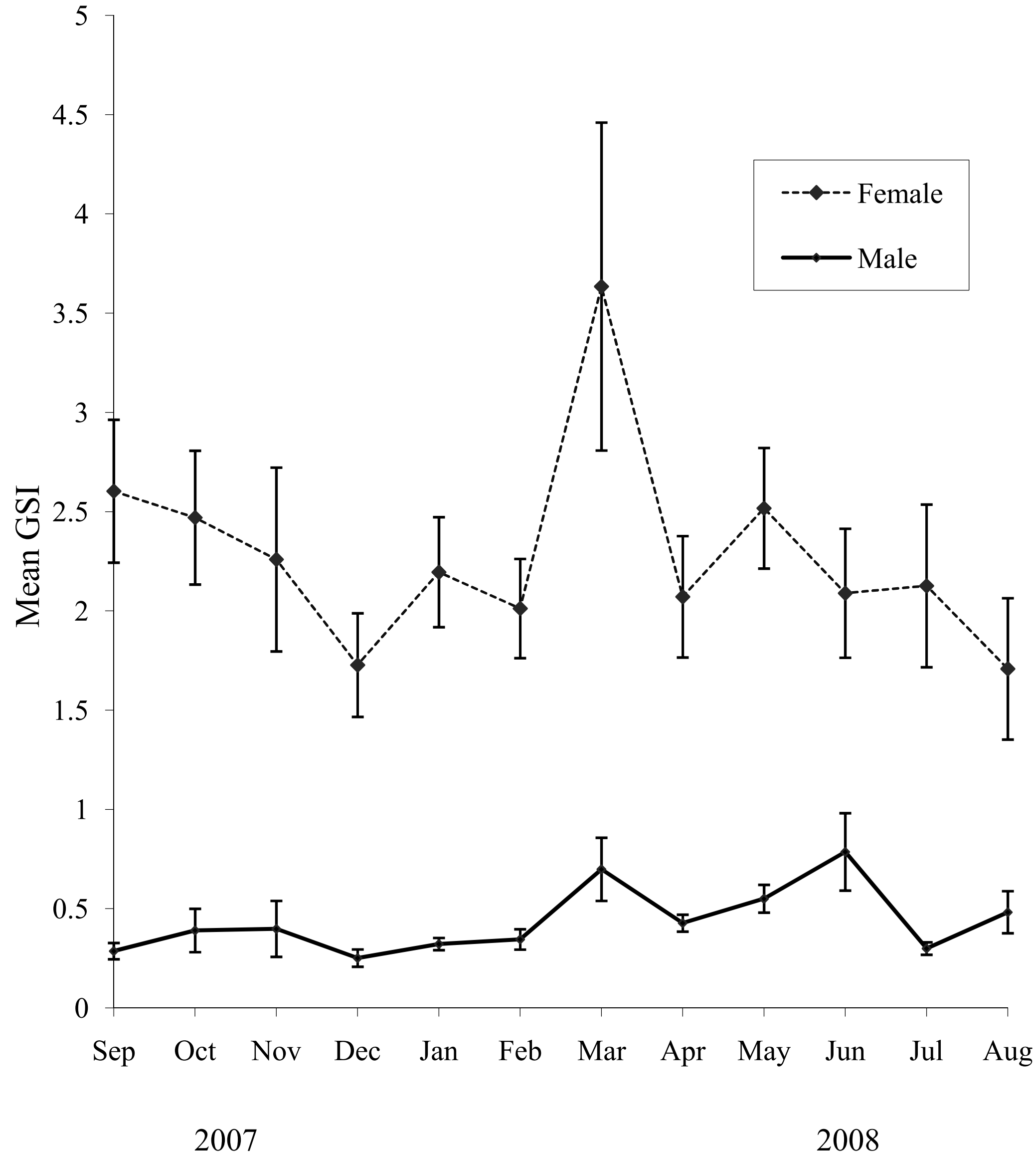

Fig. 13: Fluctuations in the gonado-somatic index (GSI) of female and male *O. niloticus* in the Weija reservoir (vertical bars = standard error).

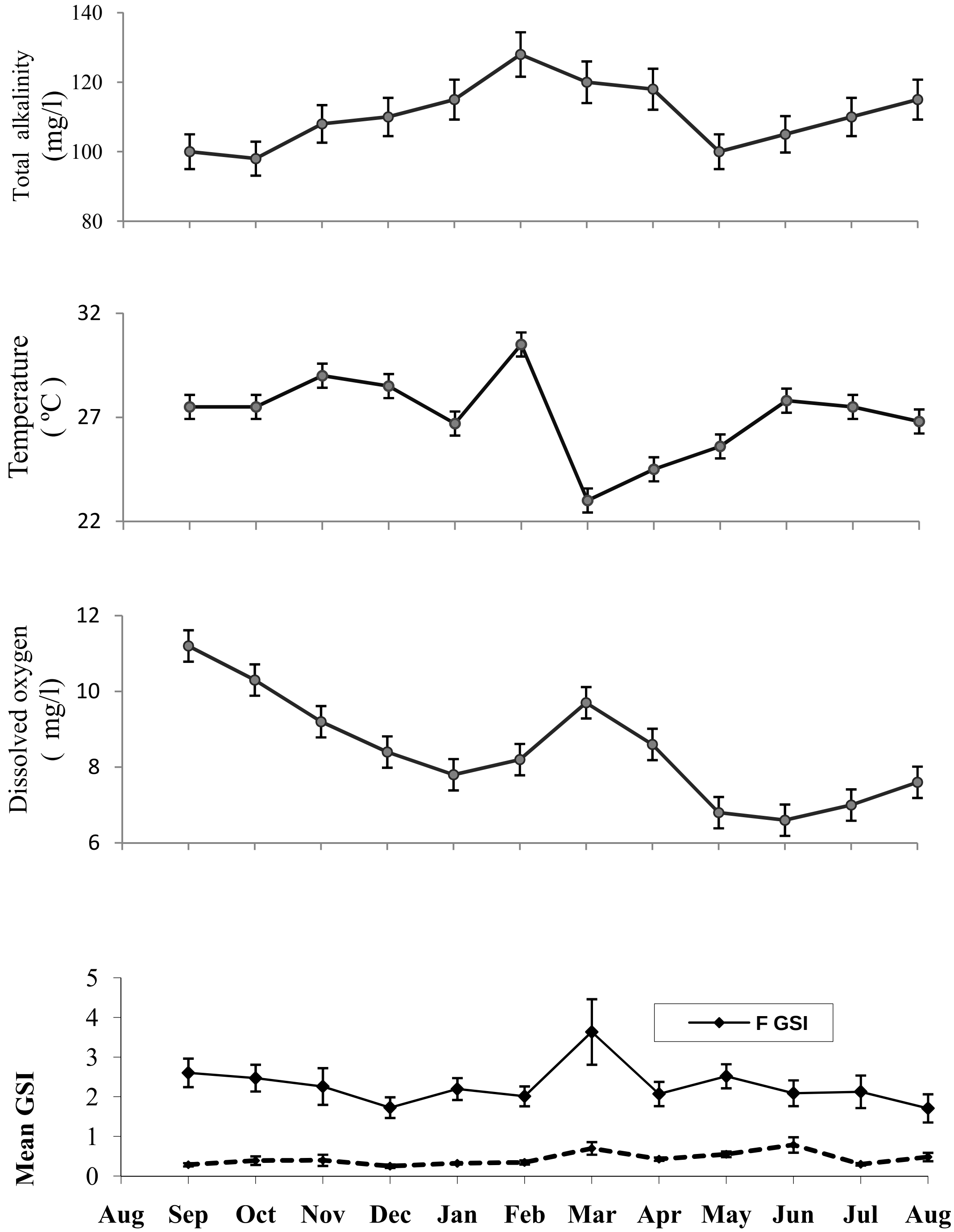

Fig. 14: Relation between fluctuations in the gonado-somatic index (GSI) of female and male *O. niloticus* and some hydrographic factors (From: GWCL/AVRL-Weija, 2008) of the Weija reservoir (vertical bars = standard error).

The maximum value of 0.78 for males was observed in June 2008. From October to December 2007 GSI of both males and females declined. The GSI then increased from January to March where the major peaks were observed for both sexes. Thereafter, the trend followed a sharp decline in the next month, and then decreased gradually during the remaining months.

Figure 14 shows the relationship between monthly variation in gonado-somatic index (GSI) and some hydrographic factors of the Weija reservoir.

The periods of marked changes in the hydrographic factors (total alkalinity, temperature and dissolved oxygen) observed in March 2008 also appeared to coincide with the month with the highest GSI values for both male and female *O. niloticus* in the reservoir.

Ovum diameter frequency distribution

The frequency distributions of ovum diameter of four ripe ovaries of *O. niloticus* are illustrated in Figure 15. The ovum diameter ranged between 1.2 and 3.1 mm for fish between 14.4 and 21.0 cm TL. Two distinct peaks which were not completely separated from each other were observed in each ovary studied. The modal sizes were: 1.4 mm and 2.0 mm for fish of total length of 15.4 cm, 1.6 mm and 2.2 mm for fish of total length of 16.8 cm, 1.6 mm and 2.2 mm for fish of total length of 14.6 cm and 1.8 mm and 2.4 mm for fish of total length of 21.0 cm.

The peaks represent the modal sizes of batches of ova that are to be spawned.

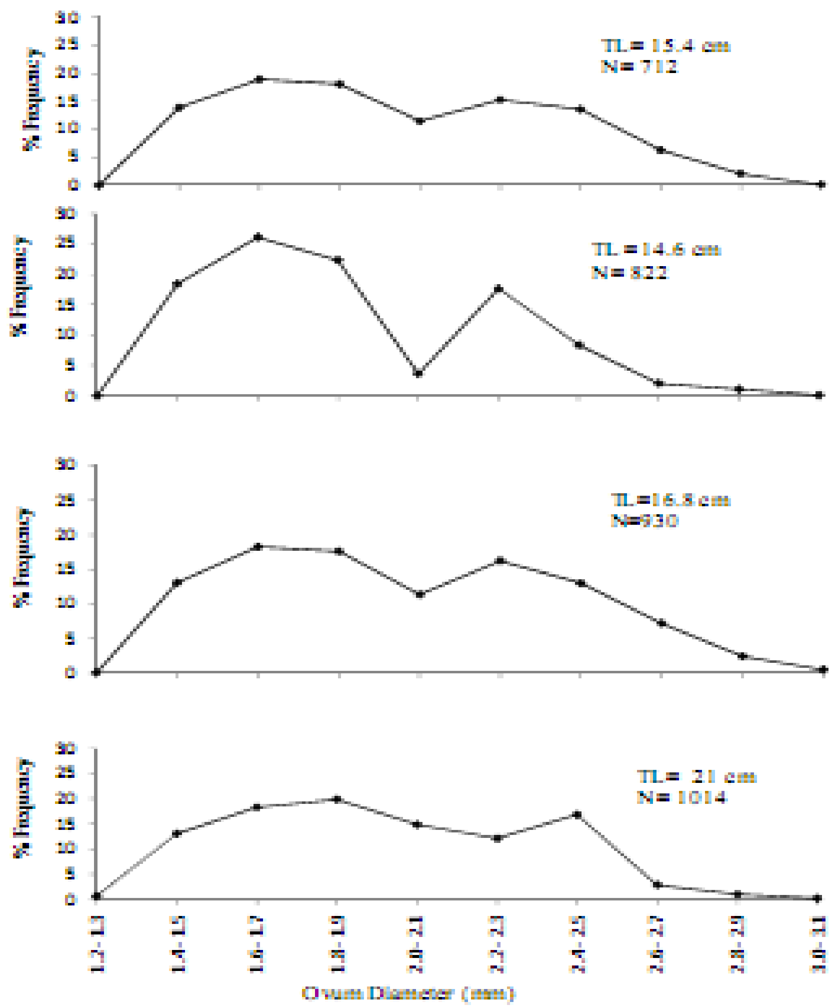

Fig. 15: Frequency distribution of ovum diameter of four ripe ovaries of *O. niloticus* in the Weija reservoir (N = total number of ova).

CHAPTER FOUR

DISCUSSION

The range of sizes of *Oreochromis niloticus* from the Weija reservoir measured 7.0 to 33.3 cm TL. This observation could be due to the fishing method and gear used by the fishermen. Bwanika *et al.* (2004) reported size ranges of 5.0 to 26.0 cm and 4.9 to 29.5 cm TL of *O. niloticus* in Lake Nyamusingiri and Lake Kyasunduka respectively in Uganda. The wider size range in the present study may be due to genetic factors and better water environmental conditions which allow the Weija population to grow to a relatively larger size than those in the Ugandan lakes.

The length-weight relationship for *O. niloticus* were exponential, as described by the relation $BW = 0.0317SL^{3.0932}$ for the length-weight relationship of *O. niloticus* in the Weija reservoir. This is a common phenomenon in fisheries (Pauly, 1993; King, 1996; Gracia-Arteaga *et al*., 1997; Kariman and Hanan, 2008). The curvilinear relationship between the length and weight of the species is common among fishes (King, 1996). For an ideal fish that shows isometric growth, the regression co-efficient is 3.0 (Allen, 1978; Bagenal and Tesch, 1978; Dalzell, 1987) and populations in which the exponent differs significantly from 3.0 exhibit allometric growth. The regression coefficient of 3.09 indicates isometric growth in the species and is similar to what has been reported for pond reared juvenile *O. niloticus* in Nigeria by Olurin and Aderibigbe (2006). Njiru *et* *al*. (2006) however, observed positive allometric growth in both males and females of the species in Lake Victoria, Kenya. Their regression co-efficient reported for the length-weight relationship was 3.32 and 3.22 for males and females respectively. Barnes (2007) also reported negative allometric growth in Nile tilapia reared in fish ponds in Sunyani district of Ghana. Within the same species, variation in the exponent of length-weight relationships could be due to different stages in the ontogenetic development, differences in sex and differences in geographical location with the associated environmental conditions (Tudorancea *et al*., 1988; Kraljevic, *et al*., 1996).

Condition factor studies describe the health and general well-being of a fish as related to its environment; hence it represents how healthy or plumpy the fishes are (Reynold, 1968). The males of the *O. niloticus* population investigated in the Weija reservoir were generally heavier than the females. This is similar to what has been reported by some researchers (Stone, 1980; Behrends, 1983; Eknath *et al*., 1993; and Bentsen *et al*., 1998). The difference in growth of the sexes observed in the present study could be attributed to genetic differences between the males and the females as suggested by Pagan (1970) and Tave (1980). The present study also reveals that the periods of better condition in the fish (October 2007 and February 2008) coincided with months with reduced reproductive activities (see Fig. 6). Lowe-McConnell (1958) also observed a similar trend in *O. niloticus* in Lake Turkana, as did Moriarty and Moriarty (1973) in Lake George. The observed increase in condition of Nile tilapia could be attributed to development of gonad materials just prior to the breeding seasons.

The high condition factor value observed for males in October 2007 probably might be due the movement of larger matured fish from their spawning arena in the shallow areas into the deeper part of the water after spawning to avoid competition for food, where they are easily caught by the net of the fishermen. Changes in condition factor of fishes could be used to interpret various biological features such as fatness, food availability, reproductive activities and environmental health (Le Cren, 1951; Dadzie *et al*., 2000).

Studies on the visceral fat of the fish have also been used to explain the well-being of the fish (El-Sayed and Teshima, 1991; Hanley, 1991; Websterand Lim, 2002). Most fish tend to accumulate fat around the visceral organs during periods of intense feeding and reduced reproductive activities (Kwei, 1966; Welcomme, 1967). The main function of this fat is for storage of high-energy molecules which they utilize during periods of less feeding activities as they channel their energy into spawning and parental care activities. Fat is digested and metabolized with greater relative ease than carbohydrates and so serve as a much better source of energy for protein sparing (Welcomme, 1967; El-Sayed, 2006). It also provides energy for immediate physiological needs during long periods with higher energetic demands. In *O. niloticus* also, excess lipid is deposited mainly as visceral fat during months when there is high food intake (Welcomme, 1967; El-Sayed, 2006; Njiru *et al*., 2006). The species is able to utilize lipid reserve for energy needs especially in the females which fast when they are orally brooding their eggs and young ones (Love, 1957). This is evident in the graph of the female fat index (see Fig. 7) having several peaks in November

2007, January, March, June and August 2008 while that of males have three peaks in September 2007, March and August 2008. The highest value of 2.69 for males observed in March 2008 may be due to increased feeding and the sharp drop in April 2008 could be attributed to the protracted reproductive activities during the major breeding season in March 2008. Males tended to have more visceral fat than females since they divert less energy into reproductive activities (Welcomme, 1967; El-Sayed, 2006; Njiru *et al*., 2006). This is in agreement with the present study (see Fig. 7). There seems to be a linkage between fat accumulation and spawning. This could be seen in the monthly fluctuation in the visceral fat index and GSI of the females with peaks of these graphs coinciding in September 2007, January, March 2008. The fluctuation is probably caused by reproductive activities as the fish accumulate fat and become 'lean' after spawning because the females eat very little or no food when they are mouth-brooding their eggs and young and therefore utilize their fat reserves. The increase in visceral fat after spawning is an indication of intense feeding during these periods.

The observed overall sex ratio of 1:0.84, in favour of males for *O. niloticus* population caught in the Weija reservoir during the period of study was significantly different from the expected 1:1 (see Table 1). This indicates that males were relatively higher in number than females. The present observation is similar to that observed by Njiru *et al*., (2006) for the species in Lake Victoria. However, other researchers made contradictory observations where females were more in the populations studied (Gómez-Márquez *et al*., 2003; Peña-Mendoza *et* *al*., 2005). Fishery workers such as Barioller (1995) attributed the occurrence of unbalanced sex ratios to environmental influences such as temperature. Variation in sex ratio may probably be due to the maternal brooding characteristic of the species. This is because once the fertilization of the eggs was completed, males possibly due to differential sexual migration, leave the spawning areas for the feeding grounds, located in shallow part of the lake, where they are captured, while females go towards submerged vegetation and rocky areas to avoid predators (including fishermen) and to carry out the oral brooding and protection of offspring (Peña-Mendoza *et al*., 2005; Offem *et al*., 2007). Lowe-McConnel (1958) and Rinne and Wanjala (1982) reported movement of spawning *O. niloticus* from foraging to breeding grounds. Differential migration of sexes could occur at this time and also during fishing operations resulting in a higher number of males than females being caught. Balirwa (1998) also observed that different habitats may favour one sex over the other. In the present study, the cause of skewed sex ratio in favour of the males might be mainly due to genetic factors as the species shows differential growth between the sexes. This is supported by the observation of Fryer and Iles (1972) that, in African lakes, it is common for males to dominate because they generally exhibit faster growth than females. This means that they attain the size at which they are caught more quickly, causing selection of males against the smaller females. Males in the present study grow to a relatively larger size as shown by the length at first maturity and length-frequency distribution of female and male *O. niloticus* (L_{50} = 13.49 cm and 16.33 cm for females and males respectively and modal class length

TL= 16.0 – 16.9 cm and 19.0 – 19.9 cm for females and males respectively). The influence of environmental factors to some extent cannot be completely overruled. The observation made in March 2008, the major breeding season, where females dominated in the monthly sample could possibly be due to bias method of fishing employed by the fishermen as they set their nets or made their catches near the breeding grounds in the submerged vegetations and rocky areas targeting the less active females carrying out oral brooding of their fertilized eggs or fry.

Studies on the total number of ripe ova in the ovary (fecundity) of the fish are essential in estimating the reproductive potential of the species in the wild. The fecundity of *Oreochromis niloticus* in the present study ranged between 563 to 1542 ova for fish with total length of 15.6 cm to 21.5 cm and body weight of 108 g to 200 g. This fecundity is low compared to that reported elsewhere. Lowe- McConnel (1955) reported on the fecundity of the species, to range from 340 to 3706 eggs in various East African waters. Lung'ayia (1992) also reported fecundity in the range of 864 to 6316 with an average of 2141 eggs in the species in the Nyanza gulf of Lake Victoria, Kenya (see Appendix 5). Unlike reports made by some researchers that there is a strong correlation between fecundity and total length, and fecundity and body weight (Lowe-McConnel, 1955; Lung'ayia, 1994; and Njiru *et al*., 2006; Kariman and Hanan, 2008), the present study showed weak correlations between fecundity and body weight (r = 0.38), and fecundity and length (r = 0.40). This could be due to the fact that the size range observed in the present study is smaller than those reported by other researchers (see Appendix 5). Njiru *et al*., (2006) observed a decreasing trend in the fecundity of the species in Lake Victoria as a result of overfishing. If the *O. niloticus* population in the Weija reservoir could be allowed to grow to a larger size by reducing the fishing pressure on the species, probably a higher fecundity could be attained.

The length at first maturity (L_{50}) of fish population is a function of their size (Siddiqui *et al.,* 1997; Mahenna, 2007). This may be influenced by environmental factors such as abundance and seasonal availability of food, predation and temperature (especially in the temperate regions), photoperiods and also the locality. According to Siddiqui *et al.* (1997), fish size is influenced by the feeding level which affects their growth. Length at first maturity (L_{50}) is also an important management parameter which can be used to monitor whether enough juveniles in an exploited population mature and spawn (Mahenna, 2007). The estimated L_{50} for female and male *O. niloticus* in this study were 13.49 cm and 16.33 cm respectively. The male growth superiority might be due to genetic factors. According to Fryer and Iles (1972), this gives the males a competitive advantage enabling them to have larger sizes at sexual maturity and higher survival rates. The L_{50} values for the Weija population seemed to be relatively higher than those of Coatetelco Lake in Mexico where the length at maturity was 11.7 cm and 12.0 cm for females and males respectively (Gómez-Márquez *et al*., 2003) and those of the Bontanga reservoir (near Tamale in the Northern region of Ghana) with an L_{50} value of 9.1 cm for both males and females (Kwarfo-Apegyah, 2010). This is because environmental factors such as hydrographic factors and fishing pressure of the species in the Weija reservoir are better compared to those of Coatetelco Lake and the Bontanga reservoir where the species are stressed. Payne and Collinson (1983), however, studied *O. niloticus* population in Lake Manzalah, Egypt and observed L_{50} values of 16.3 cm and 17.4 cm, for females and males respectively. Their L_{50} values are higher than those of the present study. Ofori-Danson (1999) also studied the population of species in the Yeji area (Stratum VII) of the Volta Lake, Ghana and observed an L_{50} value of 19.73 cm SL . Ochumba and Manyala (1992) reported even higher L_{50} values of 31.5 and 27.5 cm for females and males *O. niloticus* population in the Sondumiru River, Kenya. In Lake Kyoga, Balirwa (1998) also reported L_{50} values of 26.0 cm and 23.0 cm for females and males respectively. This agrees with Eknath *et al*., (1993) that wild strains of *O. niloticus* from East Africa and Egypt grew better than those from West Africa (Ghana and Senegal). It appeared the females in Lake Victoria become sexually mature at a relatively larger size than the males contrary to what has been observed in the Weija reservoir, Lake Manzalah, and Lake Coatetelco (see Table 2). No definite reason can be attributed to this observation but probably better environmental conditions and genetic causes might be major contributing factors. The relatively small maturation sizes of *O. niloticus* in Coatetelco Lake and Bontanga reservoir, compared to those in Weija, Manzalah, Lake Kyoga and Sondumiru River may be an indication of a relatively higher level of stunting of the population in Lake Coatetelco and Bontanga resevoir. The phenomenon of ‘stunting’ or ‘dwarfing’ in tilapias is well known and is one of the major problems in tilapia culture (Fryer and Iles, 1969;

Lorenzen, 2000). A smaller size at maturity may represent a strategy to maximize reproduction in a topographically restricted habitat, a response to a high level of competition, unfavourable environmental conditions such as pollution or a response to intensive fishing. This observation agrees with findings made by Lowe-McConnell (1982) in several waters of East Africa. She suggested that *O. niloticus* delays maturation when inhabiting large lakes and breeds when younger and smaller in small water bodies such as crater lakes, lagoons and ponds with stressful conditions.

Table 2: Maturity length of some populations of *O. niloticus*.

Water body	Location	L_{50} of Females (cm)	L_{50} of Males (cm)	Source
Weija Reservoir	Ghana	13.49	16.33	Present study
Volta Lake at Stratum VII (the Yeji sector)	Ghana	19.73		Ofori-Danson (1999)
Bontanga reservoir (near Tamale)	Ghana	9.1		Kwarfo-Apegyah (2010)
Lake Coatetelco	Mexico	11.7	12.0	Gómez-Márquez *et al.* (2003)
Lake Manzalah	Egypt	16.3	17.4	Payne and Collinson (1983)
Lake Kyoga	Uganda	26.0	23.0	Balirwa (1998)
River Sondumiru	Kenya	27.5	31.5	Ochumba and Manyala (1992)

Analysis on fluctuations in percentage mature gonads revealed that peaks of percentage mature testes (see Fig. 11) appeared to be a phase ahead of that of GSI while that of mature ova coincided with GSI. According to El-Sayed (2006), Welcomme (1985) and Trewevas (1983) this observation is a strategy in tilapia of the genera *Oreochromis* to get the males ready for spawning and also increase the fertilization success.

GSI is the percentage ratio of the gonad weight and the body weight. Fish with ripe ovaries have high GSI values. Fluctuation of GSI values gives an indication of the spawning activities of the fish. During major spawning periods, the value is high and low values occur after spawning. Generally, the GSI value for the females is higher than that of the males since the gonads of the females are heavier than that of the males. In the present study, the female *O. niloticus* population exhibited peaks in September 2007, and January, May and July 2008, an indication of breeding throughout the year. The major reproductive activities of the males also occurred in March – April, 2008 coinciding with that of the females.

From the data on the hydrographic factors of the water obtained from GWCL/AVRL at Weija, it appeared the major spawning period of the *O. niloticus* population, based on analysis of GSI and occurrence in ripe gonads, coincided with months with reducing water temperature (below 24°C), increasing concentrations of total alkalinity and dissolved oxygen, which probably correspond to the major rainy period (see Figs. 12 & 14). This finding is in agreement with the fact that most cichlids in the wild respond to changes in these hydrographic factors which serve as indicators that trigger their reproductive activities (Welcomme, 1985; El-Sayed, 2006). The *O. niloticus* population in the Weija reservoir from this study, appear to synchronise their major breeding season with periods of favourable environmental condition for rearing their young ones.

The frequency distribution of ovum diameter of fish species can be used to predict the spawning frequency of the fish. In multiple-spawning species of fish, female ovaries contain oocytes of different developmental stages. Oocyte distribution of fish with short and definite spawning periods exhibits distinct modes of ovum sizes whiles those of intermittent spawners do not show any distinct modes (Hickling and Rutengberg, 1936). In the present study, the distribution shows two peaks which are not completely separated from each other (Fig.14) indicating that *O. niloticus* in the Weija reservoir might exhibit protracted spawning, probably shedding the eggs in batches. *O niloticus* can spawn several times a year if suitable ambient environmental conditions are attained (Welcomme, 1985; El-Sayed, 2006). Blay (1981), reported restricted spawning activities in a related tilapia species, *Sarotherodon galilaeus* in a small concrete pond. The ability to spawn more than once in a season may be a strategy to reduce the risk of wiping out a reproductive run. The range of ova diameters of 1.2 mm to 3.1 mm also falls within that reported by Welcomme (1967). Residual eggs that progress into atresia have been reported in post spawned ovaries of the species (Babiker and Ibrahim, 1979; El-Sayed, 2006). Immediately after spawning, the tilapia ovaries regenerate very rapidly and are recruited in as little as one week (Coward and Bromage, 2000).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The study has brought to the fore, knowledge of aspects of the biology of *Oreochromis niloticus* in the Weija reservoir and the following conclusions and recommendations were made:

Conclusions

The length-weight relationship for *O. niloticus* in the Weija reservoir is described by the relation $BW = 0.0317\ SL^{3.0932}$ which shows that the Nile tilapia population in the Weija reservoir are growing isometrically (r = 3.09).

Observations on condition factor show that the males are generally plumpier than the females. The fish attain their best condition in February and October which are months with reduced reproductive activities.

The result from the Chi-square test revealed that males of Nile tilapia population in the Weija reservoir significantly outnumber the females with sex ratio of 1: 0.84 ($P < 0.05$)

Results on GSI and gonadal stages show that the species spawn throughout the year with the major breeding period occurring in March. In addition, the frequency distribution of ovum diameter shows that the females of *O. niloticus* exhibit protracted spawning shedding the eggs in batches. There is also a link between spawning and fat accumulation in the females. The fish build up fat reserves prior to spawning and become lean after spawning. Males have more visceral fat than female since they divert less energy into reproductive activities. The major breeding period of the fish also coincided with water temperature slightly below 24 ºC, increased dissolved oxygen and total alkalinity concentrations of the reservoir.

The fish attain maturity beyond 10.00 cm TL. Fish of total length greater than 18.00 cm is expected to be fully matured. Males mature at a larger size (L_{50} = 16.33 cm) than the females (L_{50} = 13.49 cm).

The fecundity of *O. niloticus* in the Weija reservoir ranged between 563 to 1542 eggs corresponding to fish total length of 15.6 - 21.5 cm and weight 108 - 200 g. There is a weak correlation between both fecundity and body weight (r = 0.38) and fecundity and total length (r = 0.40).

Recommendations

The fishery of the Nile tilapia population in the Weija reservoir has enhanced the success of the small scale local commercial fisheries. However, in order to adequately evaluate the *O. niloticus* stock and provide the quantitative basis for its management, periodic studies on the hydrographic components of the reservoir are important. Also, periodic studies of the relative abundance of the plankton, the fish fauna in the reservoir as well as, changes in fishing pattern, gears and effort of the fishermen are recommended.

Furthermore, extensive comparative studies on the production and aspects of the biology of the fish studied in other lakes in the country must be carried out to support any observation made in the present study and those to be carried out in the near future.

Further studies on food and feeding habit, gonadal structure and development of the Nile tilapia population in the Weija reservoir are also recommended.

Last but not least, pilot culture trials and continuous monitoring of the fisheries of the Weija reservoir are also necessary to formulate policies which will help prevent pollution as well as over-exploitation of the fish community in the reservoir.

REFERENCES

Abban, E.K., Ofori-Danson, P.K. and Biney, C.A. 1995. Fisheries potential of village dams in northern Ghana. NAGA-ICLARM Quarterly **17**: 14-15.

Allen, K.R. 1978. Some observation on the biology of the trout (*Salmo trutta*) in Windermare. *J. Anim, Ecol*. **7**: 333-349.

Asante, K.A., Quarcoopome, T. and Amevenku, F.Y.K. 2006. Water quality of the Weija reservoir after 28 years of impoundment. *West African Journal of Applied Ecology* **13:** 1-8.

Babiker, M.M. and Ibrahim, H. 1979. Studies on the biology of reproduction in the cichlid *Tilapia nilotica* (L): gonadal maturation and fecundity. *J. Fish Biol*., **14**: 437-448.

Bagenal, T.B. and Braum E. 1978. Eggs and early life history. **In**: Methods of assessment of fish production in fresh water (ed. T.B. Bagenal) Blackwell Scientific Publications. Oxford, London, Edinburgh, Melbourne. 365 pp.

Bagenal, T.B. and Tesch, F.W. 1978. Age and growth. **In**: Methods for Assessment of Fish Production in Freshwaters (Ed. T.B. Bagenal) 3rd ed. IBP Handbook, Blackwell, Oxford, 93-130 pp.

Balarin, J.D. and J.P. Hatton. 1979. Tilapia - a guide to their biology and culture in Africa. University of Stirling, Scotland, 171 pp.

Balirwa, J. S. 1998. Lake Victoria wetlands and the ecology of the Nile tilapia, *Oreochromis niloticus* (L) PhD thesis, University of Wageningen, A.A. Balkema, Rotterdam, 246 pp.

Bardach, J.E., Ryther, J.H. and McLarney, W.O. 1972. Aquaculture: The farming and husbandry of freshwater and marine organisms. Wiley-Interscience, New York, USA, 868 pp.

Barioller, J.F., Chourrout, D., Fostier, A. and Jalabert, B. 1995. Temperature and sex chromosomes govern sex ratios of the mouth brooding cichlid fish Oreochromis niloticus. *Journal of Experimental Zoology*, **271** : 1-8.

Barnes, F. 2007. Observations on some environmental factors and growth characteristics of the Nile tilapia (*Oreochromis niloticus* L.) in fish ponds in Sunyani district, Ghana. M.Phil thesis, University of Cape Coast, Ghana. 111 pp.

Beamish, F.W.H. 1970. Influence of temperature and salinity acclimation on temperature preferenda of the euryhaline fish *T. nilotica*. *Journal of the Fisheries Research Board of Canada* **27** (7):1209-1214.

Behrends, L.L. 1983. Evaluation of hatchery techniques for intraspecific and interspecific seed production in four species of tilapia. Doctorial dissertation, auburn University, Alabama, USA, 257 p.

Bentsen, H.B., Eknath, A.E., Palada-de Vera, M.S., Danting, J.C., Bolivar, H.L., Reyes, R.A., Dionisio, E.E., Longalong, F.M., Circa, A.V., Taymen, M.M., and Gjerde, B. 1998. Genetic improvement of farmed tilapias: growth performances in a complete diallel cross experiment with eight strains of *Oreochromis niloticus. Aquaculture* **160**: 145-173.

Beveridge, M.C.M. and McAndrew, B. J. 2000. Tilapia: Biology and exploitation. Kluwer Academic Publishers, Great Britain, 482 pp.

Blay, J. Jnr. 1981. Fecundity and spawning frequency of *Sarotherodon galilaeus* in a concrete pond. *Aquaculture*, **25**: 95 – 99.

Blay, J. Jnr. and Asabere-Ameyaw, A. 1993. Assessment of the fishery of a stunted population of the cichlid, *Sarotherodon melanotheron* (Ruppel), in a closed lagoon in Ghana. *J. Appl. Ichthyol.* **9** : 1-11.

Bwanika, G.N., Makanga, B., Kizito, Y., Chapman, L.J. and Balirwa, J. 2004. Observation on the biology of Nile tilapia, *Oreochromis niloticus* L. In two Ugandan crater lakes. *Afr. J. Ecol*., **42** (1): 93-101.

Charkroff, M. 1976. *Fresh water fish pond culture and management.* Manual Number 36 E. Volunteers in Technical Assistance (VITA) Publication Series, 78 pp.

Coward K. And Bromage N.R. 2000. Reproductive physiology of female tilapia broodstock. Springer, Netherlands. *Reviews in fish Biology and Fisheries.* **10**: 1-25.

Dankwa, H., Abban, R. and Teugels G.G. 1999. Freshwater fishes of Ghana: identification, distribution, ecological and economic importance. *Ann. Sci. Zool*. 283: 53. **In:** Abban, E.K., C.M.V. Casal, P. Dugan and T.M. Falk (eds.) 2004. Biodiversity, Management and Utilization of West African Fishes. WordFish Centre Conference Proceedings, Penang Malasia, 63 pp.

Dadzie, S., Abou-Seedo, F. and Manyala, J.O. 2000. Length weight relationship and condition factor of Pampus argentus (Euphrasen 1788) in Kuwait waters. *Kuwait J. Sci. Engin*. **26**: 123–136.

Dalzell, P. 1987. Notes on the biology of *Spratelloides leuvisi* (Wongratana, 1983) a recently described species of sprat from Pupa New Guinea waters. *J. Fish Biol***. 30**: 691-700 pp.

Duponchelle, F. and J. Panfili, 1998. Variation in age and size at maturity of female Nile tilapia, *Oreochromis niloticus*, populations from man-made lakes of Cote D'Ivoire. *Environmental Biology of Fishes* **52**:453-165.

Eknath, A.E., Tayamen, M.M., Palada-de Vera M.S., Danting, J.C., Reyes, R.A., Dionisio, E.E., Capili, J.B., Bolivar, T.A., Abella, A.V. Circa, H.B. Bentsen, B. Gjerde, T. Gjedrem, and R.S.V. Pullin. 1993. Genetic improvement of farmed tilapias: the growth performance of eight strains of *Oreochromis niloticus* tested in different farm environments. *Aquaculture* **111**: 171-188.

El-Sayed, A.M. and Teshima, S.I.1991. Tilapia nutrition in aquaculture. *Reviews in aquatic science.* **5**: 247-265.

El-Sayed, A.M. 2006. Tilapia Culture. CABI Pub. Series Oxfordshire, UK. 277 pp.

FAO,1997. Aquaculture Development. FAO Technical Guidelines for Responsible Fisheries No. 5. FAO, Rome pp. 40.

FAO, 2000. Fishery statistics. FAO, Rome, 215 pp.

FAO, 2004. Selected issues facing fishers and aquaculturists. **In**: SOFIA. The state of world fisheries and aquaculture. (ed. By Ottolenghi, C. Silvestri and P. Giodano) FAO, Rome 65 pp.

FAO, 2005. Report of the FAO-Worldfish Centre on small-scale agriculture. Revisiting the aquaculture target group paradigm. Limbé, Cameroon. 36 pp.

FAO, 2006. National aquaculture sector overview Ghana. **In:** Fisheries Global Information System (FIGIS); FAO, Rome.

FAO, 2007. The state of the world fisheries and aquaculture. FAO Fisheries and Aquaculture Department. Rome, 2007.

FAO, 2008. The state of the world fisheries and aquaculture. FAO Fisheries and Aquaculture Department. Rome, 2008. 196 pp.

Fitzsimmons, K. 2000. Tilapia: the most important aquaculture species of the 21st century. **In**: Tilapia Aquaculture in the 21st Century (K. Fitzsimmons and J.C. Fillho, eds.) Proceedings of the fifth international symposium on tilapia in aquaculture, **1:** 320 pp.

Frimpong, M.O. Attipoe, F.Y.K. and Paddy, J.N.1992. Development of improved culture systems for increased pond production. *Pond Culture* (Ghana). IAB/IDRC-3, 61-88 pp.

Froese, R. And Pauly, D. 2005. FishBase. World Wide Web electronic publication. www.fishbase.org (Accessed on 23/11/ 2007).

Fryer, G. and Iles, T.D. 1969. Alternative routes to evolutionary success as exhibited by African cichlid fishes of the Genus Tilapia and the species flocks of the Great Lakes. *Evolution* **23:** 359–369.

Fryer, G. and Iles, T.D. 1972. The cichlid fishes of the Great Lakes of Africa: Their biology and evolution Oliver and Boyd, Edinburgh, Scotland, 641 pp.

Garibaldi, L. 1996. List of animal species used in aquaculture. FAO Fisheries Circular. **In**: Abban, E.K., Casal C.M.V., Dugan P. and Falk T.M. (eds.) 2004. Biodiversity, Management and Utilization of West African Fishes. WordFish Centre Conference Proceedings, Penang Malasia, 63 pp.

Garcia-Arteaga, J.P., Claro, R. and Valles, S. 1997. Length-weight relationship of Cuban marine fishes. NAGA-ICLARM **20:**38-43

Gordon, C. 2006. Background paper for the multi-stakeholder consultation process for dams' development in Ghana. Volta Basin Research Project. University of Ghana. 53 pp.

Gómez-Márquez, J.L., Peña-Mendoza B., Salgado-Ugarte I.H. and Guzmán-Arroyo, M. 2003. Reproductive aspects of *Oreochromis niloticus* (perciformes: Cichlidae) at Coatetelco lake, Morelos, Mexico. *Revista de Biologia Tropical*, **51**: 221-228.

Gwahaba, J.J. 1978. The biology of cichlid fishes (Teleostei) in an equatorial lake (Lake George, Uganda). *Archiv für Hydrobiologie* **83**:538-551.

Hanley, F. 1991. Effects of feeding supplementary diets containing varying levels of lipid on growth, food conversion, and body composition of Nile tilapia *Oreochromis niloticus* (L.). *Aquaculture* **93**: 323-334.

Hickling, C.F. and Rutenberg, E. 1936. The ovary as an indicator of spawning period in fishes. *J. Mar. Biol. Assoc*. U.K. **21**: 311-317.

Houlihan, D., Boujard, T. and Jobling, M. 2001. Food intake in fish. Blackwell. Science, Oxford, UK. 130-143 pp.

Htun-Han, M. 1978. The Reproductive Biology of Dab *Limanda Limanda* (L.) in the North Sea: gonadosomatic index, hepatosomatic index and condition factor. *J. Fish Biol*. **13**:369-378

Hussain, M.G. 2004. Farming of tilapia: Breeding plans, mass seed production and aquaculturetechniques. Habiba Akter Hussain, 55 Kirstawpur, Mymensingh 2200, Bangladesh, 97 pp.

Kariman A.S.S. and Hanan M.M.S. 2008. Investigations on Some Aspects of Reproductive Biology in *Oreochromis niloticus* (Linnaeus, 1757) Inhabited Abu-zabal Lake, Egypt. *Global Veterinaria* **2** (6): 351-359.

Kirk, R.G. 1972. A review of the recent developments in tilapia culture with special reference to fish farming in the heated effluents of power stations. *Aquaculture* **1**:45-60.

Kraljevic, M. Dulcuic, J. Cetinic, P. and Pallaoro, A. 1996. Age, growth and mortality of the striped sea bream, *Lithognathus mormyrus* L., in the northern Adriatic. *Fisheries Research*, **28**: 361-370.

King, R.P. 1996. Length-weight relationship of Nigerian Coastal water fishes. NAGA-ICLARM **19**: 53-58.

Kwarfo-Apegyah, K. 2010. Stock assessment of major fish species in Bontanga reservoir, Northern Ghana, for sustainable management. Ph.d thesis, University of Ghana, Legon.

Kwei, E. A. 1966. The fat cycle in the sardine (*Sardinella aurita* C & V) in Ghana waters. *Proceedings of the symposium on the oceanography and fisheries resources of tropical Atlantic*. UNESCO/FAO/OAU.

Kwei, E.A. 1970. The migration and biology of the Spanish mackerel, *Scomber japonicas* (Houttyn). *Ghana J. of Sci.* **11** (2):75-86.

Laroche, J. L., Richardson, S.L. and Rosenberg, A.A. 1982. Age and growth of pleuronectid *Parophyrs vetulus*, during the pelagaic larval period in Oregon coastal waters. *Fish bull*. U.S **80**: 93-104.

Latif, A.F.A. and. Rashid M.M. 1972. Studies on *Tilapia nilotica* from Lake Nasser. I. Macroscopic characters of gonads. Bulletin of the Institute of Oceanography and Fisheries, Cairo **2**: 215-238.

Le Cren, E.D. 1951. The length weight relationship and season cycle in gonad weight and condition in Perch (*Perca fluviatilis*). *J. Anim. Ecol.* **20**: 179–219.

Lorenzen, K. 2000. Population dynamics and management. **In**: Tilapias: Biology and Exploitation (Eds M. C. M. Beveridge and B. J. Mcandrew). Kluwer Academic Publishers, Dordrecht, the Netherlands. 137 pp.

Love, R. 1957. The biochemical composition of fish. **In** : The physiology of fishes. Academic Press Inc. New York. **1**: 401-418.

Lovshin, L.L. 1997. Worldwide tilapia culture. **In**: *Anais do I Workshop International de Aquicultura*, Sao Paulo, Brazil, 96-116 pp.

Lowe-McConnell, R. H. 1982. Tilapias in fish communities. *Proceedings of the international conference on the biology and culture of tilapias* **1**: 83-113 pp.

Lowe-McCornnell, R.H. 1958. Observations on the biology of *Tilapia nilotica* L in East African water. *Revue* de la *Zoologie et* de *Botanique Africaines.* **57**: 129-170.

Lowe-McCornnell, R.H. 1955. The fecundity of tilapia species. *East African Agricultural journal.* **11**: 45-52

Lung'aiya, H.B.O. 1994. Some aspects of the reproductive biology of the Nile tilapia, *Oreochromis niloticus* (L.) in the Nyanza Gulf of Lake Victoria, Kenya. **In**: Recent trends of research on Lake Victoria Fisheries (Eds. E. Okemwa, E. Wakwabi and A. Getabu). ICIPE Science Press, Kenya.

Lung'ayia, H.B.O. 1992. Some aspects of the reproductive biology of the Nile tilapia *Oreochromis niioticas* (L) in the Nyanza Gulf of Lake Victoria, Kenya. Kenya Marine and Fisheries Research Institute (KMFRI), Kisumu, 121-127 pp.

Machena, C. and Moehl, J. 2001. Sub-Saharan African aquaculture: a regional summary. **In**: Subasinghe R.P., Bueno P., Philips M.J., Hough C., MacGladdery S.E., and Arthur, J.R. (eds). Aquaculture in the third millennium. technical proceedings of the conference on aquaculture in the third millennium, NACA Bangkok and FAO, Rome, pp. 341-355.

Mehanna, S.F. 2007. Stock assessment and management of the Egyptian sole *Solea aegyptiaca* Chabanaud, 1927 (Osteichthyes: Soleidae), in the Southeastern Mediterranean, Egypt. *Turkish J. Zool*., **31**: 379-388.

Magid, A. and Babiker, M.M. 1975. Oxygen consumption and respiratory behavior of three Nile fishes. *Hydrobiologia* **46**: 359-367.

Moriaty, D.J.M. 1973. The physiology of digestion of blue-green algae in the cichlid fish, *Tilapia nilotica*. *J. Zool*. **171**: 25-39.

Moriarty, C.M. and Moriarty, D.J.W. 1973. Quantitative estimation of the daily ingestion of phytoplankton by Tilapia nilotica and *Haplochromis nigrispinnis* in Lake George, Uganda. *J. Zool.* **171**: 15–23.

NAFAG, 2007. National Fisheries Association of Ghana. World Wide Web electronic publication. http://www.nafagfish.org (Accessed on 20/ 11/2010).

Njiru, M., Ojuok, J.E., Okeyo-Owuor, J.B., Muchiri, M., Ntiba, M. J. and Cowx, I. G. 2006. Some biological aspects and life history strategies of Nile tilapia *Oreochromis niloticus* (L.) in Lake Victoria, Kenya *Afr. J. Ecol*., **44**: 30–37.

Ochumba, P.B.O. and Manyala, J.P. 1992. Distribution of fishes along the Sondumiru River of Lake Victoria, Kenya with special reference to upstream migration biology and yield. *Aquacult. Fish Manage*. **23**: 701–719.

Offem, B.O., Akegbejo-Samsons, Y. and Omoniyi, I.T. 2007. Biological assessment of *Oreochromis niloticus* (Pisces: Cichlidae; Linne, 1958) in a tropical floodplain river. *African J. Biotechnol*., **6**: 1966-1971.

Ofori-Danson, P.K.1999. Stock assessment of the five major commercial fish species in the Yeji area (Stratum VII) of the Volta Lake. Phd thesis, University of Ghana, Legon)

Ofori-Danson, P.K. 2000. Status of fish stocks in the Yeji segment of Lake Volta, P. 34-35. **In** E.K. Abban, C.M.V. Casal, T.M. Falk and R.S.V. Pullin(eds.) Biodiversity and sustainable use of fish in the coastal zone. WorldFish Conf. Proc. **63.** 71 pp.

Olurin, K.B. and Aderibigbe, O.A. 2006. Length-weight relationship and condition factor of pond reared juvenile *Oreochromis niloticus. World Journal of Zoology* **1** (2): 82-85.

Pagan, F. A. 1970. Cage culture of the cichlid fish *Tilapia aurea* (Steindachner). Doctoral dissertation, Auburn University, Alabama, USA.

Pauly, D. 1976. The biology, fishery and potential for aquaculture of *Tilapia melanotheron* in a small West African lagoon. *Aquaculture* **7**: 33-49.

Pauly, D. 1993. Some simple methods for the assessment of tropical fish stocks. FAO Fish Tech. Pap. No. 234. Rome, FAO. 54 pp.

Payne, A.I. and Collinson, R.I. 1983. A comparison of the biological characteristics of *Sarotherodon niloticus* (L) with those of *S. aureus*

(Steindachner) and other *Tilapia* of the Delta and lower Nile. *Aquaculture*, **30**: 335-351.

Peña-Mendoza, B., Gómez-Márquez, J.L. Salgado-Ugarte, I.H. and Ramirez-Noguera,D. 2005. Reproductive biology of *Oreochromis niloticus* (Perciformes : Cichlidae) at Emiliano Zapata dam, Morelos,Mexico. *Intl. J. Revista de Biologia Tropical* **53**: 515-522.

Philippart, J. C. and Ruwet, H. 1982. Ecology and distribution of tilipias, **In**: R.S.V. Pullin and R.H. Lowe-McConnell (eds.). The biology and culture of tilapias. ICLARM Conference Proceedings 7, International Center for Living Aquatic Resources Management, Manila, Philippines 432 p.

Pullin, R.S.V., Eknath, A.E., Gjedrum T, Tayamen, M.M., Macaranas, J.M. and Abella, T.A. 1991. The Genetic Improvement of Farmed Tilapias (GIFT) project. The story so far. *NAGA. ICLARM Quarterly*, **14** (2):7-9.

Pullin, R.S.V. 1985. Tilapias: Everyman's fish. *Biologist* **32** (2): 84-92.

Rana, K. 1988. Reproductive biology and the hatchery rearing of tilapia eggs and fry. ***In**: Muir, J.F.*, and Roberts, R.J. (Editors). *Recent Advances in Aquaculture* **3**, Timber Press, Portland, 343-406 pp.

Rinne, J.N. and Wanjala, B. 1982. Observations on movement patterns of Tilapia spp. in Nyanza Gulf, Lake Victoria, East Africa. *J. Fish Biol*. **20**: 317–322.

Reynold, T.D. 1968. The biology of the clupeids in the New Volta**. In**: Man-made Lakes. The Accra Symposium. Ghana University Press, Accra 251 p.

Siddiqui, A.Q. Al-Harbi, A.H. and Al-Hafedh, Y.S. 1997. Effects of food supply on size at first maturity, fecundity and growth of hybrid tilapia, *Oreochromis niloticus* (L) × *Oreochromis aureus* (Steindachner), in outdoor concrete tanks in Saudia Arabia. *Aquatic Res*., **28**: 341-349.

Siddiqui, A.D. 1977. Reproductive biology, length-weight relationship and relative condition of *Tilapia leucostica* (Trewavas) in Lake Navaishe Kenya. *J. fish Biol.* **10:** 251-260.

Silva, S.S. 1985. Body condition and nutritional ecology of *Oreochromis mossambicus* (Pisces, Cichlidae) populations of man-made lakes in Sri-Lanka. *J. Fish Biol*., **27**: 621-633.

Stickney, R.R. 2005. Aquaculture: an introductory text. CABI publishing, Oxfordshire, UK, 265 pp.

Stickney, R.R. 1986. Tilapia tolerance of saline waters: a review, *The Progressive Fish Culturist* **48**:161-167.

Stone, N.M. 1980. Growth of male and female *Tilapia nilotica* in ponds and cages. Masters thesis. Auburn University, Alabama, USA 140 p.

Suresh, A.V. and Lin, C.K. 1992. Tilapia culture in saline waters: a review. *Aquaculture* **106**: 201-226.

Tacon, A.G.J. 2001. Increasing the contribution of aquaculture for food security and poverty alleviation. **In**: Aquaculture in the Third Millennium (eds. R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough & S.E. McGladdery). Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 67–77 pp.

Tave, D. 1980. Genetic and breeding of tilapia: a review. **In**: The second international symposium on tilapia in aquaculture. (R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean, eds.) ICLARM conference proceedings 15. Department of Fisheries, Bangkok, thailand, and International Centre for Living Aquatic Resources Management. Manila, Philippines, 623 pp.

Tesch, F.W. 1971. Age and growth. **In**: Methods of assessment of fish production in fresh water (ed. W.E. Ricker) 2nd edn. Blackwell, Oxford, 98-130 pp.

TRADEZONE, 2007. Tradezone International (Gh) Limited. Ghana National Chamber of Commerce. World Wide Web electronic publication. http://www.tradezoneint.com/agric.htm (Accessed on 12/ 10/2008).

Trewevas, E. 1983. Tilapiine Fishes of the Genera *Sarotherodon, Oreochromis* and *Danakilia*. British Museum of Natural History, Publ. Num. 878. Comstock Publishing Associates. Ithaca, New York. 583 pp.

Tudorancea, C., Fernando, C.H. and Paggi, J.C. 1988. Food and feeding ecology of *Oreochromis niloticus* (L.) Juveniles in Lake Awassa (Ethiopia). *Arch. Hydrobiol*., **79**: 267-289.

Vanden-Bossche, J.P. and Bernacsek, G.M. 1990. *Source book for the inland fishery resources of Africa,* Vol **1**. CIFA Technical Paper No. 18/1. 240 pp.

Watanabe, W.O., Wicklund, R.I. and Olla, B.L. 1992. Saltwater culture of Florida Red Tilapia: a summary of research at the Caribbean Research

Centre. **In**: *Aquaculture-Technology and Investment Opportunities*. Proceedings of the First International Symposium on Aquaculture Technology and Investment Opportunities, 1993 (ed. By S.A. Al-thobaiti, H.M. Al-Hinty, A.Q. Siddiqui and G. Hussain). Ministry of Agriculture and Water, King Abdulaziz City for Science and Technology and the Riyadh Chambers of commerce and Industry, Riyadh, Saudi Arabia, 49-68 pp.

Webster, C.D. and Lim, C.E. 2002. Nutrient requirements and feeding of finfish for aquaculture. CABI Publishing Series, Wallingford, UK. 418 pp.

Welcomme, R.L. 1985. River fisheries. *FAO Tech. Pap*., **262**: 330 pp. **In** Wootton R.J., 1992. Fish Ecology-(Tertiary Level Biology) Chapman and Hall, New York, USA. 61 pp.

Welcomme, R.L. 1967. Observations on the biology of introduced species of Tilapia in Lake Victoria. *Rev. Zool. Bot. Afr*. **76**: 249–279.

Witte, F. and Van Densen, W.L.T. 1995. Fish Stocks and Fisheries of Lake Victoria. A Handbook for Field Observations. Cardigan, Britain, Samara Publishing, Cardigan U.K.

Yashouv, A. 1958. Biological data on *Tilapia galilaea* and *Tilapia nilotica* in fish ponds. *Bamidgeh* **10**:46-52.

APPENDICES

Appendix 1

Raw data obtained from monthly sample.

Period: September, 2007

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G stage	Fec.	Fat Index
1	22	18	204.18	1	6.5	2		2
2	17	14	109	1	1.334	2		1
3	23	18.3	265	2	0.55	2		3
4	23.3	18.5	268	2	0.63	2		2
5	16.3	13.4	115	1	0.44	2		2
6	20.2	16.8	198	1	4.47	1		2
7	21.8	18	194	1	6.02	3	1124	1
8	17.8	14.4	120	2	0.15	2		1
9	23.2	18.8	270	2	0.72	2		1
10	18.3	14.8	123	1	4.69	2		1
11	19.6	16	165	1	7.52	2		1
12	20.9	16.6	210	2	0.38	1		1
13	23	18.2	224	2	1.17	2		3
14	22.6	18	215.95	2	1.07	1		2
15	21.7	17.6	228	2	0.29	2		2
16	18	14.6	126	2	1.15	2		2
17	18	14.6	126	1	1.66	3	764	1
18	18.5	15	135	2	0.36	2		1
19	18.5	14.9	136	1	4.55	3	839	1

20	17.9	14.4	122	2	0.13	2		1
21	17.5	14	120	1	1.25	3		1
22	19.6	15.7	170	1	2.08	1		2
23	19	15.4	160	1	8.29	3		2
24	18.8	14.8	159	2	0.45	2		1
25	19.6	15.8	160	2	0.28	2		2
26	17.5	14.2	110	1	4.76	3	799	1
27	18.4	14.8	120	1	3.37	3	846	2
28	23.4	18.9	226	2	1.09	2		1
29	21.1	17	210	2	0.76	2		2
30	17.3	14.4	126	2	0.17	2		1
31	22.1	17.6	225	2	0.81	2		3
32	21.8	16.8	212	2	0.68	2		2
33	17.8	14	118	2	0.07	2		1
34	18.9	15.1	154	2	0.26	2		3
35	20.7	16.8	170	2	0.28	2		2
36	19.1	15.3	154	2	0.44	2		1
37	17.7	14.1	98	1	2.57	2		1
38	17.2	14	112	1	0.4	3	798	1
39	18.2	14.7	120	2	0.13	2		1
40	20.1	16.2	174	1	2.46	2		1
41	19.8	16	172	1	5.4	2		1
42	20.2	16.2	167	2	0.46	2		3
43	17.7	14.2	118	2	0.2	1		1

Period: October, 2007

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G Stage	Fec.	Fat Index
1	19.7	15.7	160	2	0.15	2		1
2	16	12.9	100	1	0.27	2		3
3	26.2	20.6	400	2	1.48	2		2
4	23.1	18.2	210	2	1.36	2		1
5	21.6	17.5	220	2	0.76	2		2
6	18.7	14.4	158	2	0.27	1		2
7	20.5	16.6	177	1	2.32	2		2
8	19.7	15.8	170	2	0.27	2		2
9	18.3	14.6	140	2	0.24	2		1
10	18.5	14.6	135	1	2.67	2		2
11	18.3	14.8	138	1	3.83	2		1
12	15.5	12.3	90	2	0.06	2		1
13	17.1	13.8	100	1	3.5	3	696	1
14	14.7	11.8	90	1	0.15	1		1
15	25.8	20.7	320	2	0.93	2		1
16	18.9	15	130	1	1.53	2		1
17	23.7	18.9	250	2	1.61	2		3
18	21.5	17.2	220	2	0.24	2		1
19	21.7	17.5	218	2	0.5	2		2
20	21.5	17.4	200	1	7.74	3	1542	3
21	18.3	14.7	140	1	3.73	2		2
22	16.5	13	94	2	0.09	1		1
23	17.8	14.3	198	1	1.27	2		1
24	27	21.5	394	2	2	2		2

25	23.2	18.6	240	2	1.27	2		2
26	24	19.2	148	2	1.57	2		1
27	19.5	16	180	1	7.96	3	913	3
28	18.8	15.2	130	2	0.24	2		2
29	27.8	21.7	438	2	1.48	2		1
30	21.1	17.4	190	2	0.47	2		3
31	23.3	18.6	282	2	0.33	2		2
32	20.4	16.5	185	1	2.47	2		1
33	18.4	14.7	120	2	1.41	2		2
34	17	13.5	110	2	3.03	2		2
35	16.5	15	140	1	1.65	2		3
36	19.5	15.8	157	1	3.67	2		1
37	16.6	13.6	115	1	2.48	2		2
38	17.4	14	118	1	4.16	3	954	1
39	17.1	13.7	118	2	0.13	2		1
40	14.2	12	178	2	0.14	2		1
41	20	16	158	1	2.28	2		1
42	16.8	13.5	117	1	8.65	3	930	2
43	15.1	12.2	82	2	0.09	1		2
44	15.7	12.7	84	2	0.1	1		1
45	18.2	14.9	138	2	0.39	2		2
46	17.6	14.5	134	1	5.05	2		1
47	17.7	14.2	120	1	1.39	2		1
48	18.7	15.2	140	1	4.9	3	924	2
49	18.8	15.4	130	1	4.25	3	1032	1
50	18.5	15	125	1	1.82	2		1
51	16.3	13.5	100	1	2.51	2		2
52	18.2	14.7	140	1	2.58	2		2

Period: November, 2007

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G Stage	Fec.	Fat Index
1	10	8	18.67	2	0.02	1		1
2	22	17.5	237.57	2	0.4	2		3
3	13	10.4	48.36	1	1.32	2		3
4	11.1	8.7	29.55	2	0.03	1		2
5	13.5	10.7	53.23	2	0.06	1		1
6	12.8	10.2	44.18	1	0.12	1		1
7	24.7	19.7	304.63	1	5.17	2		2
8	22.1	17.5	249.32	1	0.28	2		2
9	22.5	17.5	276.7	1	0.44	2		3
10	12	9.8	35.62	2	0.16	1		1
11	12.5	9.9	40.3	2	0.35	1		2
12	12.7	10	41.8	2	0.24	1		1
13	15.5	12.5	86.41	1	2.49	2		2
14	13	10.4	42.83	2	0.06	1		3
15	16.5	13.4	101.44	1	4.2	3	785	3
16	17.5	14	135.6	1	2.99	3	838	2
17	20	16.4	181.86	1	0.37	2		1
18	16.5	13.5	95.66	1	9.9	3	920	2
19	17	13.5	106.02	1	5.42	3	734	3

20	14	11.5	64.48	1	1.89	2		1
21	20.3	16.2	172.15	1	0.43	2		2
22	19	15.3	132.07	1	0.59	2		1
23	15.8	12.5	96.87	1	1.15	2		1
24	13.5	10.8	49.51	2	0.17	1		1
25	14.5	11.8	67.93	1	0.93	2		1
26	20.4	16.7	166.37	1	5.68	3	872	2
27	19.2	14.8	137.42	1	3.69	3	926	3
28	15.3	12.2	74.57	2	0.17	2		2
29	15.2	12.1	77.08	1	2.25	2		1
30	13.9	11	56.85	1	0.65	1		1
31	7	5.1	7.85	1	0.02	1		1
32	13.2	10.4	47.34	1	0.55	2		1
33	12.1	9.8	39.18	1	0.23	1		1
34	12.5	10	41.31	2	0.11	1		1
35	12.7	10	44.31	1	0.04	1		1
36	13	10.5	44.06	1	1.41	1		1
37	13	10.7	42.83	2	0.04	1		1
38	11.1	9	29.97	2	0.06	1		1
39	12.5	10.2	42.94	1	0.05	1		1
40	14	11.2	57.27	1	1.35	2		2
41	12.6	10.3	43.2	2	0.09	1		3
42	8.6	7	13.08	2		1		1

43	11.5	9.5	34.62	2		1	1
44	11.5	9.8	29.89	2		1	1
45	12.1	9.7	33.77	2		1	1
46	12.7	10.3	44.45	1	0.36	1	2
47	12.5	10.4	39.03	2		1	3
48	13	10.9	43.56	2		1	2
49	11.4	9.5	28.82	2	0.07	1	3
50	11.1	9.2	27.8	2		1	1
51	12	9.7	36.48	2		1	1
52	12.4	10	37.18	2	0.06	1	2
53	14.2	11.3	66.5	1	0.7	1	1
54	13	10.8	45	2	0.98	1	1
55	12.8	10	38.3	2		1	2
56	13.3	11	53.1	2		1	2
57	14	11.5	52.3	2		1	1
58	17.3	13.9	136	1	2.7	2	3
59	14.1	11.7	53	2		1	2
60	14.7	11.9	53.5	2	0	1	2

Period: December, 2007

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G Stage	Fec.	Fat Index
1	17.5	14	118.15	2	0.07	1		1
2	12.7	10.3	42.86	1	0.1	1		1
3	15.3	12.2	72.15	1	1.73	2	915	1
4	15.4	12.2	65.4	1	1.15	2		1
5	15.9	12.7	77.65	1	2.76	2		2
6	12.6	9.8	35.07	1	0.07	2		1
7	14.1	11.2	61.36	2	0.06	1		1
8	16.5	13.2	99.14	2	0.14	1		1
9	16.1	12.5	87.77	2	0.06	1		1
10	15.5	12.4	77.7	1	0.38	2		1
11	16	12.2	72.05	1	2.19	1		2
12	16.2	12.9	80.16	2	0.14	2		2
13	16	12.9	84.94	1	4.42	3	984	2
14	16	12.9	93.61	1	1.52	3	883	1
15	21.6	16.9	204.98	2	0.71	2		2
16	15.9	12.7	79.74	1	3.04	3	867	3
17	16.5	13	93.6	2	0.1	1		1
18	13.2	10.4	43.9	1	0.12	1		1
19	16.3	13.4	95.03	2	0.12	1		2

20	14.2	11.1	60.13	1	1.86	3	765	2
21	14.3	11.5	64	1	1.11	2		1
22	16.5	13.4	96.75	1	1.63	2		2
23	16.5	12.9	94.65	2	0.3	2		
24	16.7	13.2	87.7	2	0.15	2		1
25	13.3	10.4	42.96	2	0.11	1		1
26	13.5	10.7	50.44	2	0.04	1		1
27	15.5	12.4	76.58	1	1.03	2		1
28	14.6	11.8	60.74	1	0.78	2		1
29	12.9	10.3	42.74	1	0.1	1		1
30	16.9	13.4	91.32	2	0.06	1		1
31	16.1	12.9	93.47	1	0.23	2		1
32	12	9.5	33.5	1	0.07	1		1
33	13	10.2	37.27	2	0.02	1		1
34	14.2	11.2	57.92	2	0.06	1		1
35	11.5	9.1	28.1	1	0.03	1		1
36	13.1	10.4	41.21	1	0.11	1		1
37	16.5	13.4	93.09	1	0.99	2		1
38	14.2	11.5	60.79	2	0.2	2		2
39	14.6	11.4	60.89	1	2.31	3	822	2
40	21.1	17	203.4	2	0.6	2		1
41	17.5	13.9	107.3	2	0.2	2		1
42	16.8	13.5	101.95	1	3.08	3	812	1

43	16.1	13	88.4	2	1.01	2		1
44	19.7	15.8	154.25	2	0.63	2		2
45	22.2	17.7	229.47	2	0.49	2		2
46	19.4	15.9	153.22	2	0.42	2		2
47	12.2	9.7	35.55	1	0.1	1		1
48	14.5	11.5	57.45	2	0.6	1		1
49	21	16.8	177.2	2	0.28	2		1
50	20.4	16.3	167.68	2	0.65	2		1
51	20.7	15.8	171.5	2	0.25	2		2
52	23.7	18.6	242.79	2	0.75	2		2
53	17.7	14.1	113.03	2	0.12	2		1
54	21.4	17.3	180.73	1	3.52	3	1132	2
55	16.6	13.4	92.21	1	1.89	3	869	2
56	23.5	18.7	239.61	2	0.47	2		2
57	17.1	13.7	85.74	1	1.54	2		1
58	20.2	16	172.62	2	0.24	2		2
59	16.6	13.5	101.11	1	2.82	2		1
60	16.5	13.4	91.8	2		1		1
61	21.5	17.4	206.5	2	0.44	2		3
62	30.7	24.5	575	1	4.82	3	902	1
63	31.5	25.2	640	2	1.79	2		2

Period: January, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G Stage	Fec.	Fat Index
1	11	8.7	23.96	2	0.03	1		1
2	27.1	21.2	286.85	2	0.79	2		3
3	30.2	24.3	580	2	1.37	2		3
4	26.5	20.9	367.34	2	1.67	2		1
5	20.4	16.2	164.4	2	0.58	2		2
6	19.2	15.3	143.4	2	0.72	2		3
7	18.9	14.8	130.87	2	0.03	1		1
8	15.1	12.2	67.83	1	2.25	3	691	2
9	21.4	17	165.37	2	0.81	2		2
10	23.3	18.7	229.19	1	9.3	3	832	1
11	19.5	15.4	132.66	2	0.64	2		1
12	20.7	16.5	127.01	2	0.7	2		1
13	12.3	10	36.58	1	0.11	1		2
14	19.8	15.6	136.96	1	1.31	2		1
15	18.6	14.8	124.93	2	0.5	2		2
16	15.6	12.5	68.3	1	0.8	2		2
17	15.2	12.3	69.68	1	3.28	3	907	1
18	16.2	13.1	78.73	1	1.17	2		1
19	20.1	15.9	150.4	2	0.44	2		3

20	17	13.6	91.27	1	1.64	2		2
21	18.9	15	136.7	2	0.7	2		2
22	19.5	15.4	132.61	2	0.61	2		2
23	18.2	14.5	126.93	2	0.34	2		1
24	15.2	12.4	73.38	1	2.9	3	902	2
25	11.9	9.6	31.32	1	0.13	1		2
26	15.8	12.9	76.93	1	3.7	3	876	2
27	14.4	11.6	61.68	1	0.75	2		2
28	14.9	11.9	70.69	1	1.9	2		1
29	19.9	15.7	144.63	2	0.65	2		2
30	21	16.6	173.92	2	0.64	2		2
31	19.4	15.3	148.84	2	0.69	2		2
32	13.2	10.7	45.24	1	0.35	2		2
33	18.6	14.5	124.77	2	0.62	2		2
34	14.4	11.4	59.2	2	0.07	1		2
35	15	12	59.8	1	0.82	2		1
36	16.4	12.9	80.49	2	0.09	1		1
37	15	12	61.33	1	1.77	2		1
38	17.9	14.4	117.2	1	1	2		1
39	16.2	12.9	85.52	2	0.16	2		2
40	14.1	11.3	52.42	1	1.14	2		1
41	18.4	14.9	119.63	2	0.25	2		2
42	17.2	13.7	92.97	1	2.75	3	804	2

43	16.1	12.9	85.92	1	1.16	2		1
44	19.8	15.9	138.69	2	0.59	2		1
45	13.2	10.5	46.7	1	0.36	1		3
46	12.6	10.2	44.56	1	0.41	1		2
47	15.1	12	69.52	2	0.02	1		1
48	12.5	10	35.87	1	0.19	1		1
49	18.5	14.8	126.17	2	0.24	1		2
50	10.3	8.4	21.33	1	0.06	1		1
51	16.2	13.1	84.26	1	3.16	3	821	1
52	12.8	10.4	39.77	2	0.04	1		1
53	13.5	10.4	46.34	1	0.91	3	698	1
54	14.5	11.5	61.3	1	2.24	3	806	2
55	14.7	11.9	64.8	1	0.92	2		2
56	14.7	11.7	60.87	1	1.52	2		2
57	21	16.8	156.66	2	0.62	2		2
58	16.2	13.3	83.97	1	4.01	3	954	2

Period: February, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	14.2	11.3	52.17	1	1.23	2		1
2	17.2	13.8	110.78	1	1.54	2		1
3	16.8	13.2	86.8	1	1.48	2		1
4	17.3	13.9	97.01	1	1.88	2		1
5	16.7	13.2	87.88	1	3.34	3	817	1
6	16.6	13	93.48	2	0.17	2		1
7	15.5	12.4	76.66	1	2.74	3	927	1
8	16.9	13.2	100.59	1	3.95	3	953	1
9	19.4	15.5	138.61	1	1.82	2		1
10	18.2	14.7	118.9	2	0.2	2		2
11	15.9	12.9	42.22	1	1.17	2		1
12	18.9	14.7	151.64	2	0.22	2		1
13	17	13.5	99.28	2	0.13	2		1
14	24	16.4	166.93	2	0.51	2		3
15	16.1	13	80.59	1	1.14	2		2
16	24.5	16.8	185.65	2	0.53	2		2
17	28.2	22.4	400	2	1.53	2		3
18	16.6	13.4	99.08	1	4.3	3	734	1

19	15.8	12.4	71.7	1	1.29	2		1
20	16.1	12.7	84.03	1	1.58	2		1
21	26	20.4	342.98	1	2.55	3	930	1
22	21.1	17.8	208.11	2	0.4	2		2
23	18.5	14.5	115.55	1	1.39	2		1
24	24.2	18.8	291.87	2	0.13	2		1
25	24	18.6	274.31	1	1.05	2		1
26	18.5	14.5	132.58	2	0.83	2		2
27	22.5	18	221.32	1	4.09	3	847	2
28	26	20.5	338.62	1	2.02	2		2
29	16	12.8	83.78	2	0.67	2		2
30	18.2	14.5	125.8	2	0.32	2		2
31	18.4	14.8	115.52	2	0.25	2		2
32	27.2	24.1	404	2	0.34	2		1
33	24.1	19.2	237.5	2	1.46	2		3
34	17.9	14.4	115.1	2	1.1	2		4
35	19.1	14.9	128.09	1	2.8	2		1
36	19	15.1	154.31	2	0.29	2		2
37	20	15.7	183.5	2	0.91	2		2
38	19.2	15.6	161.31	1	0.88	1		1
39	26.3	20.5	330.2	2	1.29	2		2
40	22.7	18.4	216.2	2	1.19	2		1

41	19.4	16.1	166	2	0.47	2		2
42	21.8	16.9	209	2	0.54	2		3
43	14.5	11.7	64.3	1	0.94	2		2
44	19.2	14.9	138.5	1	2.69	2		1

Period: March, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GW (g)	G Stage	Fec.	Fat Index
1	20.7	16.3	146.66	1	1.79	2		1
2	20.5	16.1	151.6	2	0.52	2		1
3	16.5	13	85.21	1	2.95	3	886	1
4	20.8	16.5	169.15	2	0.61	2		3
5	16.4	13	83.74	1	1.12	1		3
6	17.2	13.7	114.9	1	2.61	3	842	3
7	17.1	13.6	88.62	1	2.34	3	927	1
8	21.6	16.9	191.91	1	1.16	2		3
9	24.5	19.5	256.87	1	3.11	2		1
10	20.5	16.4	189.32	2	0.66	2		3

11	10.5	8.3	23.16	1	5.07	2		2
12	12.3	9.9	42.46	1	2.16	2		2
13	16.2	12.8	80.2	1	2.17	3	810	2
14	21	16.3	174.16	1	2.74	3	972	3
15	18.9	14.8	124.22	1	2.21	3	574	2
16	22	17.2	202.78	1	3.69	2		2
17	18.7	14.9	127.03	1	2.36	3	762	1
18	17.5	14.1	100.05	1	3.02	2		1
19	17	13.1	77.19	1	3.69	3	576	2
20	16.9	13.5	82.64	1	2.48	3	790	1
21	15.2	12.2	70.32	2	1.59	2		3
22	21.2	17.1	180.21	1	2.3	3	826	2
23	16	12.7	73.9	1	0.96	2		1
24	17	13.4	82.01	1	2.07	3	791	1
25	15.7	12.6	75.93	1	4.39	3	743	1
26	16.3	13	76.36	1	2.96	3	849	1
27	23.4	19.5	236.46	2	1.33	2		3
28	17.8	14.2	96.36	2	1.55	2		3
29	15.7	12.6	69.75	1	3.02	3	793	2

30	16.1	12.8	71.24	1	2.68	2		1
31	16.5	13.3	88.81	2	0.71	2		3
32	16.1	12.8	80.1	2	0.68	2		3
33	23.2	18.5	239.88	2	1.06	2		3
34	21	16.2	162.8	2	0.18	2		3
35	17.4	13.9	93.7	1	2.98	3	838	2
36	17.3	13.5	87.82	1	3.5	2		3
37	21	16.5	200.28	1	7.27	3	1014	2
38	20.5	16.1	152.2	2	0.77	2		3
39	21.5	17	191.38	1	2.69	2		2
40	17.7	13.8	102.67	1	2	2		1
41	16.1	12.9	83.28	1	3.77	2		1
42	16.7	13.3	96.66	1	3.92	3	983	2
43	10.7	8.4	23.13	2		1		1
44	12.3	9.9	42.32	2		1		1
45	16.2	12.9	79.81	1	1.04	1		1
46	21.2	16.5	173.86	2	0.34	2		3
47	18.6	14.7	123.56	2	0.8	2		2
48	22	17.1	202.02	2	1.25	2		3

Period: April, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	14.8	11.5	58.82	1	0.83	1		1
2	23.3	18.1	242.96	2	1.2	2		2
3	22.4	17.2	215.96	2	1.24	2		2
4	15.5	12.4	79.51	2	0.09	1		1
5	17	13.6	86.49	1	2.23	3	743	1
6	24.9	19.5	255.81	2	1.27	2		1
7	23.4	18.4	239.69	2	2.43	2		2
8	21.4	16.9	278.37	2	1.03	2		2
9	25.8	20.5	317.05	2	1.41	2		2
10	17.7	14.1	103.99	1	2.25	2		1
11	22.5	17.6	215.16	2	1.12	2		1
12	15.9	12.7	77.26	1	3.73	3	988	1
13	19.7	13.6	132.36	1	3.32	3	751	1
14	18.9	16.1	143.26	2	0.56	2		2
15	19.3	15.3	123.51	1	1.44	2		1
16	27.2	21.5	396.3	2	2.39	2		2
17	15.2	11.9	66.45	1	0.24	1		1
18	28.3	22.4	430	2	2.1	2		3
19	27.3	22.1	399.16	2	1.59	2		2
20	17.9	14.5	101.54	1	3.69	3	803	1
21	15.7	12.5	80.64	1	1.06	1		1

22	23.2	18.4	206.17	2	1.03	2		1
23	22.5	17.6	197.08	2	1.44	2		1
24	15.6	12.5	71.26	2	0.11	1		1
25	15.4	12.2	76.76	1	2.22	3	712	1
26	24.4	19.2	260.68	2	1.11	2		1
27	24.5	19.4	230.97	2	0.9	2		1
28	22.4	17.6	202.03	2	1.12	2		1
29	21.2	16.7	179.76	2	0.57	2		1
30	24.2	18.7	250.42	2	1.11	2		1
31	16	15.3	67.99	1	2.04	2		1
32	16.8	13.4	93.27	1	2.5	2		2
33	18.4	14.7	123.84	2	0.9	2		1
34	15.2	12.1	66.8	2	0.19	1		1
35	15.5	12.3	73.68	1	0.25	1		1
36	17.2	15.8	132.21	1	3.82	2		1
37	19.1	15.4	124.21	1	1.07	1		1
38	15	11.9	63.51	1	0.18	1		1
39	23.6	18.5	244.68	2	0.6	2		3
40	15.9	12.7	74.32	1	0.89	1		2
41	14.1	11.3	62.12	1	1.33	1		2
42	14.5	11.6	61.57	2	0.04	1		1
43	15.4	12.3	78.41	2	0.13	1		1
44	14.5	11.6	67.94	2	0.09	1		2

Period: May, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	12.5	9.5	13	2	0.2	1		1
2	13.5	10.6	47.66	2	0.3	1		1
3	15.6	12.7	73.48	2	0.18	1		1
4	12.5	9.9	36.56	2	0.3	1		1
5	17.4	13.6	35.64	1	1.13	2		1
6	12.8	9.9	37.32	2	0.4	1		1
7	13.4	10.6	47.12	2	0.5	1		1
8	12	9.4	37.07	2	0.4	1		1
9	13.5	10.8	48.46	2	0.4	1		1
10	13.6	10.8	52.72	1	1.5	2		1
11	12.5	10.4	39.05	2	0.06	1		1
12	12	9.5	34.91	1	0.6	1		1
13	12.2	9.5	35.2	2	0.3	1		1
14	16.5	13.1	81.18	1	2.45	2		1
15	17	13.4	92.2	1	2.56	3	766	1
16	13.9	11	45.52	1	0.11	1		1
17	16.3	12.1	73.68	2	0.2	2		3
18	12.2	10.5	30.63	2	0.3	1		1
19	11.9	9.5	31.8	2	0.2	1		1
20	14.5	11.4	58.12	2	0.5	1		1

21	15.6	12.5	72.56	1	3.81	3	889	1
22	16.5	12.8	78.4	1	1.38	2		2
23	14.9	11.4	67.33	2	0.1	1		2
24	16.2	12.7	80.34	1	3.05	2		1
25	15.8	12.5	79.53	1	1.16	2		1
26	13.5	10.6	73.36	2	0.03	1		1
27	23.5	18.6	228.56	2	0.67	2		2
28	19.8	16.7	169.5	1	1.76	2		1
29	23.7	18.5	225.54	2	2.16	2		2
30	20.4	16.4	177.38	1	5.24	3	936	2
31	17	13.6	84.45	1	2.33	3	815	1
32	19.3	16.4	132.65	1	5.71	3	1362	1
33	22.5	17.9	234.49	2	1.15	2		1
34	18.9	14.8	117.42	1	1.14	2		1
35	15.7	12.5	83.63	1	1.41	2		1
36	22.5	17.5	221.81	2	0.87	2		1
37	21.2	17	198.17	1	4.73	3	817	3
38	25	19.9	288.05	2	0.81	3		2
39	23	18	224.66	2	1.11	2		1
40	24.2	18.2	247.73	2	1.86	2		1
41	13	10.2	39.58	2	0.05	1		1
42	20.4	16.8	179.44	2	0.86	1		1
43	24	17.9	242.35	2	0.28	2		1

44	20.5	16.1	163.21	1	1.81	2		1
45	25.7	18.6	220.92	2	1.23	2		1
46	21.1	12.2	179.53	2	0.92	2		2
47	21	16.5	171.13	2	0.29	2		1
48	19.2	15.3	140.16	1	4.36	3	752	2
49	20.5	16.4	149.14	2	0.58	2		1

Period: June, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	15.2	11.8	67.74	2	0.1	1		1
2	15.2	12.5	73.85	2	0.03	1		1
3	15.9	12.7	74.8	1	2.91	3	697	2
4	14.2	11.5	54.08	1	0.07	1		1
5	17	13.4	98.92	2	0.06	1		1
6	16.9	13	86.22	2	0.34	2		1
7	13.8	11	49.76	1	0.31	1		2
8	16.7	13.4	92.26	2	0.22	2		1
9	18.4	14.8	105.34	1	1.63	2		1
10	15.5	12.3	73.75	2	0.09	1		1
11	14	11.2	53.89	1	0.12	1		1

12	14.8	11.8	66.95	1	0.08	2	1
13	13.8	10.8	50.76	2	0.06	1	1
14	15.1	12.2	66.27	1	1.02	2	1
15	16.5	13	85.15	2	0.34	2	1
16	16.7	13.2	92.61	2	0.14	1	1
17	15.5	12.4	70.35	1	0.21	1	1
18	16.8	13.3	96.81	2	0.14	1	1
19	21.4	16.5	155.21	1	3.1	2	2
20	14.1	11.4	53.4	2	0.05	1	1
21	16	12.5	82.55	1	0.25	2	1
22	16.5	13.3	86.45	1	2.08	2	2
23	16.8	13.3	92.91	1	0.36	2	2
24	13.6	10.7	49.58	1	0.05	1	3
25	14.8	11.5	63.07	2	0.09	1	2
26	16.8	13.3	87.98	2	1.3	2	1
27	13.9	11	51.68	1	0.63	2	3
28	16.5	13.2	92.36	2	1.32	2	2
29	16.7	13.3	84.89	1	0.33	2	1
30	16.8	13.4	87.46	1	0.56	2	2
31	16.9	13.5	84.38	1	1.09	1	2
32	16.1	12.8	85.52	1	0.78	2	3
33	17.1	13.7	96.45	2	1.22	2	1
34	16.6	13.1	89.53	1	0.67	1	1

35	13.5	10.8	49.56	1	2.36	3	716	1
36	16.2	12.8	79.58	1	1.58	2		3
37	16.1	13	89.92	1	0.03	1		1
38	15.7	12.6	76.97	2	0.19	2		2
39	16.8	13.4	95.11	2	0.6	1		1
40	16.5	13.3	88.4	2	2.6	3		1
41	14.4	11.7	56.09	1	3.21	3	846	1
42	16.1	12.7	78.9	1	4.32	2		2
43	16.6	13.1	86.79	1	0.51	1		1
44	15.5	12.6	87.7	1	0.88	1		3
45	17	13.5	99.39	1	0.24	1		1
46	17	13.4	89.2	1	2.56	2		2
47	13.5	10.5	45.56	1	1.83	2		2
48	14.5	11.3	60.56	1	3.2	3	769	2
49	12.5	9.9	37.13	1	2.3	2		1
50	13.1	10.4	44.19	2	0.26	2		1
51	16.2	13.4	93.81	1	2.01	2		2
52	16	12.6	74.93	1	2.5	3	734	3
53	16.1	12.5	85.28	1	0.11	2		2
54	15.1	12	66.59	2	0.25	1		2
55	14	11	55.73	2	1.13	1		1
56	16.6	13	88.47	1	2.3	2		1
57	16.1	12.9	93.66	2	2.05	2		1

58	14.2	11.3	57.06	1	0.86	2		1
59	14.7	11.4	59.36	1	3.6	3	881	2
60	16.4	11.8	89.2	2	2.61	2		2
61	11.9	9.2	45.56	2	0.08	2		3
62	16	12.5	82.28	1	1.47	2		1
63	14.5	11.5	63.38	1	2.44	2		1

Period: July, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	20	15.7	173.69	2	0.29	2		1
2	17.7	14.1	97.2	2	0.53	2		1
3	20.9	16.6	200.94	2	0.45	2		1
4	15.3	12.2	68.02	1	2.29	3	731	1
5	18.1	14.2	109.49	2	0.37	2		5
6	17.8	14.1	107.1	2	0.07	1		1
7	16.2	12.8	77.16	1	2.75	2	802	1
8	13.3	10.4	44.32	2	0.07	1		1
9	14.8	11.7	60.14	1	2.31	2	748	1
10	13.5	10.8	45.13	2	0.08	1		1
11	14	11.1	46.29	2	0.06	1		1
12	15	11.8	61.53	1	0.95	2		1

13	18	14.3	101.41	2	0.06	2		1
14	20.6	16.3	178.76	2	0.05	2		1
15	16.3	12.8	86.82	1	1.22	2		1
16	14.5	11.5	57.57	1	0.13	1		1
17	14.1	11.4	51.37	2	0.05	1		1
18	16.9	13.4	84.92	2	0.48	2		1
19	15.6	12.2	72.75	2	0.14	2		1
20	14	10.9	52.62	1	0.27	1		1
21	13	10.1	41.18	2	0.03	2		1
22	13.9	10.8	53.18	2	0.04	2		1
23	14.8	11.5	61.95	1	0.61	2		1
24	14.6	11.8	63.31	1	1.53	2		1
25	14.7	11.6	59.85	1	0.23	1		1
26	14.5	11.4	60.81	1	0.47	1		1
27	14	11.1	50.16	1	1.2	2		1
28	14.4	13	78.25	1	3.87	3	892	1
29	15.3	12	64.66	2	0.11	1		1
30	12.7	10	41.18	2	0.02	1		1
31	12.4	9.8	32.71	2	0.02	1		1
32	14.5	11.4	53.88	2	0.08	1		1
33	16.7	13.4	92.82	2	0.16	1		1
34	15	11.9	58.36	2	0.07	1		1
35	19.6	15.5	163.16	2	0.41	2		1

36	20.3	16.1	107.81	2	0.66	2		3
37	19	15	120.21	2	0.68	2		2
38	20.7	16.6	173.48	2	0.32	2		1
39	17.8	14	97.44	2	0.5	2		1
40	20.7	16.7	165.32	2	0.2	2		2
41	19.2	15.1	135.55	2	0.63	2		1
42	19.3	15.4	150	2	0.79	2		1
43	17.6	13.7	107.99	2	0.26	2		2
44	19.3	15	134.22	2	0.5	2		2
45	20.2	15.7	163.15	2	0.42	2		1
46	21.2	17.1	178.38	1	6.63	3	1032	2
47	20.5	16.3	184.63	2	0.33	2		1
48	18.3	14.5	127.16	2	0.6	2		1
49	20.7	16.4	195.34	2	0.44	2		1
50	20.2	15.7	173.45	2	0.21	2		1
51	16.6	13.1	92.29	2	0.13	1		1
52	18.1	14.4	107.33	2	0.03	1		1
53	13	10.4	41.7	2	0.24	2		1
54	20	15.8	155.58	2	0.8	2		2
55	19.6	14.9	155.8	2	0.23	2		1
56	19.5	15.3	151.65	2	0.6	2		2
57	18.1	14.2	114.8	2	0.82	2		2
58	19.8	15.6	141.31	2	0.11	1		2

59	15.2	12.1	63.9	2	0.15	1		3
60	17.4	13.7	109.19	2	0.12	1		2
61	26.2	20.6	350.08	2	1.7	2		3
62	23.4	18.5	254.08	2	2.2	2		3
63	24	18.7	251.55	1	2.09	3	659	3
64	20.5	16.1	183.53	2	0.64	2		3
65	25.2	19.8	303.22	2	1.93	2		3
66	25.3	20	292.39	2	2.2	2		1
67	23.6	18.9	238.9	2	1.75	2		2

Period: August, 2008

SN	TL(cm)	SL (cm)	WT (g)	SEX	GWT (g)	G Stage	Fec.	Fat Index
1	33.3	27.1	700	2	2.81	2		3
2	31.2	24.9	568	2	2.11	2		3
3	29.1	22.7	475	2	0.65	2		3
4	19.4	15.4	148.08	2	0.22	2		2
5	19.6	15.5	160.7	2	0.4	2		3
6	19.9	15.6	164.16	2	0.57	2		3
7	21.2	16.6	201.22	2	0.27	1		2
8	25.3	19.2	304.28	2	3.32	2		3
9	19.3	15	130.62	2	0.28	2		2

10	19.5	15.4	165.94	2	0.26	2		2
11	19.9	15.9	160.3	2	0.16	1		2
12	21.2	16.9	188.48	2	0.3	1		1
13	18	14.5	113.64	2	0.23	1		2
14	16.6	13.4	94.68	1	4.91	3	958	2
15	16.2	13	90.31	1	2.13	2		2
16	16.7	13.3	94	1	2.65	2		3
17	16.8	13.4	98.99	1	3.63	3	888	1
18	15.6	12.3	73.41	1	1.71	3	563	3
19	14.1	11.2	49.74	2	0.14	1		1
20	15.8	12.8	84	1	0.59	1		1
21	15.9	12.5	73.64	2	0.1	1		1
22	15	11.8	63.52	1	0.16	1		1
23	14.6	11.5	59.64	1	0.09	1		1
24	16.5	12.6	80.78	2	0.05	1		1
25	14.7	11.5	57.7	1	0.11	2		1
26	16.2	12.9	86.16	1	0.75	2		2
27	17	13.6	100.68	1	3.9	3	852	1
28	14	10.9	49.47	2	0.04	1		1
29	14.6	11.5	57.34	1	0.5	2		1
30	18.7	14.5	121.04	2	0.66	2		1
31	20.1	15.9	178.09	2	0.36	2		1
32	17.9	14	109.25	1	0.81	1		2

33	19.1	15.2	143.71	2	0.25	2		1
34	19.8	15.3	150.91	2	0.32	2		2
35	19.2	15	137.6	2	0.63	2		1
36	19.4	15.3	150.82	2	0.22	2		1
37	19.5	15.4	140.79	2	0.45	2		2
38	19.5	15.3	142.29	2	0.66	1		1
39	18.5	14.6	142.98	1	4.26	3	856	2
40	19.5	15.5	138.42	2	0.18	2		2
41	19.5	15.2	139.09	2	0.46	2		1
42	19	14.7	129.53	2	0.61	2		1
43	18.9	14.8	136.19	2	0.1	1		2
44	23.8	16.4	166.73	2	0.35	2		1
45	19.3	15.1	137.92	2	0.32	2		2
46	16.4	13.2	92.13	1	0.25	2		1
47	18.2	14	115.67	2	0.47	2		1
48	16.4	13.3	101.23	1	0.37	1		1
49	18.5	14.6	118.38	2	0.12	1		2
50	20.3	16.1	160.54	2	0.56	2		3
51	19.5	15	140.23	2	1.07	2		1
52	17.7	14.1	103.99	2	2.25	2		2
53	22.5	17.6	195.16	2	1.12	2		1
54	15.9	12.7	77.26	1	3.73	3	841	1
55	19.7	13.6	132.36	2	3.32	2		2

56	18.9	16.1	143.26	2	0.56	2		2
57	19.3	15.3	123.51	1	1.44	3	468	2
58	27.2	21.5	396.3	1	2.39	3	750	3
59	15.2	11.9	66.45	1	0.24	1		2
60	28.3	22.4	430	2	2.1	2		2
61	27.3	22.1	399.16	2	1.59	2		1
62	17.9	14.5	101.54	2	3.69	2		3
63	15.7	12.5	80.64	1	1.06	2		1
64	23.2	18.4	206.17	1	1.03	2		1
65	22.5	17.6	197.08	2	1.44	1		2
6	15.6	12.5	71.26	2	0.11	1		3

Key

SN = Serial number

SL = Standard length

WT = Body weight

SEX 1 = Female fish

SEX 2 = Male fish

GWT = Gonadal weight

G stage = Gonadal stage

Fec. = Fecundity

Fat Index = Visceral fat index

Appendix 2

Result from t-test on length-weight regression using Microsoft Excel (Statistical).

Y = Length-weight Reg!$C$2:$C$658
X = Length-weight Reg!$B$2:$B$658

Descriptive Statistics

Variable	Mean	Std Dev.	N
Column C	912.984	########	657
Column B	14.126	3.002	657

Summary

R^2	R	Adj. R^2	S.E. of Estimate
0.004	0.065	0.003	########

ANOVA

Source	Sum Sq.	D.F.	Mean Sq.	F	Prob.
Regression	########	1	########	2.816	0.094
Residual	########	655	########		
Total	########	656			

Regression Coefficients

Source	Coefficient	Std Error	Std Beta	-95% C.I.	+95% C.I.	t	Prob.
Intercept	-2878.184	2309.764		-7413.619	1657.251	-1.246	0.213
Column B	268.388	159.947	0.065	-45.683	582.459	1.678	0.094

Appendix 3

Mean monthly condition factor (K) of *O. niloticus* in the Weija reservoir.

Month	Female K ± SE	Male K ± SE
Sep 2007	4.0165 ± 0.98	4.114 ± 0.068
Oct "	4.307 ± 0.131	4.956 ± 0.125
Nov "	4.2019 ± 0.081	3.9362 ± 0.096
Dec "	3.9256 ± 0.044	4.0129 ± 0.042
Jan 2008	3.7469 ± 0.04	3.7581 ± 0.063
Feb "	3.86 ± 0.102	3.9597 ± 0.098
Mar "	3.7687 ± 0.054	3.815 ± 0.072
Apr "	3.74 ± 0.153	3.8849 ± 0.094
May "	3.559 ± 0.191	4.102 ± 0.222
Jun "	3.7923 ± 0.44	3.9749 ± 0.059
Jul "	3.7512 ± 0.059	3.8848 ± 0.053
Aug "	3.886 ± 0.053	3.9479 ± 0.051

Appendix 4

Mean monthly gonado-somatic index (GSI) of *O. niloticus* in the Weija reservoir.

Months	Female GSI ± SE	Male GSI ± SE
Sep 2007	2.603 ± 0.36	0.286 ± 0.041
Oct "	2.47 ± 0.337	0.39 ± 0.109
Nov "	2.259 ± 0.463	0.398 ± 0.141
Dec "	1.727 ± 0.261	0.251 ± 0.0434
Jan 2008	2.195 ± 0.277	0.3216 ± 0.031
Feb "	2.012 ± 0.250	0.3451 ± 0.051
Mar "	3.634 ± 0.826	0.698 ± 0.159
Apr "	2.071 ± 0.306	0.427 ± 0.043
May "	2.517 ± 0.304	0.5499 ± 0.070
Jun "	2.089 ± 0.325	0.786 ± 0.195
Jul "	2.126 ± 0.410	0.2991 ± 0.031
Aug "	1.708 ± 0.356	0.482 ± 0.106

Appendix 5

Fecundity range of some tilapiine species.

Species	Total length range (cm)	Fecundity range	Source
O. niloticus	15.6 – 19.3	563 - 1362	Present study
O. niloticus	28.0 – 56.0	340 – 3706	Lung'ayia (1994)
O. niloticus	16·5 - 32·0	318 - 3169	De Silva (2008)
O. niloticus	17.0 - 47.0	340 - 3706	Lowe McConnel (1955)
O. esculentus	17.0 – 36.0	324 – 1672	Lowe McConnel (1955)
S. galilaeus	16.0 – 30	538 – 560	”
T. zillii	8.0 – 25.0	1000 - 5711	”

Appendix 6

Mean monthly data on some physico-chemical of the Weija reservoir.

Period	Temperature (°C)	DO (mg/l)	Total Alkalinity (mg/l)
Sep. 2007	27.5	11.2	100
Oct. "	27.5	10.3	98
Nov. "	29.0	9.2	108
Dec. "	28.5	8.4	110
Jan. 2008	26.7	7.8	115
Feb. "	30.5	8.2	128
Mar "	23.0	9.7	120
Apr "	24.5	8.6	118
May "	25.6	6.8	100
Jun "	27.8	6.6	105
Jul "	27.5	7.0	110
Aug "	26.8	7.6	115

(Source: GWCL/AVRL-Weija, 2008)

Appendix 7

PROCEDURE FOR THE PREPARATION OF GILSON'S FLUID

The Gilson's Fluid was prepared according to Simpson (1951) using the following reagents.

Nitric acid, 80%	15	ml
Acetic acid, glacial	18	ml
Mercuric chloride	20	g
Ethanol, 60%	100	ml
Distilled water	880	ml

The mercuric chloride was dissolved in about 100ml of the distilled water in a beaker, and the mixture warmed intermittently to enhance dissolution. The other reagents were then added.

Appendix 8

Frequency Distribution of ovum diameter of four ripe ovaries of *O. niloticus* in the Weija reservoir (N= total number of ova).

Ovaries 1: (TL=15.4 cm)	Ovum Diameter (mm)	Frequency	% Frequency
	1.2-1.3	0	0.00000000
	1.4-1.5	99	13.90449438
	1.6-1.7	135	18.96067416
	1.8-1.9	129	18.11797753
	2.0-2.1	82	11.51685393
	2.2-2.3	109	15.30898876
	2.4-2.5	97	13.62359551
	2.6-2.7	45	6.320224719
	2.8-2.9	15	2.106741573
	3.0-3.1	1	0.140449438
		N= 712	

Ovaries 2: (TL=14.6 cm)	Ovum Diameter (mm)	Frequency	% Frequency
	1.2-1.3	0	0.00000000
	1.4-1.5	152	18.49148418
	1.6-1.7	215	26.15571776
	1.8-1.9	184	22.38442822
	2.0-2.1	30	3.649635036
	2.2-2.3	145	17.63990268
	2.4-2.5	69	8.394160584
	2.6-2.7	17	2.068126521
	2.8-2.9	9	1.094890511
	3.0-3.1	1	0.121654501
		N= 822	

Ovaries 3: (TL=16.8 cm)	Ovum Diameter (mm)	Frequency	% Frequency
	1.2-1.3	1	0.107526882
	1.4-1.5	122	13.11827957
	1.6-1.7	170	18.27956989
	1.8-1.9	164	17.6344086
	2.0-2.1	106	11.39784946
	2.2-2.3	151	16.23655914
	2.4-2.5	121	13.01075269
	2.6-2.7	67	7.204301075
	2.8-2.9	23	2.47311828
	3.0-3.1	5	0.537634409
		N= 930	

Ovaries 4: (TL=21.0 cm)	Ovum Diameter (mm)	Frequency	% Frequency
	1.2-1.3	7	0.690335306
	1.4-1.5	133	13.11637081
	1.6-1.7	186	18.34319527
	1.8-1.9	202	19.92110454
	2.0-2.1	151	14.89151874
	2.2-2.3	123	12.13017751
	2.4-2.5	171	16.86390533
	2.6-2.7	29	2.859960552
	2.8-2.9	10	0.986193294
	3.0-3.1	2	0.197238659
		N= 1014	